UNIVERSITI TEKNOLOGI MARA

INTEGRATED PROJECT DELIVERY BEST PRACTICES (IPD-BP) MODEL FOR INDUSTRIALISED BUILDING SYSTEM (IBS) PERFORMANCE IN MALAYSIA

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PhD

June 2026

UNIVERSITI TEKNOLOGI MARA

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Thesis submitted in fulfilment
of the requirements for the degree of
Doctor of Philosophy
(Built Environment)

Faculty of Built Environment

June 2026

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I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the results of my own work, unless otherwise indicated or acknowledged as referenced work. This thesis has not been submitted to any other academic institution or non-academic institution for any degree or qualification.

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ABSTRACT

The Malaysian construction industry is progressing toward the Construction 4.0 Strategic Plan, which necessitates the adoption of advanced technologies, including Industrialised Building System (IBS), a notable component. Transitioning to IBS presents numerous challenges, making it a complex process. The identified problems include low adoption and poor performance of IBS in Malaysia, a lack of integration among IBS participants in managing IBS projects, the unsuitability of traditional procurement approaches for IBS projects, and limited research on procurement, particularly on Integrated Project Delivery (IPD) in IBS. The study aims to propose an Integrated Project Delivery (IPD) Best Practices (IPD-BP) Model for IBS performance in Malaysia with the establishment of four objectives which are (i) to identify Integrated Project Delivery (IPD) best practices in the Industrialised Building System (IBS) project; (ii) to identify the performance elements of the Industrialised Building System (IBS) project; (iii) to analyse the relationship between Integrated Project Delivery (IPD) best practices and the Industrialised Building System (IBS) project performance, and (iv) to develop an Integrated Project Delivery Best Practice (IPD-BP) Model for Industrialised Building System Performance in Malaysia. The study identified a total of forty-one (41) IPD best practices, categorised into four primary elements: People, Process, Strategy, and Technology. Additionally, the study identified four key factors of IBS project performance: Time, Cost, Quality, and Integration. The study used a deductive and quantitative methodology to develop a conceptual framework for the IPD best practices model for IBS, utilising a comprehensive literature review and a questionnaire survey. The questionnaire surveys were distributed to 1,037 respondents, including IBS precast G7 contractors, IBS consultants, IBS clients, IBS manufacturers, and IBS suppliers involved in IBS projects, of which only 259 responded. The data were analysed using IBM SPSS version 28 and SmartPLS version 4 software. Based on the findings, the study reveals that People, Process, and Technology had a positive relationship with the IBS project performance. Conversely, Strategy does not show a significant relationship with IBS project performance. The validation by expert panels concurs with the finding that the proposed IPD best practices model can enhance IBS project performance. Ultimately, it is anticipated that this research model contributed to improving the performance of the IBS project through the implementation of IPD. The IPD-BP model can assist IBS stakeholders in identifying areas requiring development to augment performance. The IPD-BP model can serve as an alternative to the conventional methods of managing IBS projects and aligns with the IBS agenda in the National Construction Policy 2030 in Thrust 6: strengthening good governance and adoption of best practices, which aims to enhance public procurement systems and promote best practices in construction. Finally, other researchers may utilise it in formulating their research frameworks for future studies.

ACKNOWLEDGEMENT

In the Name of Allah SWT, The Most Beneficent, The Most Merciful.

Firstly, I am profoundly grateful to Allah S.W.T., for granting me the health and strength to complete this Ph.D. research. My gratitude and thanks go to my supervisor, Dr. Izatul Laili, as well as Professor Ts. Sr. Dr. Abdul Hadi Nawawi and Professor Sr. Dr. Mohd Nasrun Mohd Nawi, for their unwavering support, invaluable suggestions, and boundless patience throughout my Ph.D. journey.

I would also like to express my sincere appreciation to my wife, Syuibah Mohamad, for her unwavering support and understanding, and to my wonderful children, Raiyan Miqhaieel and Raihanah Madeena, for their thoughtfulness and consideration.

Finally, I am grateful to my beloved mother, , my sister, and my friends for their encouragement and motivation throughout my Ph.D. journey. Additionally, I would like to thank all the expert panels for their insightful comments and guidance during the research process, which provided valuable input and direction. A special acknowledgment goes to UiTM for their support throughout my studies, and I would like to extend my gratitude to all respondents who participated in the study. Thank you very much.

Allahu Akbar and Alhamdulillah.

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LIST OF SYMBOLS

Symbols

β	Beta Value
R^2	Coefficient of Determination
f^2	Effect Size
Q^2	Predictive Relevance
%	Percentage
>	Greater Than
<	Less Than
≥	More Than or Equal to Sign
≤	Less Than or Equal to Sign

LIST OF ABBREVIATIONS

Abbreviations

AFVIF	Average Full Variance Inflation Factor
AIA	American Institute of Architects
AR	Augmented Reality
AVE	Average Variance Extracted
BIM	Building Information Modelling
BP	Best Practice
CA	Cronbach Alpha
CAD	Computer-Aided Design
CAM	Computer-Aided Manufacturing
CB	Covariance Based
CIDB	Construction Industry Development Board
CIMP	Construction Industry Master Plan
CITP	Construction Industry Transformation Program
CIS	Construction Industry Standard
CMB	Common Method Bias
CR	Composite Reliability
CREAM	Construction Research Institute of Malaysia
DV	Dependent Variable
GDP	Gross Domestic Product
HTMT	Heterotrait-monotrait
IBS	Industrialised Building System
ICT	Information & Communication Technology
IMPACT	IBS Manufacturer & Product Assessment & Certification
IoT	Internet of Things
IPD	Integrated Project Delivery

IV	Independent Variable
OSM	Off-Site Manufacturing
PLS-SEM	Partial Least Squares-Structural Equation Modelling
PWD	Public Work Department
SDG	Sustainable Development Goal
SPSS	Statistical Package for The Social Sciences
VIF	Variance Inflation Factor

CHAPTER 1
INTRODUCTION

1.1 Introduction

This chapter provides an overview of the research background and presents a clear definition of the research problems. The discussions established the research questions, research aim, and research objectives. This is followed by an analysis of the importance and contribution of the research. Subsequently, the methodology employed to accomplish the research objectives is presented. Next, this section addressed the extent and constraints of the research. Finally, the structure of the thesis, the comprehensive scope of the research, and a summary of this chapter are presented.

1.2 Research Background

IBS is the term used by government and construction industry stakeholders to represent the concept of prefabricating building components and adopting industrialisation in the Malaysian construction industry. IBS is defined as a construction method in which components are manufactured in a controlled environment (on or off-site), transported, placed and assembled into a structure with minimal additional work (CIDB, 2003; Musa et al., 2016; Tajul Ariffin et al., 2019). IBS adoption in Malaysia aims to reduce the dependence on unskilled foreign workers and save the country from a loss in currency trade (CIDB, 2018b). IBS also enables stakeholders in the construction sector to project a new image of the Malaysian construction industry, bringing it on par with manufacturing-based industries. Moreover, adopting IBS promises to elevate every level of industrialisation and mechanisation in the Malaysian construction (CIDB, 2018b; Jing Le & Zainal, 2021). Additionally, adopting IBS provides efficient, clean and improved safety features associated with the Malaysian construction industry. IBS also saves valuable time, and it helps reduce the risk of project delays and possible monetary losses (Al-Awag et al., 2023; Jing Le & Zainal, 2021)

In an effort to promote the IBS agenda in Malaysia, the Malaysian government, through the Construction Industry Development Board (CIDB), encourages a paradigm

shift in the construction industry. The paradigm move involves shifting from the conventional construction method approach to the industrialisation perspective by promoting IBS in the construction industry (Nawi, Riazi, et al., 2017). The Malaysian government and CIDB have introduced plans and policies to encourage the implementation of IBS, promoting its adoption in the Malaysian construction industry. The introduction of the Construction Industry Master Plan 2006-2015 (CIMP 2006-2015) is a guide for the future direction of IBS, which highlighted the importance of IBS and sustainability for the Malaysian construction industry (CIDB, 2007). Furthermore, the IBS Roadmap is also introduced to guide the direction of IBS implementation and address issues related to IBS. IBS Roadmap 2003-2010 was the first IBS Roadmap, and it was replaced by IBS Roadmap 2011-2015. The new IBS Roadmap 2011-2015 aims to achieve a high-level intended outcome of implementing IBS, surpassing the previous roadmap. After completing CIMP 2006-2015, CIDB introduced the Construction Industry Transformation Program 2016-2020 (CITP 2016-2020), the guideline for the future direction of the Malaysian construction industry. CITP 2016-2020 has highlighted the importance of IBS under the Productivity thrust (CIDB, 2015). The government ensured the IBS agenda in the Construction 4.0 Strategic Plan (2021-2025) as one of 12 emerging technologies to be focused on CIDB, 2021).

The construction industry is generally multifaceted. There are a number of key stakeholders, including contractors, consultants, government agencies, private investors and others (International Labour Organization, 2019). In IBS scenario, there are also significant backward links to this process, such as suppliers of material and equipment, accountants, lawyers, and insurers, as well as beneficiaries of income earned and infrastructure built. This process required integration among stakeholders and for decades, critical writings have discussed the fragmentation of the construction process and the competing interests between the parties and how they still negatively impact the current process (Lahdenperä, 2012; Ng, 2021). In order to overcome the fragmentation, there is a need for improved integration among construction stakeholders, and one option is Integrated Project Delivery (IPD) (Hu & Chong, 2020; Liyana et al., 2018; Tajul Ariffin et al., 2019).

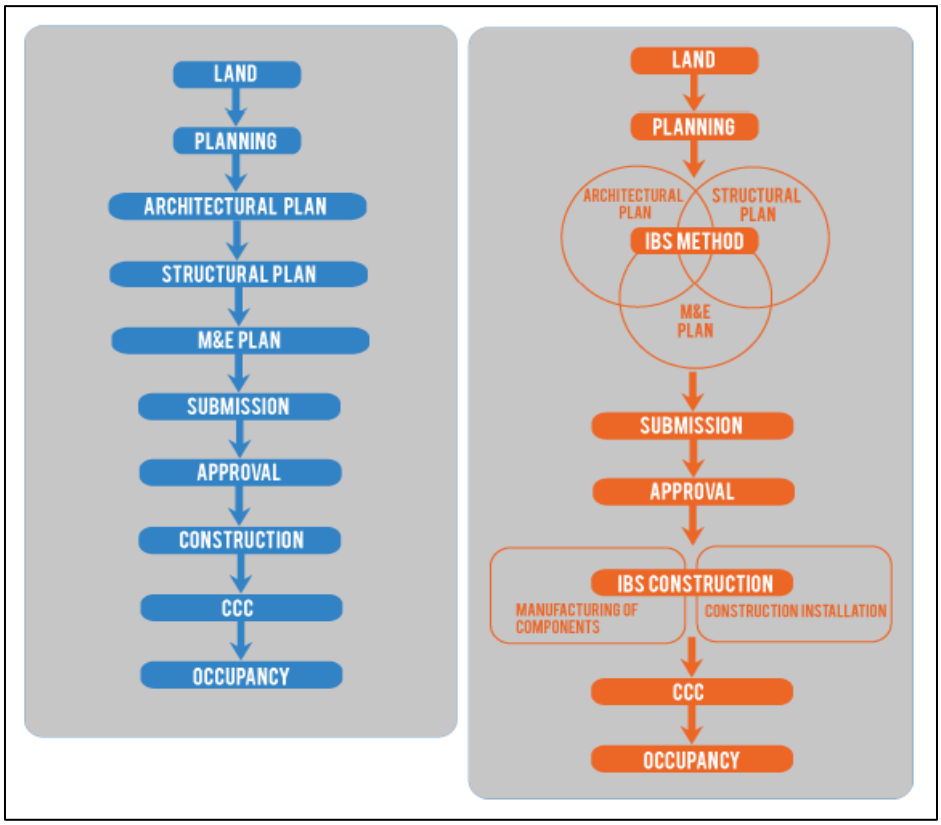


Figure 1.1 Process Flow Using Conventional and IBS Approach. Source: Hamid et al. (2017)

Figure 1.1shows the comparison between conventional and IBS approaches in terms of the construction process flow. The IBS approach is almost similar to conventional project management, however, IBS requires a high level of integration among project parties due to major constraints in the design, such as transportation of components, logistics of installation, permits, and inspections (Hamid et al., 2017). As a result, structural changes are required within the design and construction stages. The performance of IBS can be seen in the study by CIDB, which reported that switching from conventional construction methods to IBS can result in a 34.74% savings in preliminaries and a 0.83-10% savings in total building costs (CIDB, 2018b). In the IBS project, the construction period is shortened from 24 months to 18 months (CIDB, 2018a). The continued reliance of IBS stakeholders on the conventional approach to IBS presents a significant obstacle to its implementation (Al-Aidrous et al., 2023). According to Zairul, (2022), the advantages of IBS cannot be realised if archaic conventional methods and strategies continue to be employed in IBS projects.

Integrated Project Delivery (IPD) is a project delivery approach that integrates people, systems, business structures and practices into a process that collaboratively

harnesses the talents and insights of all participants to optimise project results, increase value to the owner, reduce waste, and maximise efficiency through all phases of design, fabrication, and construction (AIA, 2007). An IPD team can include members beyond the owner, architect, and contractor triad. IPD principles can be applied to various contractual arrangements. In all cases, integrated projects are uniquely distinguished by highly effective collaboration among the owner, the consultant, and the contractor, which commences at early design and continues through to project handover (Ling et al., 2020). According to Ghassemi & Becerik-Gerber (2011), the main characteristics of IPD include multi-party contract, early involvement of key participants, collaborative decision making and control, shared risks and rewards, liability waivers among key participants, and jointly developed project goals. Pal & Nassarudin, (2020) research found that 22 IPD-related case studies were completed with successful outcomes throughout the USA and Canada, including Mosaic Centre for Conscious Community and Commerce, Akron Children's Hospital, Kay Jewelers Pavilion, USA, Sutter Medical Office Building, USA, among others.

Several benefits of IPD can bring about change in the construction industry. According to research conducted by Mei et al. (2022), IPD has a significantly positive impact on project performance. Niazmandi et al. (2024) also mentioned that the IPD approach improves project performance in terms of time and cost by reducing construction claims during the project. Additionally, Tayab et al. (2025) and Ibrahim et al. (2020) stated in their research that IPD is superior in aspects such as schedule performance, cost control, and overall project quality. In addition to enhancing project performance, IPD integrates people, systems, business structures, and practices into a collaborative process that harnesses the talents and insights of all participants to reduce waste and optimise efficiency throughout all phases of design, fabrication, and construction (AIA, 2014). Abd Hamid et al. (2011) and Yin et al. (2025) highlighted that the integration of all stakeholders in a project is an essential element in IBS that cannot be separated, and this can be improved further with innovative procurement for IBS projects. Nevertheless, IPD outperformed the conventional method and design-build approach, as demonstrated by research conducted by Ibrahim et al. (2020). This finding aligns with research conducted by Adamtey (2021), who found that the IPD project also outperformed the traditional project and that the level of integration among stakeholders significantly improved its performance.

1.3 Problem Statements

1.3.1 Low Adoption and Poor Performance of IBS in Malaysia

Although IBS has been introduced for over 40 years, with well-documented benefits and strong support from the government, the pace of implementation and usage of IBS is still slow and below the government's target, as reported by the CIDB, (2007). Significant efforts have been made to promote the adoption of IBS. However, these efforts have yet to yield sufficient impact, and the adoption rate is still low, as reported by the CIDB (2015). A survey conducted by CIDB showed an adoption rate of 36.1% for public projects and 33.1% for private projects in 2019 (CIDB, 2021b). In reality, IBS adoption is still relatively low and is still in the growing stages, as stated by (Esa et al., 2023; Halil, 2015; Shukor et al., 2011) This statement is also in line with the study by Abdullah et al., (2021) and Samsi et al. (2024), where IBS implementation remains low, despite the government's strong recommendation of it. According to Al-Awag et al., (2021), the initiatives by the government to encourage the implementation of IBS also seem not to impact the adoption rate of IBS in Malaysia significantly. Recent research by Al-Awag et al., (2023), Tarang et al., (2022), Shukri et al. (2022) and Jaffar et al. (2025) highlighted that adoption of IBS in Malaysia still has a long way to go. This aligns with research conducted by Nizam et al. (2024), Shukri et al. (2022) and Jaffar et al. (2025),which also indicates that the incidence of IBS in Malaysia remains relatively low. The latest CITP report from CIDB on IBS adoption in government and private projects in Malaysia (2020) showed a growth in the adoption rate of IBS for federal government public projects from 24% to 87%, up from the 2014 figure. The adoption rate in private projects improved to 41% in 2020 from 14% in 2014, which is still behind the government's goal (CIDB, 2021d).

On the other hand, the construction industry implementation of IBS is still deficient compared to conventional methods (Rahim & Qureshi, 2018). Several issues impede the performance of IBS during construction projects, including the preference for conventional methods, lack of integration, logistic issues, poor IBS knowledge and high capital cost and others (Khalil et al., 2016; Samsi et al., 2024) This poor performance illustrates the need for the IBS project to investigate alternative management practices that improved the performance (Rahim et al., 2020). According

to Jaffar & Lee, (2020), the integration factor is one of six (6) critical factors that have a significant impact on IBS project performance.

Several benefits of IPD can bring about change in the construction industry. According to research conducted by Mei et al. (2022), IPD has a significantly positive impact on project performance. Niazmandi et al. (2024) also mentioned that the IPD approach improves project performance in terms of time and cost by reducing construction claims during the project. Additionally, Tayab et al. (2025) and Ibrahim et al. (2020) stated in their research that IPD is superior in aspects such as schedule performance, cost control, and overall project quality. In addition to enhancing project performance, IPD integrates people, systems, business structures, and practices into a collaborative process that harnesses the talents and insights of all participants to reduce waste and optimise efficiency throughout all phases of design, fabrication, and construction (AIA, 2014). Abd Hamid et al., (2011) and Yin et al. (2025) highlighted that the integration of all stakeholders in a project is an essential element in IBS that cannot be separated, and this can be improved further with innovative procurement (IPD) for IBS projects. Nevertheless, IPD outperformed the conventional method and design-build approach, as demonstrated by research conducted by Ibrahim et al. (2020). This finding aligns with research conducted by Adamtey, (2021), who found that the IPD project outperformed the traditional project and that the level of integration among stakeholders significantly improved its performance.

1.3.2 Lack of Integration Among IBS Participants in Managing IBS Projects

Further investigation by previous researchers by Nawi et al., (2014), Ibidapo et al., (2017), Kasim et al., (2019) and Aini et al. (2025) had identified that one of the low adoption factors for IBS implementation in the Malaysian construction industry is related to poor integration among stakeholders involved during the design and contract stage. This statement is supported by Pozin et al., (2019) and Rahim et al. (2025), where the lack of integration can cause disorder in the IBS project and it has become an issue in the IBS construction industry. According to Hu & Chong, (2020), the construction industry has been widely criticised for its fragmentation since various organisations are participating in a project at different stages. The traditional procurement system has been criticised for its fragmented procedure to project delivery in terms of integration and collaboration of the project team (Liyana et al., 2018; Nawi et al., 2023). As a result

of that problem, several issues have recently arisen, such as reworks, time delays, rising costs, lack of communication and coordination, and wastage (Tajul Ariffin et al., 2019). As reported by Hussein, (2007), the lack of integration among relevant stakeholders in the design and contract stage has resulted in a need for redesign and additional costs incurred if IBS is adopted. Abd Hamid et al., (2011) and Yin et al. (2025) highlighted that the integration of all stakeholders in a project is the element in IBS that cannot be separated and this can be improved with innovative procurement for IBS projects.

1.3.3 Traditional Procurement Approach Unsuitable for IBS Projects

The traditional procurement commonly used for IBS projects is unsuitable for IBS construction and poses a substantial barrier to its adoption (Nawi et al., 2023; Osman et al., 2017; Zuber et al., 2019). This statement aligns with the research conducted by Al-Aidrous et al. (2023), which revealed that the traditional approach is a significant obstacle to stakeholder reluctance when implementing IBS. Furthermore, Nawi et al. (2011) reported that improving procurement systems is one of the keys to achieving IBS success in the Malaysian construction industry. Moreover, according to Zairul, (2022), IBS benefits cannot be reaped if outdated conventional methods and strategies are still practised in IBS construction management. There are several studies by Ahamad et al. (2024), Viana et al., (2020), Hu & Chong, (2020), Liyana et al., (2018) and Nawi et al., (2014) which recommends that the industry change from its traditional procurement to other innovative procurement in order to increase integration. This statement is also in line with a study done by Saad et al., (2022), which confirms that improving procurement and contracts can establish a clear statement of client needs to carry out IBS projects. According to Hu & Chong, (2020), Tajul Ariffin et al., (2019) and Liyana et al., (2018), innovative procurement such as Integrated Project Delivery (IPD) is recommended to overcome issues in the aspect of integration and collaboration of the IBS project team. The IPD method creates better integration and involvement of IBS project teams compared to other delivery methods (Tajul Ariffin et al., 2019; Ibidapo et al., 2017).

The integration of project teams has the potential to remediate the fragmentation that is dominant in the construction industry, which is often associated with poor performance. In addition, IPD provide a significant step for the IBS industry to improve the project delivery performance, (Osman et al., 2015). According to research from

Mesa et al., (2016) and De Marco & Karzouna, (2018), the IPD project delivery system improves stakeholders' integration and project performance by reducing fragmentation. Through IPD, construction projects are improved by improving performance and shortening project delivery times (Durdyev et al., 2020). Research conducted by Adamtey, (2021) found that the IPD project outperformed the traditional project and that the level of integration among stakeholders significantly improved its performance. The adoption of IPD in construction projects leads to improved project performance (Ling et al., 2020), and the decision-making process is becoming more efficient (Kalsaas et al., 2020). Therefore, the IPD can perform better than traditional delivery systems and save time and money in the long run.

1.3.4 A limited Study Was Conducted on Procurement, Especially on IPD in IBS

Research on the IBS topic flourishes after the introduction of the IBS Roadmap 2003 – 2010. Various studies have been done after that by researches focus on IBS area such as supply chain management (Abd. Shukor, 2015; Nawi et al., 2018), contract in IBS (Fateh et al., 2016), IBS business strategy (Mohamed, 2021; Tarang et al., 2022), IBS project management (Hee, 2017; Kasim et al., 2019; Nawi et al., 2017; Jabar, 2017; Saad et al., 2022; Yusof et al., 2015) , IBS maintenance (Ismail, 2019), IBS formwork (Baharuddin et al., 2019), IBS modular construction (Musa et al., 2016), IBS robotic & automation (Davila Delgado et al., 2019; Rahim et al., 2020; Abd Rashid et al., 2021), communication in IBS (Nawi et al., 2017; Pozin et al., 2019), sustainable in IBS (Yunus et al., 2020).

There are various studies on IPD in IBS procurement, however most of the studies focus on IPD in IBS on readiness (Osman et al., 2017), literature review (Zuber et al., 2019) and design team communication (Nawi, 2012). Several researchers (Ahamad et al., 2020; Dzulkalnine et al., 2016; Jalil et al., 2015) had previously concentrated on IBS procurement; however, they had not specifically addressed IPD within IBS.

Whang et al., (2019) and (Yu et al., 2019) stated that the identified best practices of IPD have the potential to significantly influence the implementation of IPD systems in the construction industry. Construction projects are improved in terms of performance and shortening the project delivery times by IPD adoption (Durdyev et al., 2020). Research conducted by Adamtey (2021) found that the IPD project outperformed

the traditional project by improving the level of integration among stakeholders, which significantly improved the project performance. In short, the adoption of IPD in construction projects brings better project performance (Ling et al., 2020).

Nevertheless, minimal efforts have been undertaken to identify best practices in IPD within the context of IBS and to ascertain their relationship with IBS's performance. Frefer et al., (2018) stated that best practices need to be identified in order to provide a focus on the success of the project. Thus, it is crucial to establish the relationship between IPD best practices and IBS performance that contributes to the successful implementation of IBS.

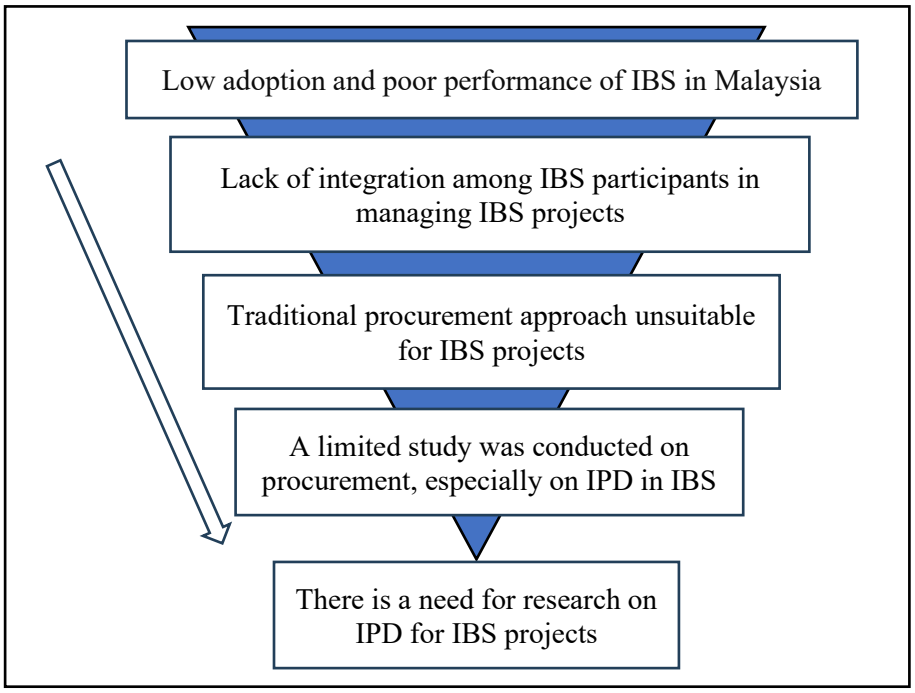


Figure 1.2 Problem Statement Flow

Figure 1.2 illustrates the flow of the problem statement for this research, which initially starts with the low adoption rate and poor performance of IBS in Malaysia. This issue arises from the lack of integration among IBS participants in managing IBS projects. The absence of proper integration is primarily due to Malaysia's continued reliance on conventional procurement methods that are not suitable for IBS itself.

1.3.5 Preliminary Survey

To support the above problem statements, the researcher conducted a preliminary survey via an interview with the IBS stakeholders. The objective of the preliminary survey is to identify the current challenges faced by IBS stakeholders in

implementing IBS for their projects. This is to ensure that the issues are genuine and valid from the literature review and the industry stakeholders' perspective. All interview surveys were conducted through face-to-face interviews and took place within a three-month period (January–March 2022). The respondents for this preliminary interview were selected from the CIDB website and the IBS Orange Book. The interview was conducted with all the representatives of IBS's key stakeholders in the industry, namely, contractors, manufacturers/suppliers, and consultants in the Klang Valley. The respondent's backgrounds are summarised in Table 1.1.

Table 1.1
Respondent's Background

Respondent	Respondent Sector	Experience in the industry	No. of involvement in the IBS Project
Respondent 1	Contractor	More than 3 years	6 – 10 projects
Respondent 2	Contractor	More than 10 years	1 – 5 projects
Respondent 3	Manufacturer/ Supplier	More than 10 years	1 – 5 projects
Respondent 4	Manufacturer/ Supplier	More than 10 years	1 – 5 projects
Respondent 5	Architect Consultant	More than 10 years	6 – 10 projects

The interview result highlighted the current issues and challenges of IBS construction in Malaysia as per Table 1.2. The interviewees were explained and questioned about eight (8) issues and challenges of integration in managing IBS project such as procurement, teamwork, coordination, site management, supply chain, parties involved, transportation and payment. The interviewees unanimously agree that all these issues have had a slight impact on the integration in the IBS project. However, only the highlighted main issues related to integration are shown in Table 1.2.

Table 1.2
Main Issues Related to Integration in Managing IBS Project

Interviewee	Main integration issue/s
Interviewee 1	Teamwork/collaboration and procurement.
Interviewee 2	Procurement, teamwork/collaboration and coordination.
Interviewee 3	Teamwork/collaboration and coordination.
Interviewee 4	Procurement.
Interviewee 5	All eight (8) issues related to integration.

Four (4) out of five (5) interviewees stated that the main integration issues are teamwork/collaboration and procurement. The findings from the preliminary survey are in line with the problem statement in this study and research done by Rahim (2025), where the lack of integration can cause disorder in the IBS project, and it has become an issue in the IBS construction industry. Besides that, Ahamad et al. (2024), Viana et al., (2020), Hu & Chong, (2020), Liyana et al., (2018) and Nawi et al., (2014) recommend that the IBS industry change from its traditional procurement to other innovative procurement in order to increase integration. According to Hu & Chong, (2020) and Liyana et al., (2018), these issues can be minimised by improving procurement through Integrated Project Delivery (IPD). Early involvement of key stakeholders, collaboration, and trust are identified as the most important elements of IPD (Piroozfar et al., 2019) thus by IPD adoption it is perceived that these issues overcomes. On the other hand, in comparison with traditional systems, IPD requires a lot of effort from all stakeholders to collaborate, but in the end, it contributes to a high-performing project that is important to all stakeholders. Additionally, IPD is about forming a highly synergistic team, with the consultant and contractor supporting the owner and collaborating with mutual trust and respect (Pal & Nassarudin, 2020). A successful IPD implementation is expected to give consultants and contractors a competitive advantage, save the owner time and money, and provide users with a product of value.

1.4 Research Flow

An overview of the research flow is shown in Figure 1.3 and Figure 1.4 below. The process begins with identifying the issues in the Malaysian construction industry and then defining the problem statement. The third step is to identify a research gap and, finally, to formulate a research aim.

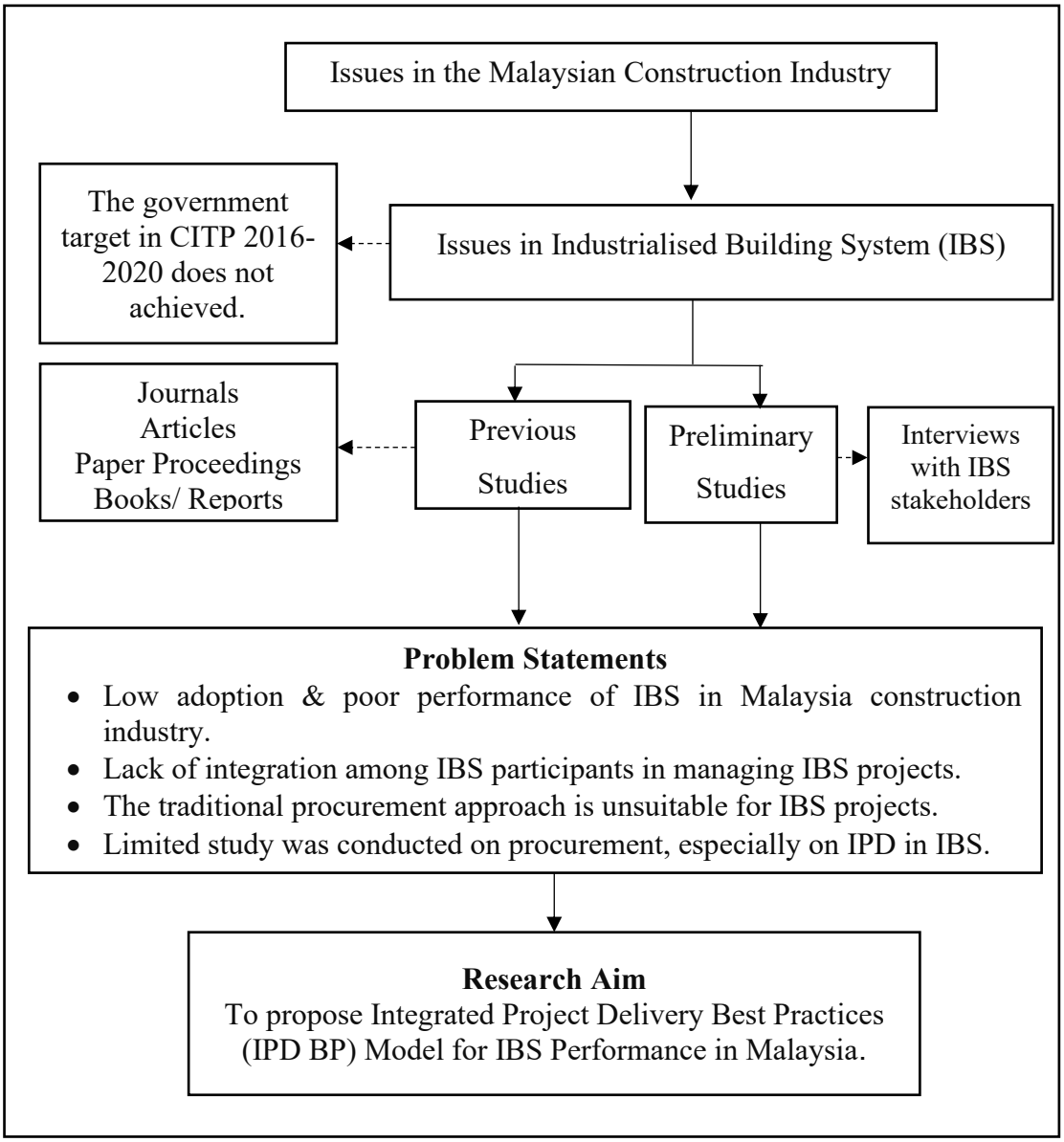


Figure 1.3 Summary of Research Flow

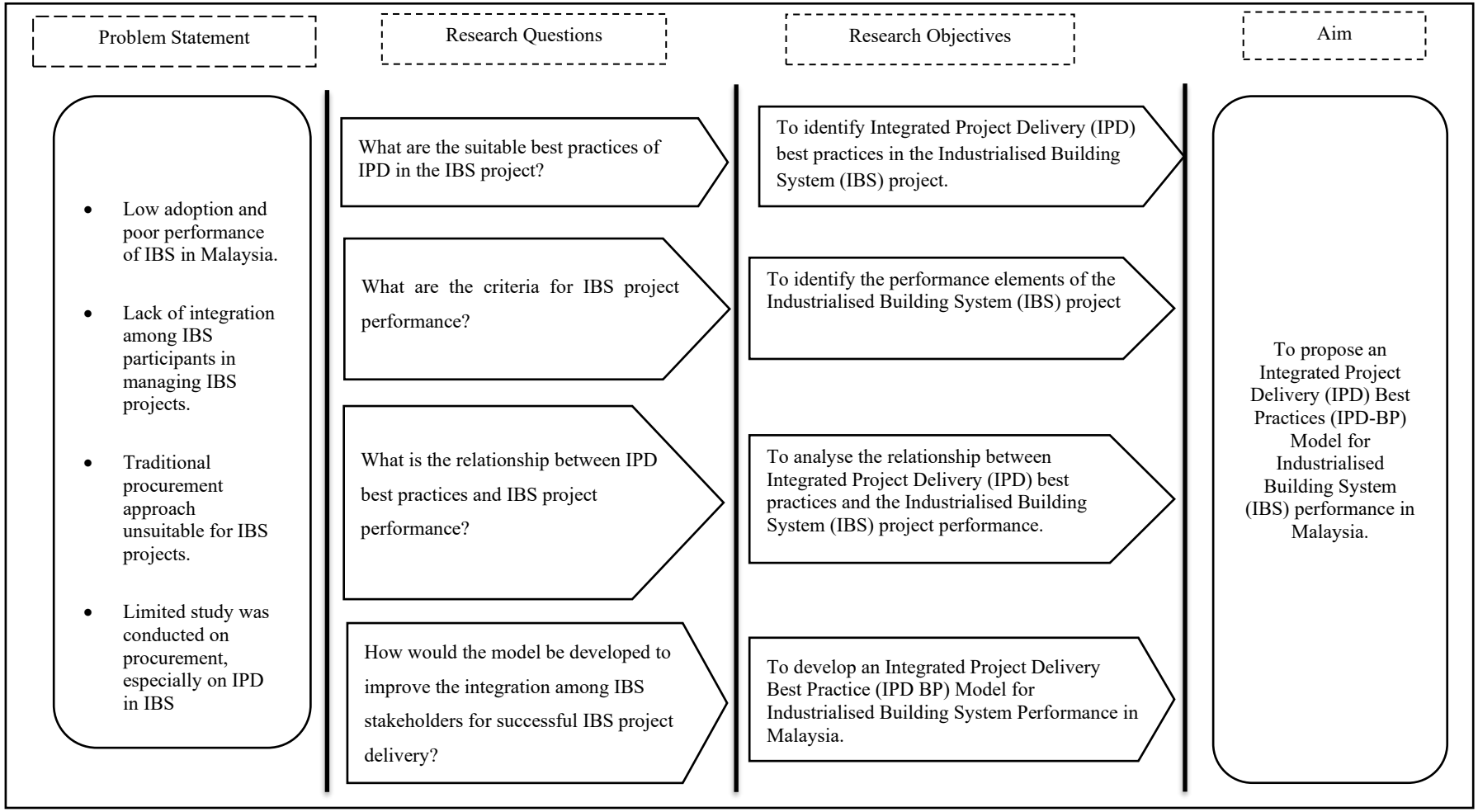


Figure 1.4 Research Relationship, Problem Statement, Research Question, Research Objectives and Research Aim

1.5 Research Questions

a) What are the best practices of IPD in the IBS project?
b) What are the elements for IBS project performance?
c) What is the relationship between IPD best practices and IBS project performance?
d) How would the model be developed to improve the integration among IBS stakeholders for successful IBS project delivery?

1.6 Research Aim and Objectives

This research aims to propose an Integrated Project Delivery (IPD) Best Practices (IPD-BP) Model for Industrialised Building System (IBS) performance in Malaysia. To achieve the aim, several objectives were identified:

a) To identify Integrated Project Delivery (IPD) best practices in the Industrialised Building System (IBS) project.
b) To identify the performance elements of the Industrialised Building System (IBS) project.
c) To analyse the relationship between Integrated Project Delivery (IPD) best practices and the Industrialised Building System (IBS) project performance.
d) To develop an Integrated Project Delivery Best Practice (IPD-BP) Model for Industrialised Building System Performance in Malaysia.

1.7 Scope of Study

The primary justification for having a research scope is to narrow the research area and set boundaries for what should be investigated. The limitation of scope is further discussed as follows:

a. This study focuses on IPD and IBS, especially on the relationship between best practices of IPD in IBS and the performance of IBS projects.
b. The respondents of this study include clients, consultants, and contractors

involved in IBS projects, particularly those using precast concrete systems in Malaysia. The list of consultants and contractors was sourced from the IBS Orange Book, which contains details of IBS suppliers, manufacturers, professionals, consultants, and contractors registered with the Construction Industry Development Board. The consultant group comprises architects, engineers, and quantity surveyor firms. Respondents from the contractor side from grade G7 and are registered under categories for building and specialised in B01: IBS – Precast Concrete System. Additionally, the IBS manufacturers and installers are participating as respondents in this research. This specific selection is due to the prevalence of the precast concrete system in IBS projects within Malaysia.

1.8 Significance of The Study

This research has contributed to both theoretical and practical aspects, benefiting construction stakeholders, especially in decision-making processes and by implementing the Integrated Project Delivery Model Best Practices (IPD-BP) Model to enhance IBS project performance. Additionally, it can serve as a knowledge-sharing model for improving the performance of construction stakeholders in the context of IBS project management. Therefore, it provides future researchers with a clearer understanding of Integrated Project Delivery in Industrialised Building Systems.

The Integrated Project Delivery Best Practices (IPD-BP) Model for IBS in Malaysia can also serve as an alternative to the conventional methods of managing IBS projects and aligns with the IBS agenda in the Construction 4.0 Strategic Plan (2021-2025), Thrust 6 of the National Construction Policy 2030, which aims to enhance public procurement systems (4.6.1) and promote best practices in construction (4.6.4) and Sustainable Development Goals (SDG's) No. 17, Partnerships for the Goals.

This study aims to implement the Integrated Project Delivery Best Practices (IPD-BP) model within the context of IBS to bring together various construction stakeholders, systems, business structures, and practices into a collaborative process. This approach seeks to harness the collective talents and perspectives of all participants to enhance project outcomes, provide better value for the project owner, reduce inefficiencies, and optimise efficiency.

Furthermore, this research also enhances the academic scope because IPD in IBS remains underdeveloped in Malaysia, presenting potential opportunities for further exploration. Other researchers can utilise the model as a foundation for future studies. Additionally, the research enhances the methodology section by employing a quantitative approach using Smart PLS-SEM to examine the model's relationships.

1.9 Research Methodology

Research design for this study employs a quantitative approach. The research methodology comprises four distinct stages. The initial stage involves a comprehensive review of existing literature on IPD and IBS within the construction sector. The primary goal is to identify effective IPD practices and assess the performance of IBS projects in construction. Data are collected from various sources, including books, articles from international and national journals, proceedings, reports, and bulletins. This is followed by a preliminary survey via interview and the formulation of problem statements, research aims, objectives, and a conceptual framework.

In the second stage, data were collected through a questionnaire. An expert panel validated the questionnaire variables, and a pilot test was also conducted during this process before distribution. In the third stage, after data collection, survey analysis was performed using SPSS and Partial Least Squares – Structural Equation Modelling (PLS-SEM) to examine the relationship between IPS best practices and IBS project performance. The model is subsequently validated by expert panels. In the final stage, the study interprets the findings, draws conclusions, and provides recommendations for future research and the construction industry. Figure 1.5 provides a summary of the research process and the research methodology matrix table.

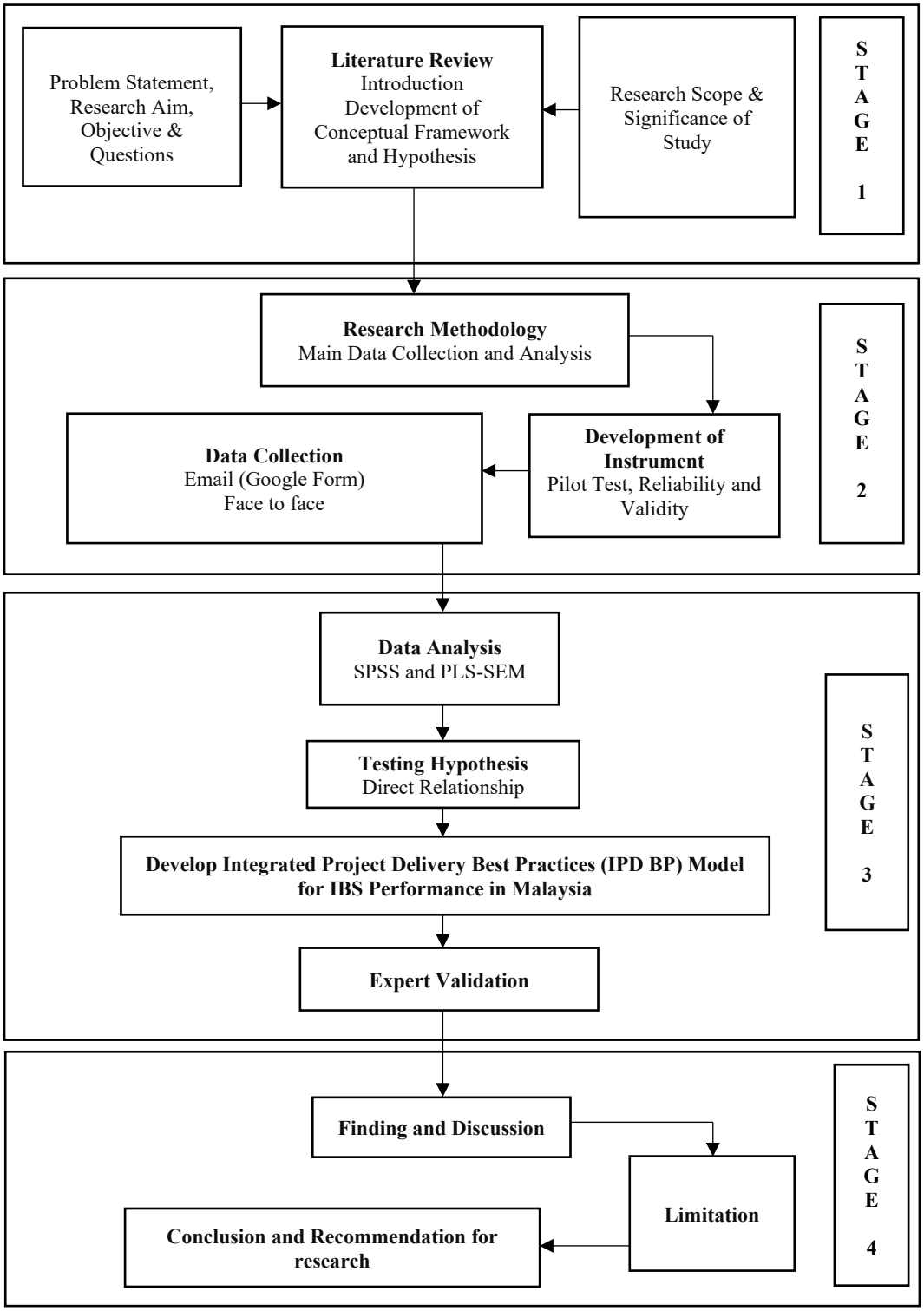


Figure 1.5 Summary of The Research Process

1.10 Organisation of Thesis

This thesis comprises six chapters. The first chapter offers an overview of this research and its context, provides background information on the study, identifies the research problem, outlines the research questions and objectives, and emphasises the significance and scope of the study, while also clarifying the definitions of key terms. The second chapter offers a comprehensive review of the literature on the Industrialised Building System (IBS), including its development, definition, classifications, benefits, and integration in Malaysia. It also discusses Integrated Project Delivery (IPD), covering its definition, principles, and advantages. Furthermore, it examines other IBS Project Delivery Methods used in Malaysia. The chapter reviews research studies on best practices for IPD in IBS and evaluates the performance of IBS projects. Additionally, it gathers insights from previous researchers to deepen understanding in the field.

Chapter Three outlines the fundamental theory of the study, the research model, and the proposed hypotheses. This chapter also emphasises the relationship between the IPD best practices and IBS project performance. This is followed by the fourth chapter, which outlines the research methodology used to answer the research questions. The chapter begins with an explanation of the research paradigm, research design, process, research setting, and the reasons for choosing such a setting. It then details the population and sampling approach, the data collection methods, survey instruments, and the operationalisation of the research constructs, as well as the pre-test and final survey procedures, the choice of statistical software, and ethical considerations.

Following that, Chapter Five presents the statistical results of the study, including respondents' profiles, descriptive analysis, measurement model, and structural model evaluations. The proposed Integrated Project Delivery (IPD) Best Practices (IPD-BP) Model for Industrialised Building System (IBS) performance, along with the results from expert validation, are also included. Finally, Chapter Six discusses the research findings and provides a conclusion. This chapter summarises the process, findings, and significance of the study, ending with an examination of research limitations and suggestions for future research.

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

This chapter reviews the related literature concerning the three main groups of knowledge relevant to this research, namely IBS, IPD, and project performance. This chapter introduces the Malaysian construction industry, followed by a review of the literature relating to the development of IBS in Malaysia, including its definition, classification, benefits, and integration. The second part of this chapter discusses the definition, key stakeholders of IPD, IPD principles, benefits and IPD implementation in IBS. The third part presents the IBS project delivery methods and compares them between IPD, conventional, and design & build. The final section of this chapter addresses project performance. Finally, the summary of the chapter is presented at the end of the section.

2.2 Malaysian Construction Industry

The construction industry is vital to any nation's growth as it plays an economic role, and physical development provides employment and contributes to the nation's Gross Domestic Product (GDP). This industry is also one of the most challenging industry in many countries. From 2011 to 2015, Malaysia experienced significant economic growth, having grown at a steady rate of 6% per annum (CIDB), 2015). The Malaysian economy experienced significant repercussions in 2020 due to the global dissemination of the COVID-19 virus, resulting in a notable decline in the country's Gross Domestic Product (GDP), reaching a negative growth rate of -6.3%. However, there has been a subsequent recovery in 2021, with the GDP rebounding to a positive growth rate of 3.5% (DOSM, 2021). Following the year 2022, the gross domestic product (GDP) of Malaysia experienced a growth rate of 8.7% (DOSM, 2022). During the period spanning 2023 and 2024, Malaysia's Gross Domestic Product (GDP) experienced growth rates of 3.5% and 5.1%, respectively (DOSM, 2025).

The Malaysian construction industry has played a pivotal role in the consumption of a broad range of services and goods, as well as the provision of core

infrastructure. Infrastructure provision through the construction industry has also initiated growth and development throughout Malaysia. The Malaysian construction industry is an integral component of the Malaysian economy. According to the Ministry of Works, (2022), the construction industry constituted 4.5% of the overall Gross Domestic Product (GDP) in 2019. Subsequently, in 2022, the industry's contribution increased to 6.1% following the worldwide spread of the COVID-19 virus from 2020 to 2021, as reported by the Economic Planning Unit, (2022). In 2023, the construction industry contributed 6.0% to Malaysia's GDP, and this contribution increased to 17.5% in 2024 (DOSM, 2025).

Moreover, the construction industry offers large-scale positive spillover effects on the manufacturing and services sectors. The construction industry accounts for 15% of the total output of Malaysia's manufacturing sector. It is also a large consumer of a range of services, including knowledge-driven consultancy and engineering, and a broad base of financial services to deliver on infrastructure needs and contribute 5% of the total output of the Malaysian services sector. It is a primary job creator within Malaysia, providing jobs for nearly 9% of the workforce (CIDB, 2015).

Despite its growth and active contribution to the GDP, the Malaysian construction industry is under constant pressure to improve its performance. Construction Industry Master Plan 2006-2015 (CIMP 2006-2015) targeted to increase the construction industry's GDP to 5% by 2015 and from the National Construction Policy 2030, the Malaysian construction industry's GDP failed to achieve 5%, an average of 4% in 2021 (Ministry of Works, 2022). The conventional construction method that is extensively practised in Malaysia is labour-intensive, involving formwork fabrication, steel bending and concreting. Even though efforts to promote Industrialised Building System (IBS) in the Malaysian construction industry have been made, the adoption and uptake of IBS are still low. The Malaysian construction industry is also struggling to cope with performance, productivity, quality, environment and health and safety issues. Moreover, the Malaysian construction industry has to deal with the influx of foreign labour in construction (Bariono & Kamaruding, 2025; CIDB, 2018b; Mazlan et al., 2024) With its current levels of productivity, quality, safety, and excessive reliance on unskilled foreign workers, the condition of the industry is not in line with the future development of Malaysia.

An introduction to the Construction 4.0 Strategic Plan 2020-2025 by CIDB is to continue the previous agenda in CITP 2016-2020. This strategic plan is primarily geared towards the construction industry for the Fourth Industrial Revolution. The Construction 4.0 is created to be aligned with the Shared Prosperity Vision 2030 (SPV 2030) and the National Policy on IR 4.0 (Industry4WRD) implementation. In the Construction 4.0 Strategic Plan, the government focus on five (5) core values where digital technology plays a central role in Well Being, Safety and Health, Sustainability and Resiliency, Productivity and Integrity in construction (CIDB, 2021).

2.3 The Development of IBS in Malaysia

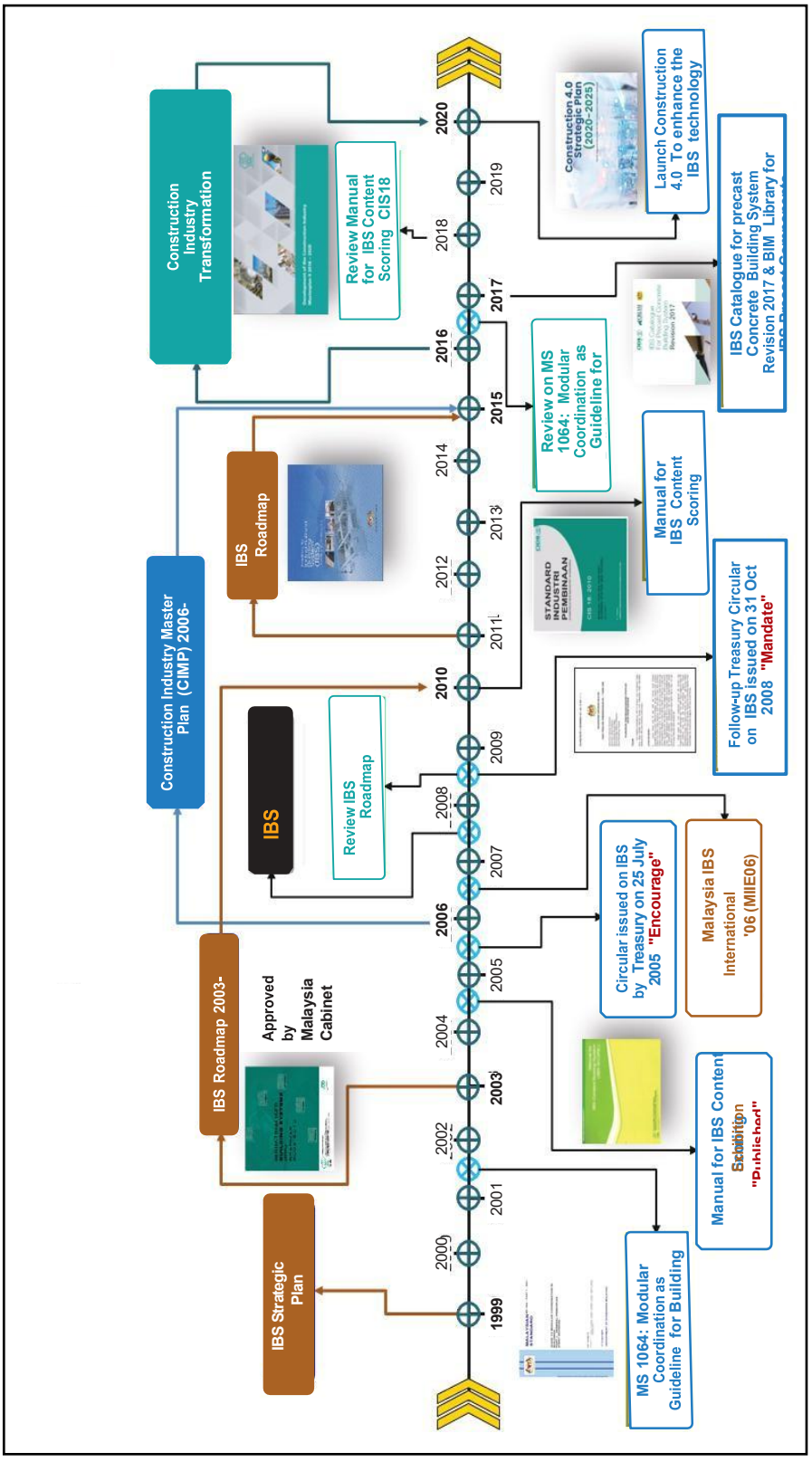


Figure 2.1 IBS Timeframe and Development by CIDB (2021a)

According to Figure 2.1, the implementation and acceptance of IBS in Malaysia have been ongoing for almost 50 years. Since the early 1960s, the use of Industrialised Building Systems (IBS) in the Malaysian building sector has significantly improved and continues to progress. Once again, the initial introduction is reminiscent of other countries where this construction technology was first implemented for urban housing expansion in areas with strong housing demand.

IBS, or Industrialised Building Systems, were introduced in the early 1960s by the Public Works Department (PWD) and the Ministry of Housing and Local Government (MHLG) and this decision was made after its officials and professionals toured various European countries that had already embraced this innovative construction system (CIDB, 2018b). The initial implementation of the IBS project took place during the First Malaysian Plan from 1960 to 1965, followed by the Second Malaysian Plan from 1966 to 1970. In 1964, a residential building called flat apartments was constructed in Jalan Pekeliling in Kuala Lumpur. The project consists of 7 blocks, each with 17 floors, including a total of 3000 low-cost flats with 40 shops and the contract was awarded to a joint venture consisting of Gammon, Larsen, and Nielsen, who used a Danish System of large panel pre-cast concrete walls and plank slabs (Al-Awag et al., 2021; CIDB, 2003). The project was finished in a span of 27 months, specifically between 1966 and 1968. A second IBS housing project was finished in 1965, consisting of six blocks of 17-story flats and three blocks of 18-story flats that were constructed with the French Estoit System, from Hochtief and Chee Seng (CIDB, 2003; Din et al., 2012; Thanoon et al., 2003). A housing construction project utilising Industrialised Building System (IBS) was implemented in Taman Tun Sardon, Penang in 1978. The project consisted of 1,000 units of five-storey walk-up flats. The IBS pre-cast components and system used in this project were designed by the British Research Establishment specifically for low-cost housing in tropical regions, known as the BRECAST system. Two years later, the Ministry of Defence implemented a large-scale prefabricated panel construction system to construct 2800 living quarters at Lumut Naval Base (Abedi et al., 2011; Trikha & Ali, 2004).

A study conducted by the CIDB found that structural steel components were installed in Malaysia in the 1980s and 1990s, particularly for building projects involving high-rise buildings. The Dayabumi Complex, a 36-storey building, was constructed by Takenaka Corporation, a Japanese construction company, and was completed in 1984

(Din et al., 2012). IBS gained popularity in the 1990s because to the construction of numerous Malaysian infrastructure and mega projects, particularly for the Commonwealth Games in 1998. Therefore, during 1994-1997, precast construction, steel frame construction, and other IBS construction methods were utilized as hybrid construction methods in the Malaysian construction industry to construct national landmarks such as the Bukit Jalil Sports Complex, Kuala Lumpur Convention Centre, Lightweight Railway Train and Petronas Twin Towers (Nawi et al., 2011).

In 1999, the CIDB established the IBS Steering Committee to address all issues related to Industrialised Building Systems (IBS) in order to promote its broader adoption in the construction industry and propel the industry's progress. As a result of this committee's establishment, the IBS Strategic Plan was published in 1999 (CIDB, 2021). The Strategic Plan was designed to serve as the initiative to initiate the implementation of IBS in the construction industry of Malaysia with specific deadlines and expected outcomes, the plan outlined goals, initiatives, and tasks to be accomplished. An initial measure implemented was the implementation of the Modular Coordination Guideline for Building Designs ("MS1064"), which is crucial for the integration of Industrialised Building Systems (IBS) in the industry (Abedi et al., 2011). This guideline was a collaborative endeavour between the public and private sectors aimed at achieving uniformity through modular coordination.

After the launch of the IBS Strategic strategy, a comprehensive strategy called the 'Industrialised Building Systems (IBS) Roadmap 2003-2010 was implemented. This was developed in collaboration with industry stakeholders and received official approval from the Malaysian government. The roadmap outlined the 5-M Strategy as a means to focus on promoting IBS within the sector. The key factors for establishing an industrialised construction sector by 2010 are: (i) Manpower, (ii) Materials, Components and Machines, (iii) Management, Processes and Methods, (iv) Monetary, and (v) Marketing. These factors aim to implement 'open building' practises (CIDB, 2003; CREAM, 2021).

The IBS Scoring System was created to promote the use of IBS construction. The grading system offers a standardised and systematic framework for evaluating the utilisation of IBS. The initial iteration was introduced in 2005. A revised and enhanced version was published in 2010, incorporating recommendations for enhancements

suggested for the initial version to accommodate the new IBS technology. The third iteration was implemented in 2018, and the fourth was introduced by CIDB in 2024.

In 2005, it was declared that all government building projects must incorporate a minimum of 50% IBS content to comply with the IBS Roadmap 2003-2010. In order to incentivise the private sector to adopt the same approach, a tax exemption was also proposed for housing projects that achieve a minimum IBS Score of 50% (CIDB, 2021). In November 2008, the Treasury Malaysia issued a Treasury Circular Letter, known as SPP 7/2008, to all Malaysian government agencies instructing them to raise the IBS content of their building development projects to a minimum of 70 points on the IBS score (Abd. Rahsid, 2022; Nawi et al., 2015). This means that IBS must be included as a contractual requirement in the tender documents.

The Construction Industry Master Plan (CIMP) 2006-2015, released in December 2006, serves as a blueprint for the future trajectory of the Malaysian construction sector. The Sustainable Modular IBS aligns with Strategic Thrust 3, which aims to achieve the highest standards of quality, worker safety and health, and environmental practises. It also aligns with Strategic Thrust 5, which focuses on innovation through research and development to implement a new building method (CIDB, 2007; Yusof et al., 2024). The objective of CIMP 2006-2015 is to establish a forward-thinking construction sector that is based on sustainable and innovative development.

The IBS Centre was established by CIDB in 2008 under the IBS Roadmap 2003-2010. Its purpose is to serve as a comprehensive reference centre for IBS, facilitating knowledge sharing and cooperation among industry IBS stakeholders. The IBS Centre engages in many activities, such as serving as the secretariat for IBS industry planning, promotion, and marketing. It also conducts research and development (R&D), provides IBS certification, verification, and testing services, and offers IBS training (CREAM, 2021). CIDB has also arranged IBS seminars at both national and international levels since 2006, to promote dialogue, present, and promote IBS products and services. In addition to promoting the understanding of the advantages of IBS adoption, particularly among government officials, developers, construction experts, manufacturers, and researchers, the seminars aimed to provide a forum for local and international IBS stakeholders to share ideas and establish connections (CIDB, 2021a). Several initiatives by CIDB are the IBS Digest magazines, IBS Townhall, IBS Modul Programme, IBS

training, and the setup of the IBS company called CIDB IBS Sdn. Bhd. and other programmes related to IBS.

The second IBS roadmap, known as IBS Roadmap 2011-2015, was introduced by CIDB. The main goal of this strategy is to promote more usage of IBS by the commercial sector. This was accomplished by fostering the creation of superior designs for IBS components using inventive methods, decreasing the time required to finish projects, guaranteeing an ample pool of skilled IBS professionals and workers throughout the entire project duration, and establishing a financially viable IBS industry that takes into account both user affordability and manufacturer sustainability. The Construction Industry Development Board (CIDB) implemented the Construction Industry Transformation Programme (CITP 2016-2020) in September 2015. IBS remains a key focus for the government in the construction industry, since it is included under the productivity category of the four Strategic Thrusts in CITP. This aims to expedite the implementation of IBS, mechanisation, and modern practises. The government aims to enhance the facilitators for the adoption of Industrialised Building Systems (IBS), enhance the economic aspects of IBS adoption, and modify the approach to public procurement (CIDB, 2015; Yusof et al., 2024).

The Construction 4.0 Strategic Plan (2021-2025) was implemented amidst the Covid-19 outbreak in 2020. The Construction 4.0 Strategic Plan serves as a guide for the Malaysian Construction Industry to adopt the Fourth Industrial Revolution (IR 4.0) in a manner that enhances its productivity and competitiveness. According to CIDB (2021), IBS falls within the category of Prefabrication & Modular Construction, which is one of the twelve emerging technologies aimed at revolutionising the Malaysian construction sector in order to achieve the goals of the Shared Prosperity Vision 2030 (SPV 2030) and the National Policy on IR 4.0 (Industry4WRD).

2.4 The Definition of IBS

The literature on this issue area highlights many definitions provided by writers who have conducted studies in this field. These definitions primarily focus on concepts such as prefabrication, off-site manufacturing (OSM), and the mass manufacture of building components (Abd Rahman & Omar, 2006). Table 2.1 shows the various definitions of IBS available in the literature.

Table 2.1
Definition of IBS

Authors	Definitions
(CIDB, 2003)	A construction technique in which components are manufactured in a controlled environment (on or off site), transported, positioned and assembled into a structure with minimal additional works.
(Richard, 2005)	Industrialisation has demonstrated a high capacity to reduce costs, improve quality and make complex products available for the vast majority people.
(Richard, 2006)	Industrialisation is a generic organisation based on quantity and offering an individualised finished product: (a) A generic organisation (b) Based on the quantity (c) Offering an individualised finished product.
(Abdullah & Egbu, 2009)	A method of construction developed due to human investment in innovation and on rethinking the best ways of work deliveries. It was developed based on categories which can be classified as pre- building system, modern construction, and advanced automation and volumetric.
(Hassim et al., 2009)	IBS is an organisational process continuity of production implying a steady flow of demand, standardisation, integration of different stages of the whole production process, a high degree of organisation of work, mechanisation to replace human labour wherever possible.
(Abdullah et al., 2009)	IBS is a process in which components are manufactured, positioned and assembled as a structure with minimal additional site works both off-site and on-site.
(Kamar et al., 2011)	A process of building construction using the concept of mass-production through industrialised system,

	produce at a factory or onsite within controlled environments, including the logistics and assembly aspects of it, done in appropriate coordination with through planning and integration.
(Nadim & Goulding, 2011)	A business strategy that transforms the traditional construction process into a manufacturing and assembly process in order to reduce cost, time, and improve the quality of the [final] product/service. This is achieved through engaging people, embracing new technologies [process/ products], and translating clients' needs into building requirements through new contractual working relationships across the whole supply chain.
(Nawi, 2012)	IBS is an innovative process of building construction using the concept of mass-production of industrialised systems, produced at the factory or onsite within controlled environments, that includes the logistic and assembly aspect using proper planning, coordination and enhancing value to end users.
(Jabar, 2017)	IBS construction project had been defined as construction process execution with the integration of industrialised system and conventional construction system. It involved managing initial works, manufacturing, transporting, and assembling work to form a structure throughout a project management phases.
(Abd Rashid, 2022)	IBS is a system through which the main elements of a building are fabricated off-site and transported to the site for installation.

The majority of the definitions presented in Table 2.1 centre around the core terms of industrialised, manufacturing, integration, and standardisation. It can be inferred that the concept of IBS refers to a modern method of construction using

manufacturing and assembly processes to produce mass production of building components through industrialisation across the construction period.

2.5 Classification of IBS in Malaysia

Throughout the years, IBS has had a variety of classifications, which are material, process and system. IBS was introduced in Malaysia since the early1960s when the Public Work Department, the Ministry of Housing and the local Government of Malaysia visited a few European countries to evaluate their program of residential development (Abd Rashid, 2022). The systems available during those days were the frame system, panel system and box system (Badir et al., 2002; Musa et al., 2014). The Construction Industry Development Board (CIDB) implemented a system of categorising Industrialised Building Systems (IBS) in its IBS Roadmap 2003–2010, which consisted of five distinct classifications. The introduction of the innovative system occurred at the end of 2010 as part of the IBS Roadmap 2003–2010, where it was classified as number six in the IBS classification (CIDB, 2018b). Table 2.2 summarises the classification of IBS in Malaysia.

Table 2.2
Categorisation of System and Component of IBS

System	Components	Descriptions
Precast Concrete System	Column, beam, wall and slab	The common IBS used includes precast concrete elements, lightweight precast concrete and permanent concrete formwork.
Reusable Formwork System	Column, beam, wall and slab	The common IBS used includes precast concrete elements, lightweight precast concrete and permanent concrete formwork.
Metal Framing System	Column, beam and roof truss	Commonly used with precast concrete slab, the metal framing system has always been a popular choice and used extensively in the fast-track construction of skyscrapers. The recent development of this IBS includes the usage of light steel trusses consisting of cost-efficient profiled cold-formed channel and steel portal

		frame systems. These are alternatives to the heavier, traditional hot-rolled sections.
Timber Framing System	Column, beam and roof truss	This system consists of timber building frames and timber roof trusses. Timber building frame system also has its market and demand, offering attractive designs from simple dwelling units to buildings that require high aesthetic values, such as resorts and chalets.
Block Work System	Column, beam and wall	The construction method of using traditional bricks has been revolutionised by the developments of interlocking concrete masonry units and lightweight concrete blocks. The tedious and time-consuming traditional bricklaying tasks are vastly simplified by the use of these practical solutions.
Innovative System	Wall	To classify new systems introduced in the Malaysian construction industry that do not belong in the five main IBS in the CIDB's IBS classifications (2003), CIDB introduced an innovative system to classify new and innovative systems in the IBS approach.

Source: (CIDB, 2018b)

Based on Table 2.2, the precast concrete system is extensively employed within the IBS framework in Malaysia. It accounts for 50.2% of the systems used, compared to 49.8% from a combination of five other systems and in 2019, a total of 136 IBS projects utilised the precast concrete system out of 272 projects overall (CIDB, 2021a).

2.6 Benefits of IBS

The implementation of IBS in the construction sector provides evident and manifold advantages to the industry stakeholders. Typically, the primary elements that influence decision-making are cost, time efficiency, speed, quality, and safety. These

factors are further bolstered by other advantages, including increased productivity, reduced risk, and consideration for environmental factors. The advantages of implementing IBS can be classified into various categories, as outlined below:

2.6.1 Saving Cost

Despite the high initial capital cost associated with implementing IBS construction, this drawback is typically balanced out by the earlier completion time, leading to cost savings. According to research conducted by the (CIDB, 2021b), the findings showed that the use of the IBS resulted in reduced costs compared to the conventional construction approach due to the faster completion time for IBS project, the operational cost of a IBS project can be reduced. A shorter construction period ultimately results in reduced site staff overhead and cost savings on equipment rental (Hamid et al., 2017). The contractor can claim the tax refund for an IBS project that meets the conditions of the construction levy for private homes. The asserted levy can be regarded as an additional benefit, so serving as a means of reducing costs for a project.

2.6.2 IBS Has Faster Construction Time Compared to Conventional

IBS has been demonstrated to decrease the duration of construction projects in comparison to traditional construction methods. According to Mohammad et al., (2016), time reduction is accomplished through the simultaneous execution of tasks. For instance, in an IBS project, while earthwork or substructure work is being carried out on site, the IBS components are being produced concurrently (CIDB, 2018a; CIDB, 2021b). IBS provides a controllable construction timetable through the utilisation of planning control, predicted lead time, and projected downtime (Oliewy et al., 2009).

2.6.3 High Quality and Fewer Defects

The building sector has used IBS as a strategy to achieve improved construction quality and productivity, as stated by Amin et al. (2017). IBS components are of superior quality as skilled worker with specific scope of works improves efficiencies

and reduces errors during manufacturing process (CIDB , 2020). Research conducted by Le & Zainal (2021) has demonstrated that buildings created utilising the Industrialised Building System (IBS) exhibit unaffected by weather elements due to controlled environment of casting area in comparison to structures constructed using conventional methods and the products are of great quality because they are manufactured in controlled environment in the factory. This environment ensures tight quality assurance, superior material selection, and the use of advanced mechanised technology (CIDB, 2021a). Rahim & Qureshi, (2018) stated that IBS is associated with improved product quality due to its commitment to industry-wide expertise.

2.6.4 Increasing Safety at Site

According to Kasim et al., (2019), through the implementation of the IBS application, construction site safety would be enhanced by promoting a more organised and cleaner environment, which would indirectly weaken the dangers associated with construction. In contrast with conventional method, workers at IBS manufacturing facilities and prefabrication facilities are less affected by the effects of temperature, wind, and precipitation as they are at construction sites. IBS can reduce exposure to heights, weather, hazardous operations, and neighbouring construction activities (Rosman et al., 2023).

2.6.5 Green and Sustainability in Construction

Bari et al., (2018) stated that IBS offers a practical solution for on-site waste generation, particularly by reducing the utilisation of timber at construction sites. This implies that there are fewer trees used for harvesting in the construction business, thereby contributing to the preservation of the environment. Amin et al., (2017) found that the utilisation of IBS can result in reduced waste, fewer on-site resources, and a cleaner and more organised environment, as the components of IBS are prefabricated in a factory. This viewpoint aligns with the research conducted by Yusof et al., (2023), which found that certain IBS manufacturers can achieve a waste reduction of less than 1%. The prefabrication moulds used for precast and reusable formworks, such as steel and aluminium, can be repurposed for various designs after they are no longer needed

(CIDB, 2018b). Therefore, IBS seems to be a beneficial alternative for maintaining site cleanliness and preserving the environment.

2.6.6 Reduce the Dependency for Foreign Workers

As a part of the implementation of IBS, the country seeks to minimise manual foreign labour (CIDB, 2003). According to Shahrin & Zakaria, (2016), in comparison to conventional methods, IBS is more efficient in reducing foreign labour and material costs, since it requires a lower number of workers than conventional methods and the reduction of foreign labor would reduce many social issues involving foreign workers, particularly for IBS projects that are located in city centers. In light of the ongoing labour shortage following after the Covid-19 pandemic, the IBS has gained significant attention recently (Wai, 2023). Thus, the use of the IBS technology is seen as the best way to reduce dependent on foreign labour.

2.6.7 Better Quality

According to Ali et al., (2012) and Thanoon et al., (2003), IBS components exhibit superior quality due to specific material selection, use of cutting-edge technology, rigorous quality assurance protocols, and resilience against extreme weather conditions. CIDB Malaysia introduced the IMPACT programme in 2018 is based on the CIDB standard known as the Construction Industry Standard (CIS) 24:2023 IBS Manufacturer & Product Assessment & Certifcation. The IMPACT scheme is an extensive process that includes the evaluation, examination, and validation of IBS products according to the criteria established by the CIDB. These standards aim to increase awareness among industry participants in order to assure the systematic quality of IBS products and components (CIDB, 2021). The approach guarantees the production of products that are both of excellent quality and reasonably priced, all while ensuring that the building site operates in a methodical, cost-effective, and well-organised manner.

2.7 Barriers to IBS Implementation

Although IBS has been widely recognised and implemented globally within the industry, its adoption remains limited, particularly in Malaysia. Numerous barriers impede the adoption of IBS in the industry. Malaysia has become highly accustomed to traditional construction methods; consequently, introducing innovations or alternative approaches encounters considerable resistance. This may be due to:

Table 2.3
Barriers to IBS Implementation

Barriers	Description	Source
Public Perception	There exists a perception that IBS lacks sufficient rigidity and flexibility in both form and dimension to meet all variable construction demands adequately.	(CIDB, 2020) (A. hussein M. H. Al-Aidrous et al., 2023) (N. M. Q. B. Abdullah et al., 2021) (Masram et al., 2024)
Lack of Integration	IBS manufacturers and contractors are typically engaged after the design phase. This lack of integration has led to the necessity for design modifications and the incurrence of additional costs should IBS be implemented.	(CIDB, 2020) (Al-Awag et al., 2021) (Aini et al., 2025) (N. S. A. Rahim et al., 2025) (Nawi et al., 2023) (Hu & Chong, 2020)
Large initial investment cost.	The cost incurred for implementing IBS was for setting up the factory. The IBS contractor needed more than 30% of the up-front payment.	(Al-Awag et al., 2023) (Kasim et al., 2019) (A. M. M. Alawag et al., 2021) (A. hussein M. H. Al-Aidrous et al., 2023) (N. M. Q. B. Abdullah et al., 2021) (Jing Le & Zainal, 2021) (Esa et al., 2023) (Masram et al., 2024) (Saberi et al., 2022)
Traditional stakeholders' concerns	Reluctance in adaptation of IBS due to a traditional mindset that prefers conventional methods.	(Al-Awag et al., 2023) (A. hussein M. H. Al-Aidrous et al., 2023) (Masram et al., 2024) (CIDB, 2020b)
Transportation Limitation	The IBS necessitates adequate channels for transporting all components to the construction site for assembly work.	(Jing Le & Zainal, 2021) (Esa et al., 2023) (Al-Awag et al., 2021) (Masram et al., 2024) (Saberi et al., 2022)
Lack of skilled labours	Limited technical knowledge and experience in handling IBS components.	(Jing Le & Zainal, 2021) (A. hussein M. H. Al-Aidrous et al., 2023) (Al-Awag et al., 2023) (Masram et al., 2024) (Saberi et al., 2022)
Ineffective Policies	Ineffective incentives and support are provided by the government, as well as the	(A. hussein M. H. Al-Aidrous et al., 2023) (Al-Awag et al., 2021)

	sluggish enforcement of governmental policies and regulations.	(Saberi et al., 2022)

2.8 Integration in Industrialised Building System (IBS)

Although IBS has been introduced for over 40 years, with well-documented benefits and strong support from the government, the pace of implementation and usage of IBS is still slow and below the government target, as reported by Jaffar et al. (2025) and Shukri et al. (2022). The construction industry implementation of IBS is still deficient compared to conventional methods (Rahim & Qureshi, 2018). Recent research by Al-Awag et al., (2023), Tarang et al., (2022), Shukri et al. (2022) and Jaffar et al. (2025) indicates that the adoption of IBS in Malaysia still faces significant challenges. This finding is consistent with studies conducted by Nizam et al. (2024), Shukri et al. (2022) and Jaffar et al. (2025), all of which report that the prevalence of IBS in Malaysia remains low. According to the most recent CITP report from the CIDB on the adoption of IBS in both government and private projects (2020), adoption rates have increased. Specifically, the adoption rate for public projects rose from 24% in 2014 to 87% but only for the federal government projects. In private projects, the adoption rate improved from 14% in 2014 to 41% in 2020. However, these figures still fall short of the government's objectives (CIDB, 2021d).

Several issues impede the performance of IBS during construction projects, including the preference for conventional methods, lack of integration, delays, poor quality and cost overrun and others (Khalil et al., 2016). This poor performance illustrates the need for the IBS project to investigate alternative management practices that improve the performance (Rahim et al., 2020). Further investigation by previous researchers by Nawi et al., (2014), Ibidapo et al., (2017), Kasim et al., (2019) and Yusof et al. (2024) had identified that one of the low adoption factors for IBS implementation in the Malaysian construction industry is related to poor integration among stakeholders involved in IBS projects.

According to Koolwijk et al., (2018), the integration of activities concerns project-related activities that are undertaken together and the physical facilities that are shared by the organisations or participants that are part of an integrated supply chain. Baiden et al., (2006) describe integration as the merging of different disciplines or organisations with different goals, needs and cultures into a cohesive and mutually

supporting unit. Based on the information provided, it can be deduced that integration refers to the integration of project-related activities and shared physical facilities within an integrated supply chain, involving the merging of different disciplines or organisations with diverse goals, needs, and cultures into a cohesive and mutually supporting unit.

According to Hu & Chong, (2020), the construction industry has been widely criticised for its fragmentation since various organisations are participating in a project at different stages. The term fragmentation can be defined in terms of the number of firms/ specialists involved in construction projects, and in terms of its effects on the multiple processes in construction projects (Nawi, 2012). A fragmented system does indeed create a high level of specialisation for each part; however, the integration of the different specialities becomes increasingly difficult as the number of parts increases, making it more necessary for the specialities to interact more and more effectively (Ng & Tang, 2010). According to Al-Aidrous et al., (2023), traditional contract strategies (procurement) are fragmented, promoting confrontational cultures, and promoting a lack of feedback loops between design and construction. A prior study conducted by (Aini et al., 2025) (Kasim et al., 2019; Nawi, Osman, et al., 2014; Ibidapo et al., 2017) revealed that poor integration among stakeholders involved in the design and contract stage plays a major role in the low adoption rate of IBS implementation in Malaysian construction. Furthermore, IBS projects are often composed of individual professionals who adhere to a sequential approach. As a result of that problem, several issues have recently arisen, such as reworks, time delays, rising costs, lack of communication and coordination, and wastage (Ariffin et al., 2019).

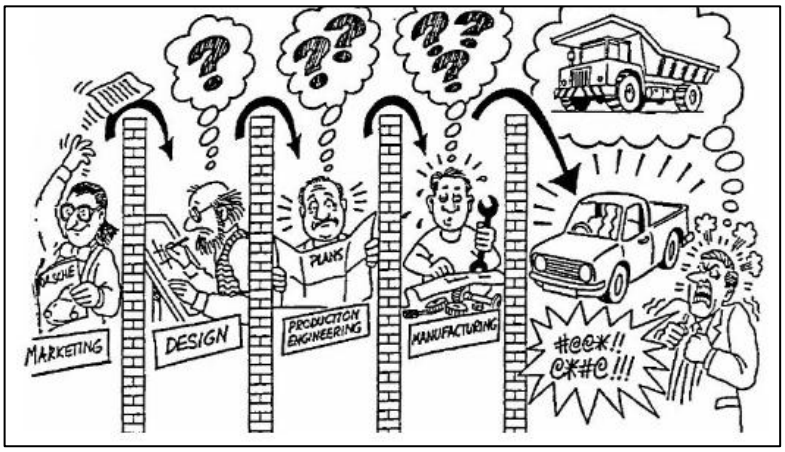


Figure 2.2 'Over the Wall Syndrome' by Osman et al. (2015)

The IBS construction industry, especially in developing countries such as Malaysia, is still not ready to change from the old construction practice of ‘over the wall syndrome’ and move towards an integrated and collaborative approach (Osman et al., 2015).

The traditional procurement system has been criticised for its fragmented procedure to project delivery in terms of integration and collaboration of the project team IBS project (Liyana et al., 2018; Nawi et al., 2023). Abd Hamid et al., (2011) and (Yin et al., 2025) emphasised that the integration of all stakeholders in a project is an essential aspect of IBS that cannot be overlooked and this integration can be enhanced through the implementation of new procurement methods for IBS projects. In addition, Nawi et al., (2011) stated that enhancing procurement mechanisms is crucial for attaining success in implementing IBS in the Malaysian construction sector. This is in line with Zairul, (2022) stated that traditional, out-of-date approaches to IBS construction management prevented the advantages of IBS from materialising. Previous initiatives by CIDB aimed at promoting the use of IBS through training, awareness campaigns, conferences, and magazine publications have not prioritised integration. Consequently, IBS continues to rely on conventional design and build methods, failing to fully leverage the potential for collaboration among IBS stakeholders. In conclusion, integration plays a crucial role in uniting all IBS stakeholders to achieve optimal IBS performance. The preliminary survey in sub-chapter 1.3.5 also indicated that the absence of integration remains a significant obstacle to IBS implementation.

2.9 The Definition of Integrated Project Delivery (IPD)

The term "Integrated Project Delivery" (IPD) is presented as a dynamic method that can improve project implementation. This method has played a particularly prominent role in recent studies conducted by researchers. Different researchers have defined IPD differently in the construction industry. The existing definitions of IPD in terms of delivery method are presented in Table 2.4.

Table 2.4
The Definitions of IPD

Author	Definition
(AIA, 2007)	A project delivery method that integrates people, systems, business structures, and practices into a collaborative process that harnesses the talents and insights of all participants to reduce waste and optimise efficiency through all phases of design, fabrication, and construction.
(Sive & Hays, 2009)	Collaborative teams, including the architect, engineer, contractor, and the owner, work in a contractually connected manner, generally within a risk or profit-sharing format.
(Decker, 2009)	A collaborative project delivery method utilising relational contract principles to harness the strengths and capabilities of the owner, designers, and constructors, focusing them on a single goal: the efficient delivery of the project as a whole.
(Ghassemi & Becerik-Gerber, 2011)	A highly collaborative process that integrates the expertise of project teams during the early project stages.
(Anderson, 2012)	A business model for design, execution, and delivery of buildings by collaborative, integrated and productive teams composed of key project participants.
(Asmar et al., 2013)	A system that determines the relationships between the different project stakeholders and their timing of engagement to provide a built facility.
(Chen et al., 2017)	Integrated project delivery method is an approach to building design that seeks to achieve high performance on a wide variety of well-defined environmental and social goals while staying within budgetary and scheduling constraints.
(Zuber et al., 2019)	A collaborative project delivery or process that integrates all project members to achieve specific shared goals.
(Garcés & Peña, 2023)	A high level of collaboration between the client, the designer and the general contractor, from the initial phases of the design to the commissioning of the building, focusing its objectives on improving human resource relations in construction projects by changing the moments in which the project developers intervene to increase the level of understanding of the project and shorten its phases.

The definitions offered in Table 2.4 primarily focus on the essential concepts of collaboration, relationship, and integration. Therefore, it can be inferred that the concept of IPD refers to a collective venture of integrated people, technology, strategy and practice to achieve the project goal with minimal risk through all project stages.

2.10 IPD at Worldwide

The IPD was introduced by AIA in 2007 in the United States of America (USA). The success of IPD can be seen in several projects across various countries such as the USA, Canada, the Middle East region, Norway, Finland, Ireland, the Asian region, and others. Pal & Nassarudin, (2020) research found that 22 IPD-related case studies were completed with successful outcomes throughout the USA and Canada, including Mosaic Centre for Conscious Community and Commerce, Akron Children's Hospital, Kay Jewelers Pavilion, USA, Sutter Medical Office Building, USA, and others. The case studies showed that the IPD reliably meets the schedule and cost while achieving the owner's quality goals. The IPD provided a contractual environment and motivation for collaboration through sharing of risk and reward, early involvement, and equality of stakeholders, project-first thinking, limitation of liability, and some of the mechanisms for trust, such as development of the contract, open-book transparent finances, shared understanding of each other's goals, values, and business objectives (University of Minnesota, 2016).

In the Middle East, the Saxum project was successfully delivered using IPD principles. The Saxum project did not fully capitalise on all of the widely acknowledged opportunities associated with IPD (Korb et al., 2016). Nevertheless, the project upheld the fundamental principles of IPD and achieved a successful outcome, despite the potential for cost savings. According to Sherif & Abotaleb (2023), the IPD remains in the early stages of implementation within Egypt and Saudi Arabia. Future studies are needed to identify novel strategies to encourage and coach relevant parties to adopt IPD.

The Tønsberg project in Norway, a healthcare infrastructure, employed an IPD method. The results of the Tønsberg project using IPD indicate heightened ownership among participants and a decrease in unforeseen issues during construction, attributed to more feasible solutions (Rodrigues & Lindhard, 2023). Moreover, teamwork improves when the focus shifts from personal achievements to collective project

objectives. The contractual terms create an atmosphere that promotes trust, respect, good communication, and cooperation (Simonsen et al., 2019).

Finland is undergoing a significant transformation in the execution of real estate development and construction projects (Ashcraft, 2022). Several projects have already used the IPD method instead of using the conventional method, including the Lielahti-Kokemäki railway renovation project, the City of Tampere (Tampere Tunnel), and the University of Helsinki (Vuolukiventie Campus renovation) (Petäjäniemi, 2023). In IPD, the experience with integrating contracting authorities and service providers has demonstrated the benefits that can be achieved. The contracting authority can leverage the expertise of various stakeholders early in the process, as designers and contractors collaborate to plan the execution methods. Additionally, sharing risks and benefits promotes completing projects more closely aligned with the budget and schedule (Petäjäniemi, 2023). The performance of the completed IPD projects has achieved the target schedule and budget.

In the United Kingdom and Ireland, IPD was an emerging methodology under discussion and investigation in the construction industry (Piroozfar et al., 2019). A project in Ireland that implemented the IPD approach achieved highly advantageous results concerning the project control process and adopted a more cost-effective strategy, as the number of production errors, on-site modifications, and assembly delays was decreased or potentially eliminated entirely (O'Dwyer et al., 2024; Scott et al., 2013).

Several Asian countries already implement the IPD, for example, Singapore and Korea. The government of Singapore is actively advocating for the Integrated Project Delivery (IPD) as a "Collaborative Contract Method" through the Building and Construction Authority (BCA). According to Boyani (2024), a sports complex in Singapore has been constructed utilising IPD, in which the client, consultant, and contractor collaborate closely throughout the project to ensure efficiency and innovation. For South Korea, IPD is in the testing phase of the construction project industry (Whang et al., 2019). Several projects in Indonesia have also used IPD (Siregar et al., 2025) and IPD in Indonesia has gained popularity through research (Sari et al., 2023). Other Asian countries, such as Malaysia, are also beginning to promote IPD through research initiatives. IPD implementation in Malaysia remains comparatively limited. The majority of Malaysian construction projects continue to use traditional

delivery methods, such as Design-Bid-Build and Design-Build, rather than adopting fully integrated approaches like IPD. This conventional methodology has faced substantial criticism for its tendency toward fragmentation and inadequate coordination. Academic research in Malaysia, in sub-chapters 2.14 and 2.15, has examined the potential benefits and challenges of IPD, particularly in IBS projects, where collaborative strategies could enhance productivity and be incorporated into construction project performance analysis.

Other nations, such as Nigeria, India, and South Africa, are also promoting IPD through research initiatives or pilot projects. In conclusion, IPD is being examined as a potential remedy to the inefficiencies in delivery methods in the construction industry, driven by the imperative to enhance project performance, risk distribution, and collaborative efforts. These phenomena can be seen in several countries that have already adopted the IPD as one of their construction delivery methods, and other nations are also following in their footstep by promoting IPD through research. Although traditional methods and Design and Build remain widely used, the growing recognition of IPD's advantages, such as shorter project timelines and cost savings, is evident in its adoption.

2.11 IPD Key Stakeholders

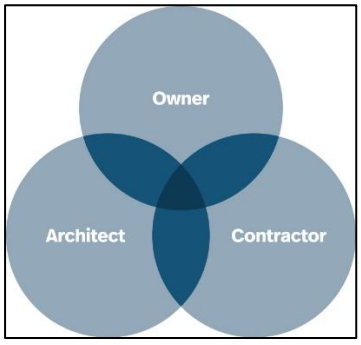


Figure 2.3Key stakeholders in IPD by AIA (2007)

IPD is a new approach to project implementation that has emerged in some nations over the past few years, known as Integrated Project Delivery (IPD). This technique was established to enhance conventional project implementation methods. IPD was introduced by the American Institute of Architects (AIA) in 2007. IPD is characterised by a high level of collaboration between the owner, the prime designer,

and the prime contractor (Figure 2.3) (AIA, 2007). This collaboration begins early in the design phase and continues through to the project's completion and handover. The IPD team fosters collaborative project design, construction, and commissioning (Lichtig, 2010). Everyone on the IPD team must work together and individually to provide project information transparently and cooperatively. As part of the project assessment criteria, they must provide recommendations for improving project delivery. Construction clients are the initiators of projects and those who contract with other parties for the supply of construction goods and services (Atkin and Flanagan 1995). Based on the Oxford English Dictionary, a contractor is someone responsible for the construction of buildings or other significant permanent structures (such as highways, bridges, and so on). On the other hand, a designer is someone competent to provide professional advice or services, such as in issues pertaining to management or design.

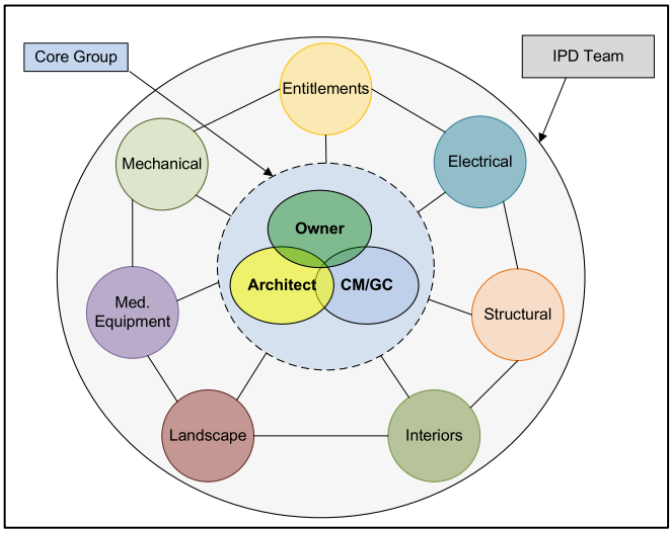


Figure 2.4 IPD Team by Mesa et al. (2020)

According to Una & Bydall (2018), a team working on an IPD project consists of Primary and Key personnel who provide assistance (Figure 2.4). The major members are those who have a significant engagement and obligations in the project, such as the owner, the architect, and the contractor. On the other hand, key supporting participants have specific responsibilities that play a crucial role, such as subcontractors. This is consistent with the findings of the research conducted by Lichtig (2010) and Mesa et al. (2020), which revealed that the core group of the IPD team consists of the owner, the architect, and the contractor. The consultants and subcontractors are grouped as a cluster

(Figure 2.4). The core group bears the primary responsibility for choosing the remaining members of the IPD team and for overseeing and running the project. The outer layer of the IPD team is structured into multidisciplinary cluster groups, which are divided by their respective areas of expertise and are tasked with the responsibility of coordinating their work both within their own cluster group and with coordinating the work of other cluster groups (Mesa et al., 2020).

The parties understand that the success of their project depends on the performance of other participants. Therefore, the parties must cooperate, collaborate, and respect each other for the project's benefit, utilizing their professional knowledge and capacities. The parties shall utilise their best efforts to complete the work quickly and economically in accordance with the project's objectives.

2.12 IPD Contract – AIA Document C191–2009

AIA Document C191–2009 functions as a standard multi-party agreement whereby the owner, architect, contractor, and potentially other principal project stakeholders establish a unified contractual arrangement for the design, construction, and commissioning of a project (AIA, 2026). This document establishes a framework that encourages collaboration, enabling the parties to work together to achieve mutually defined cost and performance objectives. The conflict resolution process is designed to facilitate prompt and effective problem-solving as issues emerge (AIA, 2026). This collaborative methodology aims to deliver a high-quality project for the owner, while providing considerable monetary and intangible benefits to the other participating parties.

2.13 IPD Principles

The IPD method promotes teamwork and emphasises the project's objectives rather than the participants' individual gains (AIA , 2014). While IPD has the potential for improved results, it is crucial to recognise that these results can only materialise if the individuals accountable for achieving them transform. Therefore, to obtain the advantages of IPD, all individuals involved in the project must adopt the Principles of IPD fully (AIA, 2007; Kent et al., 2010; Ling et al., 2020; Nawi, 2012):

2.13.1 Mutual Respect and Trust

In an IPD, all stakeholders, including the owner, designer, consultants, constructor, subcontractors, and suppliers, recognise the importance of cooperation and are dedicated to working together as a cohesive team for the benefit of the project (AIA, 2007). Collaboration necessitates the presence of both respect and trust. The project team pledges to uphold mutual respect and trust, valuing and considering each professional's opinion. Trust-based collaboration arises when individuals prioritise project outcomes over their own objectives (Pishdad-Bozorgi & Beliveau, 2016).

2.13.2 Mutual Benefit and Reward

According to Kent et al. (2010), IPD contracts have components that are specifically intended to foster collaboration and advance the project's overall success, rather than favouring any one team member. IPD contracts diverge from conventional projects by consolidating the risks and benefits of all team members, fostering teamwork, and motivating them to achieve shared project objectives. The IPD process necessitates the early engagement of several stakeholders. IPD remuneration models acknowledge and incentivise this early involvement (AIA, 2007). This decision-making process ensures that the impacts on the choice are aligned, resulting in a conclusion that is optimal for the project and beneficial for all parties (AIA, 2014). Three common ways employed in Integrated Project Delivery (IPD) involve pooling a portion of the project team members' profit at risk, pooling contingency funds, and distributing any residual money after project completion. These approaches aim to share the cost savings or cost overruns in relation to an assessed cost of work (Thomsen et al., 2009).

2.13.3 Collaborative Innovation and Decision Making

For the IPD to be optimised, the project team must engage in continuous, close, and profound collaboration. Participants in a collaboration must feel a sense of ownership regarding the project and its final objectives. The principal objective of IPD is to optimise collaboration and decision-making throughout the project, and these IPD

serve as the means by which these objectives can be accomplished with minimal disruption (Kent et al., 2010). In the IPD mode, it is essential to prevent favouring one or a small number of parties while balancing the interests of all; since collaborative decision making and control are required, which facilitates the participants' perception of a project as "our project" rather than "their project" (Ling et al., 2020).

2.13.4 Early Involvement

IPD necessitates prompt collaboration among the owner, designer, and contractor, with the potential inclusion of other stakeholders based on the project's particular requirements (Rodrigues & Lindhard, 2023). In an integrated project, the key stakeholders are involved from the earliest practical moment. Their collective knowledge and experience are most potent at the first phases of the project, where well-informed decisions have the most significant impact (AIA, 2007). Early engagement is recommended as a solution to the industry's fragmentation issues, as it helps to avoid inefficient work methods and costly adjustments that often arise during the latter stages of construction (Kent et al., 2010; Piroozfar et al., 2019).

2.13.5 Early Goal Definition

According to AIA, (2007), all participants identify, agreed upon, and uphold the project's objectives in their early stages. Within a context of individual participant aims and values, IPD embraces and encourages innovation and exceptional performance places a premium on each member's insight. Each key stakeholder independently aligns their individual objectives with the objectives of the project (Mesa et al., 2016). As these objectives are collaboratively created, every key stakeholder makes a commitment to achieve these aims (Ling et al., 2020).

2.13.6 Intensified Planning

The IPD method acknowledges that more planning effort leads to higher executional efficiency and cost savings (AIA, 2007, 2014). According to AIA (2012), when all of the key stakeholders participate in the collaborative decision making process

about project planning and their objectives, they establish a common awareness of the requirements of the project as well as a sense of co-ownership of the project, which helps to form connections that ultimately lead to trust (AIA, 2012). Enhancing project planning and design often leads to better project performance in terms of cost, time, and quality, as well as a higher chance of achieving the collaboratively agreed project aims (Larsen et al., 2018; Rodrigues & Lindhard, 2023).

2.13.7 Open Communication

According to AIA, (2007), the IPD places a strong emphasis on team performance, which is supported by communication that is open, direct, and honest among all members. Open communication among team members was necessary to ensure transparency; it was not limited to a conventional approach (Zuber et al., 2019). All forms of information, ranging from the reasoning behind design decisions to the use of Building Information Modelling (BIM), are stored in a centralised area to ensure that all members of the team can easily access up-to-date and precise information (AIA, 2014). The teams set out to open communication and resolve recognised issues promptly within the project's team, rather than seeking to assign blame, and it makes communication is important to enhance understanding of identified problems within the team (Rodrigues & Lindhard, 2023).

2.13.8 Appropriate Technology

Integrated projects frequently depend on modern technologies (AIA, 2007), and throughout the design, construction, and operation phases, BIM is utilised in almost all IPD projects (Rodrigues & Lindhard, 2023). Building Information Modelling (BIM) serves as an instrument for facilitating collaboration, integration, and the pooling of intellectual capital among members of an IPD team (Thomsen et al., 2009). By implementing BIM in IPD for collaboration and three-dimensional interaction, the project team gains greater assurance that the undertaking fulfills the owner's goals by facilitating comprehension of the project's scope, scheduling, and cost verification (Allison et al., 2018). According to Piroozfar et al., (2019), IPD eliminates the contractual and responsibility divisions, hence enhancing the collaborative atmosphere

required for successful adoption of BIM. IPD and BIM are complementary, and they mutually enhance and reinforce one other. Taking advantage of BIM technology also allows for open information sharing (Ling et al., 2020).

2.13.9 Organisation and Leadership

IPD is a team-managed, cost-based project that by its very nature necessitates more administrative work and leadership than a lump sum, hierarchical project (Allison et al., 2018). The successful implementation of the IPD approach requires competent project leadership and precise value management. AIA, (2007) stated that the team member who has the highest level of competence in a particular task or service assumes the role of leadership. The responsibilities of the team's leader and members are well-defined, and no artificial barriers are erected to prevent risk-taking and free communication. Based on research done by Kent et al., (2010), the effective leadership is essential in fostering a cooperative team atmosphere. The absence of effective leadership, the strong strategic coordination among the key participants may be significantly compromised compared to the conventional method of team members who do not actively participate (Thomsen et al., 2009).

2.14 IPD Benefits

The IPD approach delivers numerous benefits in a project. It has identified the subsequent advantages of IPD in Table 2.5 based on the reviewed literature and prior research done by AIA (2007, 2012), Garcés & Peña (2023), Kahvandi et al. (2020), Kent et al. (2010), Pal & Nassarudin (2020), Rodrigues & Lindhard (2023), Sherif & Abotaleb (2023), Simonsen et al. (2019), and Viana et al. (2020).

Table 2.5
IPD Benefits

Benefit Characteristics	Description	Source
Shared risk and reward	All project stakeholders are bound by a single contract, which entails shared rewards and risks.	(AIA, 2007, 2012) (Kahvandi et al., 2020) (Pal & Nassarudin, 2020) (Rodrigues & Lindhard, 2023) (Sherif & Abotaleb, 2023) (Simonsen et al., 2019)

Minimum variation orders	All parties participating in the project are involved in the early stages, sharing information and progress together to minimise variation orders in the future.	(AIA, 2007, 2012) (Garcés & Peña, 2023) (Kent et al., 2010) (Sherif & Abotaleb, 2023) (Viana et al., 2020)
Lower cost	Fewer variation orders lead to lower costs and a more optimal schedule.	(Garcés & Peña, 2023) (Kent et al., 2010) (Pal & Nassarudin, 2020) (Sherif & Abotaleb, 2023)
Improved project profit	An IPD contract has the potential to maximise profits for all parties involved.	(AIA, 2007, 2012) (Garcés & Peña, 2023) (Sherif & Abotaleb, 2023) (Simonsen et al., 2019)
Better communication	All parties involved in projects are able to communicate more effectively due to their shared objective.	(AIA, 2007, 2012) (Sherif & Abotaleb, 2023)
Optimise materials' use and time	As the project's overall success directly impacts everyone's profit, there is a strong motivation for all individuals to discover the most effective approaches to accomplish the task.	(Pal & Nassarudin, 2020) (Sherif & Abotaleb, 2023)
Quality	Enhanced construction quality as a result of improved coordination and collaboration.	(AIA, 2007, 2012) (Kent et al., 2010) (Rodrigues & Lindhard, 2023) (Simonsen et al., 2019) (Viana et al., 2020)
Planning	Shorter and optimised work schedule as a result of thorough early planning at the initial stage of projects.	(AIA, 2007, 2012) (Garcés & Peña, 2023) (Kent et al., 2010) (Pal & Nassarudin, 2020) (Rodrigues & Lindhard, 2023) (Simonsen et al., 2019) (Viana et al., 2020)
Integration	Decisions are made throughout every stage of the construction process as a team. IPD has played a role in reducing the culture of blame and fostering a more positive work environment.	(AIA, 2007, 2012) (Garcés & Peña, 2023) (Kahvandi et al., 2020) (Pal & Nassarudin, 2020) (Rodrigues & Lindhard, 2023) (Simonsen et al., 2019) (Viana et al., 2020)
Respect &Trust	IPD can achieve its goals by encouraging desired behaviours, such as respect and trust, teamwork, and open communication.	(AIA, 2007, 2012) (Kahvandi et al., 2020) (Rodrigues & Lindhard,

		2023)
Contract	The contract is perceived as facilitating effective collaboration, as it promotes the resolution of problems and the mutual identification of optimal solutions.	(Simonsen et al., 2019) (Kahvandi et al., 2020) (Kent et al., 2010) (Pal & Nassarudin, 2020) (Rodrigues & Lindhard, 2023)
Technology	Technological advancements, such as BIM, have enhanced communication and facilitated the exchange of information in IPD projects.	(Simonsen et al., 2019) (AIA, 2007, 2012) (Kent et al., 2010) (Pal & Nassarudin, 2020) (Simonsen et al., 2019)

The benefits of Integrated Project Delivery (IPD) are derived not just from previous researchers' questionnaires but also from case studies of projects that have implemented IPD. Based on the case study conducted by Rodrigues & Lindhard (2023), the implementation of the IPD approach has resulted in the establishment of a favourable working environment characterised by extensive collaboration, trust, and respect. Consequently, this has led to enhanced problem-solving capabilities and a decrease in the prevalence of a blame-oriented culture. The collaboration is enhanced by redirecting attention towards shared project objectives rather than individual accomplishments.

The statement above is substantiated by research conducted by the AIA (2012). The AIA conducted the research utilising the IPD approach on a total of twelve (12) projects. The research found that IPD teams benefit from shared financial risk and reward incentives, as well as the sharing of project information, ideas, and opinions among all team members. Additionally, collaborative project delivery has a positive impact on the efficiency of the project and the quality of design. Furthermore, it enables effective communication among team members from different contracting parties.

2.15 Challenges to IPD Implementation

Notwithstanding the aforementioned advantages, IPD encountered certain challenges during its implementation within construction projects. The subsequent challenges of IPD are delineated in Table 2.6, as derived from the reviewed literature and prior research.

Table 2.6
Challenges to IPD Implementation

Challenges	Description	Source
Cultural challenges	Unwillingness of the industry to vary from its traditional methods	(Yee et al., 2017) (Ghassemi & Becerik-Gerber, 2011) (Durdyev et al., 2020) (Pal & Nassarudin, 2020) (Zadeh et al., 2025) (D. Roy et al., 2018a) (Viana et al., 2020) (Rodrigues & Lindhard, 2023) (Evans et al., 2023)
Lack of experience of the IPD user	The parties involved lack experience with using IPD.	(Ibidapo et al., 2017b) (Rodrigues & Lindhard, 2023) (Evans et al., 2023) (Sherif & Abotaleb, 2023)
Contract challenges	The conventional contract for traditional construction is not appropriate when using IPD.	(Ibidapo et al., 2017b) (D. Roy et al., 2018a) (Durdyev et al., 2020)
Insurance challenge	The preparedness of insurance companies to address the changing needs of the IPD project by providing coverage for all participating parties under a single policy.	(Ibidapo et al., 2017b) (D. Roy et al., 2018a) (Durdyev et al., 2020) (Rodrigues & Lindhard, 2023) (Sherif & Abotaleb, 2023) (Evans et al., 2023)
Financial challenge	The difficulty of choosing an appropriate compensation and incentives package that is proportionate to the distinctive characteristics of the IPD projects and to the participants involved in their delivery.	(Ibidapo et al., 2017b) (D. Roy et al., 2018a) (Viana et al., 2020) (Kahvandi et al., 2023) (Rodrigues & Lindhard, 2023)
Technology challenge	The liability, ownership, and interoperability are involved in implementing the integrated software into the project.	(Viana et al., 2020) (Zadeh et al., 2025) (Durdyev et al., 2020) (Evans et al., 2023)
Insufficient staff training	Underscoring IPD's disruptive impact at both the individual and process levels.	(Zadeh et al., 2025) (Durdyev et al., 2020) (Kahvandi et al., 2023)

2.16 IPD Implementation in IBS

The AIA established IPD in 2007 as a project delivery approach that combines design, engineering, architecture, and construction. IPD aims to synchronise the goals and methods of stakeholders to leverage their perspectives for enhancing project

efficiency (Lu et al., 2021). The concept of Integrated Project Delivery (IPD) emphasises the necessity of early involvement in parallel processes to integrate people, systems, business structures, and practices in order to minimise waste and maximise efficiency throughout all stages of design, fabrication, and construction (Nawi, 2012). According to Allison et al. (2018) and Lopez et al. (2022), IPD is suitable for IBS because it enables early alignment of the project team, allowing them to plan the project scope and budget before the design phase begins (Figure 2.5). Besides that, Rahim et al. (2025) mention that insufficient integration might lead to disarray in the IBS project, which has emerged as a significant concern within the IBS construction sector. This is in line with research done by Yin et al. (2025), that the integration of all stakeholders in a project is the element in IBS that cannot be separated, and this can be improved with IPD for IBS projects. Integration with IPD stakeholders during the early design stage results in the availability of more specific information sooner than in the conventional design process. Thus, integration among IPD stakeholders can assist in recognising and managing potential risks during the manufacturing and construction phases using IBS concepts (Lu et al., 2021). Therefore, IBS projects can be executed more efficiently with the support of new project management and delivery methodologies through IPD to address the lack of integration in the current IBS industry.

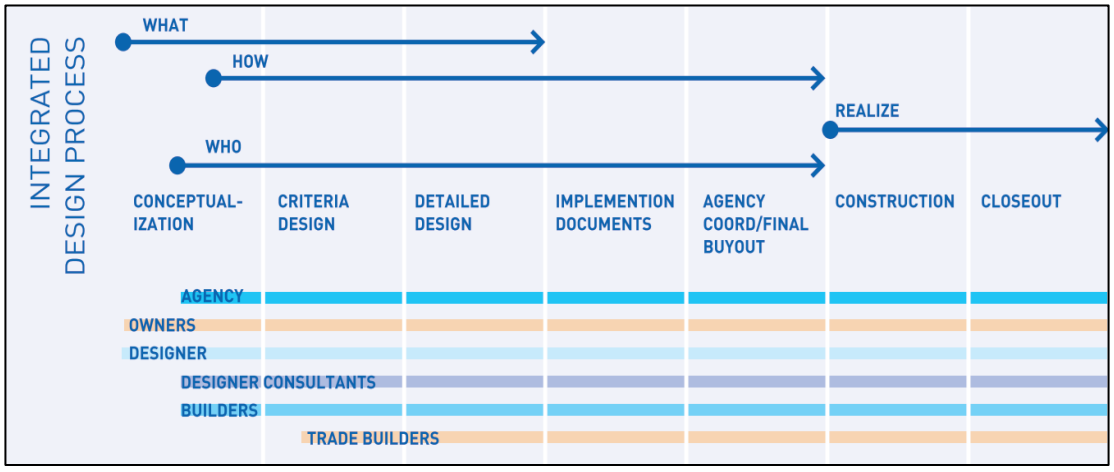


Figure 2.5 IPD Project Phases by AIA (2014)

2.17 IBS Project Delivery Method in Malaysia

Owners, designers, and contractors are integral to the decision-making process, service provision, and execution of the work required to bring construction projects to fruition. According to Moynihan & Harsh, (2016), the term "project delivery system" defines the organisation of the involved parties and the structure needed to transform the client's goals and objectives into a completed facility. Initially, the owner maintains full control over the project.

2.17.1 Conventional Project Delivery Method

The conventional project delivery method known as the design-bid-build (DBB) has been practiced throughout the history of the construction industry and is the most common method used to date (Bennett, 2003; Ibidapo et al., 2017a). This conventional method consists of two independent contractual arrangements established between the project owner and the consultants (e.g., architects, engineers, and quantity surveyors) to create the project specification, and between the project owner and main contractors for actual on-site building work (Mincks & Johnston, 2024). According to Brook, (2017), the consultant's role is seen as an independent entity. The architect is employed to: advise the client, design, and ensure the work is kept within the cost limit and complies with the standards required. A quantity surveyor can be engaged to give guidance on budgets, the costs associated with evolving designs, preparation of bills of quantities, check tenders, prepare interim valuations and advise on the value of variations. Engineers may be employed either by the client to design the specialist parts of the project.

The conventional method is progressive because its design and construction stages are separate and distinct and the absence of contractor involvement in the design process only speaks of a greater problem (Ibidapo et al., 2017a). A contractor holds certain practical information and expertise in constructing feasibility, estimating true costs, and scheduling that would vitalize the entire design process. But when they were not part of an early conversation and decision-making, key matters may be left missing and only be discovered during construction. According to AIA (2007, 2014), this non-involvement can conceal a variety of challenges that only become apparent during the actual construction phase. Consequently, projects often encounter increased errors,

disputes, and unforeseen complications, resulting in higher overall costs and extended project timelines**.**

2.17.2 Design and Build Project Delivery Method

The design and build project delivery method is an attractive option for clients. It simplifies the contractual links between the parties to the main contract because the contractor accepts the responsibility for designing and constructing (Ibidapo et al., 2017a). This approach enhances collaborative efforts and enables early contractor involvement for feedback provision.

The benefits include single-point responsibility, prices that reflect more closely the final cost to the client, inherently more buildable designs, and overlap of design and construction phases leading to early completion (Bennett, 2003; Nawi, 2012). A design-and-build contractor may engage external consultants for design and cost services or use an internal design team from inside their firm (Ibidapo et al., 2017a). Occasionally, the customer might ask the contractor to execute a design that their chosen consultant initiated, but these consultants are still under the main contractor's supervision and could potentially clash with the owner's interests. This compromises the checks and balances provided by the conventional method (Azhar et al., 2014).

2.18 Comparison between IPD, Conventional and Design & Build Project Delivery Method

The study outlines the distinctions among project delivery methods, specifically Integrated Project Delivery (IPD), the conventional method, and design-and-build models, which are prevalent procurement strategies in the Industrialised Building System (IBS) construction industry. Table 2.7 provides a comparative analysis informed by the reviewed literature and prior research conducted by Azhar et al. (2014), El Asmar et al. (2013), Ibidapo et al. (2017a), Mollaoglu-Korkmaz et al. (2013), Nawi (2012), Una & Bydall (2018) and Zuber et al. (2019).

Table 2.7
Overview of IPD, Conventional and Design & Build Project Delivery Method

	IPD	Conventional	Design & Build
Type of Contract	Integrated Contract	Transactional Contracts	Transactional Contracts
Team Structure	Horizontal	Pyramid	Pyramid
Contracts	Integrated contracts between the client, contractor and consultant. Legally: direct and bind team activity Eliminate or reduce the ability to sue and claim compensation	Separate contracts Set up outlining how to sue and claim compensation.	Separate contracts Set up outlining how to sue and claim compensation.
Risk/Reward	Risk is mainly distributed. The owner bears the risk of overspending but only bears the basic cost. Reward: Pooled profit, distributed depending on the team's success in reaching the project objective.	Risk is primarily allocated: The Owner carries the risk for design and construction. Others manage risk, transferring as much as possible. Reward: Based on the percentage agreed upon for the consultant and a lump sum for the contractor.	Risk is primarily allocated: The Builder carries the risk for construction. Others manage risk, transferring as much as possible. The owner carries the risk for quality and pays for additional extras. Reward: Lump sum payment for construction
Decision Control	Joint decision making at top management level	Top to down	Top to down

Source: Adapted and modified from Una & Bydall (2018)

IPD contracts are integrated agreements that legally bind all team members, thereby eliminating the possibility of separate lawsuits or claims for compensation. The risks associated with the project are primarily shared, with the owner assuming the risk of overspending. Profits are pooled and distributed among team members in proportion to the project's overall success. Furthermore, the owner is responsible for covering any additional expenses. Decision-making within the IPD framework typically involves collaborative input from all parties involved. The conventional method often involves transactional contracts with separate agreements and inconsistent terms. In this approach, the majority of the risk is allocated to the owner, who is responsible for both the construction costs and the associated risks. At the same time, other parties seek to transfer their risks as much as possible. The reward in this scenario is typically based on payments made in instalments. In contrast, design-and-build contracts place the construction risk on the contractor. The owner, in turn, assumes the risk concerning quality and is responsible for paying for any additional extras. The reward for the

contractor is typically a lump sum payment upon completion of the construction. Decision-making for both the conventional and design-and-build models is hierarchical, with top management making the final decisions.

2.19 IPD Best Practices in IBS

According to Szulanski (1996), the term "best practice" refers to the process by which a corporation replicates an internal practice that is carried out in a superior manner in a particular part of the organisation and is regarded as being superior to both internal alternative practices and other practices that are known to exist outside of the company. The concept of 'Best Practice' is defined by Stephenson & Bandara (2007) as the systematic establishment and adherence to a standardised process that can be applied constantly such as in software systems development, policy formulation, and management. Best practice is essentially the process of designing a formalised procedure in order to make use of beneficial experiences and successfully transfer these experiences both internally within an organisation through the implementation of process improvements and externally between organisations through the utilisation of models for quality improvements, standardised information technology systems, and professional networks (Axelsson et al., 2011). Therefore, it can be concluded that best practice refers to a systematic approach for identifying the most effective solutions to specific issues within a particular context, where certain suggestions are considered superior to others.

This study focused on identifying best practices for IPD in IBS. Previous similar studies also concentrated on identifying best practices within the same field. After examining the literature written by multiple researchers, it was determined that the 41 BPs listed in Table 2.8 are the essential criteria needed for the successful application of IPD in IBS. Therefore, the constructive discussion on each of the BPs is intentionally included in the research conceptual framework, precisely described below.

Table 2.8
IPD Best Practices in IBS

	Author / **Best Practice**	(Yusof et al., 2015)	(Yunus et al., 2017)	(Nduka et al., 2019)	(El-Abidi et al., 2019)	(Bahar uddin et al., 2019)	(Kasim et al., 2019)	(Wuni & Shen, 2020a)	(Rashid et al., 2019)	(Al-Awag et al., 2022)	(Saad et al., 2022)	(Al-Aidrous et al., 2022)	(Nawi, 2012)	(Yu et al., 2019)	(Whang et al., 2019)	(Hamzeh et al., 2019)	(Franz & Roberts , 2022)	**Total (√)**
1	Communication channel	√	√	√	√		√	√	√	√		√	√	√		√	√	**13**
2	Key decision	√	√	√			√	√			√			√	√	√		**9**
3	Extension planning & schedule	√	√	√	√		√	√	√	√		√		√				**10**
4	Supply chain	√		√	√		√		√									**5**
5	Top-down management	√	√	√	√		√	√	√	√			√	√				**10**
6	Business and financial approaches	√	√	√	√	√		√		√		√						**8**
7	Close relationship with suppliers and sub-contractors	√		√					√	√			√					**5**
8	Information and communication technology (ICT)	√	√	√				√	√	√		√	√	√		√		**11**
9	Procurement systems	√	√	√	√	√	√		√		√	√	√	√	√		√	**13**
10	Efficient and experienced workforce	√	√	√	√	√	√	√	√		√	√					√	**11**
11	Teamwork	√	√	√	√	√	√			√	√	√	√		√	√	√	**13**
12	Standardisation	√		√	√		√		√		√	√						**7**
13	Good management for site, transportation and machineries	√	√		√					√								**4**

14	Continuous improvement and learning	√	√	√				√			√	√	√					√				**8**
15	Education and training	√	√		√	√				√	√		√					√				**8**
16	Personal working attitude		√											√								**2**
17	Government policy				√	√					√		√	√								**5**
18	Collaboration		√				√	√	√	√	√	√						√	√			**7**
19	Risk management			√	√		√		√										√			**5**
20	Government support				√	√			√		√	√										**5**
21	Quality management									√	√				√							**2**
22	Project trend & knowledge				√	√						√										**3**
23	Adaptability		√	√					√													**3**
24	Roles and responsibilities					√						√	√									**2**
25	Shared risk & reward												√	√	√	√	√					**5**
26	Customer focus		√							√										√		**3**
27	Better coordination		√	√	√				√	√										√		**6**
28	Early Involvement			√	√			√	√		√	√						√				**7**
29	Demand & Supply			√					√													**2**
30	IoT								√			√										**2**
31	Robotic & Automation								√			√										**2**
32	Share objective & goal														√					√		**2**
33	Adequate staff																			√		**1**
34	PM leadership & commitment																			√		**1**
35	Mutual respect & trust		√											√	√							**3**
36	Speed of Construction								√													**1**

37	Availability of Plant	√										**1**
38	Owner Competent										√	**1**
39	BIM	√	√		√	√	√	√	√			**7**
40	CAD					√		√	√			**3**
41	CAM	√				√						**2**

2.19.1 Top-Down Commitment

As per the studies conducted by El-Abidi et al. (2019), Kamar (2011), Kasim et al. (2019) and Yusof et al. (2013), a robust and unwavering top-down commitment from both the institutional and executive levels is crucial to persuade decision makers, customers, clients, and the internal business structure to use innovative technologies like IBS. These are in line with statements made by Nawi (2012), where both top management and senior managers from various departments must be supportive in order to have an efficient integrated team. Effective leadership at all levels of management can facilitate the integration of building components in the manufacturing process and ensure efficient management of the communication of information (Yunus et al., 2017). The implementation of the top-down commitment leadership style in IPD showed a significant impact on project performance, and it was found that various technique styles produced superior outcomes under distinct project environments (Franz & Roberts, 2022). Kissi et al. (2025) also found that top management commitment is crucial for enhancing performance, given its direct connection to performance outcomes. Therefore, the top-down commitment plays a crucial role in IPD within IBS.

2.19.2 Risk Assessment

For any construction company or organisation, risk management is an essential tool for addressing and resolving project-related issues in the business structure (Hamzeh et al., 2019). El-Abidi et al. (2019), state that, from a strategic perspective, when making decisions during the trial-and-error phase of IBS, a risk management and mitigation plan should be developed. This is especially true in an environment of uncertainty, where early detection of these risks and estimation of their likelihood can improve decision-making (Yusof et al., 2013). Implementing a risk management approach is crucial to effectively address issues such as late design changes, delayed payments, and contract problems in the context of IBS (Kasim et al., 2019). Developed countries have significant experience in risk management, acquired from the analysis of both successful and unsuccessful instances of IBS implementation in the construction sector. Implementing IPD results in a better method of handling risk management and reduces overall project risk by linking project uncertainties to the final outcome and

collaboratively managing them (Ghassemi & Becerik-Gerber, 2011). As an incentive, IPD projects remunerate team members through rewards that are based upon the successful completion of project outcomes (AIA, 2007).

2.19.3 Government Support

The development of the Roadmap IBS (2003–2010), the IBS Roadmap (2011–2015), the Construction Industry Transformation Programme (CITP, 2016–2020), and the current Construction 4.0 Strategic Plan (2021–2025) demonstrates the government's dedication to promoting the use of IBS. According to El-Abidi et al. (2019), the CIDB is responsible for putting IBS projects and plans into action in order to raise construction performance and quality. Government initiatives, such as fee exemption, continuous professional development (CPD) training programmes, and ongoing awareness campaigns, are major contributors to IBS sucesses (Lou & Kamar, 2012). Al-Aidrous et al. (2022) mention that the financial incentives, such as tax privileges and credit support, are considered the most efficient means of encouraging developers and contractors to implement IBS. The government supports an open dialogue between IBS stakeholders and government agencies through roundtable meetings, which help in implementing and aligning with the national agenda as well as the business structure, strategy, vision, and mission of the stakeholders (Baharuddin et al., 2019).

2.19.4 Government Policies

IBS has been promoted in several countries through policies and programs. The government's role as a major client in the construction industry makes government policy a significant factor in driving the adoption of new techniques or goods in this sector (El-Abidi et al., 2019; Lou & Kamar, 2012). Construction companies that commit to constructing more sustainable buildings and utilising less labour-intensive delivery methods may benefit from IBS policy (Zakaria et al., 2018). According to CIDB (2018b), the treasury circular, Surat Pekeliling Perbendaharaan Bil. 7 Tahun 2008, issued in October 2008, emphasised the imperative use of Industrialised Building System (IBS) in government projects. The circular emphasised two important requirements: first, that the utilisation of IBS components in government projects must

be at least 70% for projects with a value of RM10 million or more, and second, that IBS must be explicitly mentioned in the contract agreements for all government construction works. In the Programme Jelajah Bina Townhall Se-Malaysia, the CIDB announcement on December 12, 2023, stated that the government's policy on Industrialised Building System (IBS) for private projects requires a minimum of 70% utilisation for projects valued at RM50 million and above, with a minimum gross floor area of 50,000m2. This policy was implemented in 2024. El-Abidi et al. (2019) suggest that government policies regarding IBS should consider alternative procurement approaches instead of traditional ones. This is because the contracts and payment mechanisms of IBS stakeholders need to be more dependable than those used in traditional procurement. The demand for IBS in Malaysia is limited as a result of the lack of policies specifically designed to promote its growth and development (Al-Aidrous et al., 2022). It can be summarised that government policies on IBS can significantly influence the business structure and direction of an organisation in achieving its goals.

2.19.5 Business and Financial Approach

IBS is a term that refers to a construction method that is being developed within the construction company in Malaysia. IBS also presents potential for the development of novel business structures and strategies. IBS companies need to have a distinct business structure model from the conventional method in order to establish their presence in the growing market (El-Abidi et al., 2019) and gain a competitive edge for long-term survival (Al-Aidrous et al., 2022). According to the research conducted by Baharuddin et al. (2019), Nduka et al. (2019), Wuni & Shen (2020a) and Yunus et al. (2017) which suggested to consider business and financial structure as best practices for the successful implementation of IBS. Creating an IPD business structure model is capable of managing projects that employ a collaborative business model to achieve targeted project performance (Whang et al., 2019). As to the findings of Hall et al. (2022), if these construction organisations can achieve greater efficiency by adopting IBS and IPD business structure models, they have the potential to progress from lower-value projects to more intricate projects.

2.19.6 Project Trend and Knowledge

IBS contributes significantly to the growth and development of the Malaysian construction industry. By implementing IBS, the issue with the conventional approach in Malaysia was minimised (Jing Le & Zainal, 2021). According to a survey done by the CIDB (2021a), the government implemented the use of IBS in 7 projects in 2008, which increased to 175 projects in 2019. These projects achieved an IBS score of over 70, with a total of 762 IBS projects completed during a span of 12 years (2008–2019), prior to the emergence of the COVID-19 pandemic in 2020. The use of IBS in public projects climbed from 24% in 2015 to 85.3% in 2020, while in private projects it increased from 14% in 2015 to 41% in 2020, and the number of professionals trained from 2016 to 2020 increased, rising from 356 in 2016 to 6592 in 2020 (CIDB, 2020). The trend employing IBS revealed that a total of 14,139 IBS contractors and 10,719 installers were certified and registered with CIDB, compared to 2016, with only 8170 for contractors and 7814 for IBS installers in 2016. The increase in IBS projects, contractors, and installers demonstrates that IBS in Malaysia is gaining recognition among construction stakeholders. On the project knowledge, enhancing the knowledge of IBS among construction stakeholders would enhance the competitiveness of IBS and bolster its position within the industry (Al-Aidrous et al., 2022). AIA (2014) and (Viana et al. (2020) noted that the use of IPD in the construction industry has significantly increased due to its high success rate, particularly in areas such as cost and time management; thus, IPD exhibits a prominent trend in the building business. Gaining knowledge about IBS enhances understanding of the IBS process, potentially enhancing decision-making, and it becomes an important criterion in determining business structure in an organisation (Yusof et al., 2015). Saad et al., (2022) found that a lack of knowledge of the IBS system in a Malaysian context discourages its adoption. Wuni & Shen, (2020) mention that knowing the changing project trends and knowledge are required in the adoption of IBS and IPD in order to maintain the viability of the organisations in the industry.

2.19.7 Quality Management

According to Franz & Roberts (2022), quality is defined as the degree to which a product or service satisfies the expectations and standards of the client. Reduced defects, which indicate the quality of the product, and change orders, which represent the quality of the process, are two ways that quality management in IPD helps to improve the quality of IBS projects (De Marco & Karzouna, 2018; Yu et al., 2019). Luo et al. (2015), asserted that design norms and standards have a direct impact on the quality of Industrialised Building System (IBS) components, suggesting that inappropriate codes and standards can significantly impact component quality. As per El Asmar et al.'s (2013) survey, quality management in IPD results in quicker delivery of higher quality projects without a notable rise in costs. Furthermore, the quality management system in IPD can also be used to integrate construction professionals and government agencies in the process of discovering important areas where the quality of an IBS project could be affected (Al-Awag et al., 2022). The quality management makes it possible to develop suitable solutions and quality control procedures in order to ensure that IBS projects are of a high quality.

2.19.8 Adaptability

The adaptability of Integrated Project Delivery (IPD) in the context of IBS is crucial for organisational business structures to maintain resilience in a construction market filled with uncertainty (Orozco et al., 2023). Zuber et al. (2019) found that organisations' adaptability with limited resources caused IBS participants to be hesitant to switch from traditional project delivery methods. Furthermore, the application of IBS requires adaptation to different IBS systems and alternative methods of procurement to thrive in the construction business (Khalili-Araghi & Kolarevic, 2018). The concept of IPD is becoming increasingly popular in IBS construction because of its economic and administrative benefits, highlighting the importance for industries to adapt accordingly (Jayasena & Senevirathna, 2012).

2.19.9 Share Objectives & Goals

IPD engaged all levels of project parties in IBS to establish a shared understanding of objectives and goals within the team and committed to project (Franz et al., 2017; Franz & Roberts, 2022; Wuni, Shen, & Darko, 2022). Furthermore, IPD usually transforms conflicting relationships by aligning goals through a system of sharing goals (De Marco & Karzouna, 2018). Ghassemi & Becerik-Gerber (2011) and Yu et al. (2019) emphasised that in IBS, the owner/client should involve key project teams in establishing and coordinating project goals, managing a goal-setting session, determining the budget, specifying expectations, and defining roles. This approach allows the teams to tailor the project to meet the owner's quality and financial goals. Therefore, team integration promotes shared objectives between IPD parties, enhancing project efficiency (Kahvandi et al., 2020)

2.19.10 Demand & Supply

Kouch et al. (2018) stated that the construction industry, especially the IBS sector, demands efficient and well-integrated management from project start to project closure. The bidding contract procedure in IBS is a significant requirement of the integrated approach (Nawi, 2012). Hence, integrating the project team using IPD can start the process of systematic integration in IBS (Yee et al., 2017). According to Salama et al. (2018), the study revealed that design and build are the predominant project delivery approaches for IBS, with IPD on the rise and conventional methods decreasing. The IPD concept is not widely recognised in IBS, but clients are likely interested in it in the future, given the economic and management benefits it offers. As a result, IBS industries must be able to adjust their systems when needed (Jayasena & Senevirathna, 2012).

2.19.11 Roles and Responsibilities

According to Brege et al. (2014) and Mohamed et al. (2019), it is essential to establish roles and business structures that facilitate the implementation of IBS. The key parties in IPD play essential roles that impact the IBS project's relational capability as

well as display the project's stability and relational depth (Steinhardt et al., 2020). A study by Nawi (2012) found that, for a team to integrate effectively, each key party must possess a sense of ownership, comprehend their tasks properly, and take responsibility for the project from start to finish. Besides that, the government also plays a crucial role in the construction industry, and policies should be implemented to promote the wider use of the IBS (Li et al., 2018). Thus, roles are well-established, avoiding the creation of unnecessary obstacles that hinder construction process and innovation (Jayasena & Senevirathna, 2012).

2.19.12 Shared Reward and Risk

One best practices for achieving success in IPD is implementing a "shared reward and risk" approach to drive stakeholders to meet project objectives (AIA, 2007; Ghassemi & Becerik-Gerber, 2011; Kahvandi et al., 2020). The alignment of IPD teams' interests and sharing of shared risk and reward with the overall project objectives fosters the development of collaboration (De Marco & Karzouna, 2018). According to Ghassemi & Becerik-Gerber (2011), sharing rewards is when project team members together decide on a set budget and divide the savings achieved during the project. For sharing risk, an IPD team should agree on ways to share and collectively manage risk, ensuring all project participants have a financial stake in identifying and mitigating risks, thereby reducing overall project risk (Jayasena & Senevirathna, 2012). Thus, an effectively designed risk and reward strategy in a business structure is crucial for promoting collaboration among the involved IBS parties, regardless of whether the project is on or exceeds the goal cost (Hamzeh et al., 2019). This practice is also important for industry stakeholders who are unfamiliar with the IBS and want to engage with experienced IBS companies through an IPD (Rashid et al., 2019).

2.19.13 Information and Communication Technology (ICT)

ICT is a crucial and dependable tool that enhances every stages of IBS construction through the integration of accurate data and efficient management of project papers (Abd Rashid, 2022; Yusof et al., 2015). According to Wuni & Shen (2020a) and Yunus et al. (2017), enhancing the information flow network can enhance problem-solving by promoting transparency and fostering mutual understanding among

employees. By utilising various ICT management solutions, IPD inside IBS can combine diverse information, work processes, and activities (Whang et al., 2019). For example, effective communication and information exchange among the logistics business, manufacturers, and assembly contractor are crucial to keep all parties updated of the progress at every phase of the supply chain (Nawi, 2012; Whang et al., 2019; Wuni & Shen, 2020b). The view above aligns with research conducted by Al-Aidrous et al. (2022) and Yunus et al. (2017) indicating that ICT is a key component affecting the successful implementation of IBS. Thus, utilising ICT communication across all project stages, particularly when addressing specific issues, accelerates the problem-solving process, leads to a more optimal solution (Hamzeh et al., 2019) and fostering mutual understanding among employee (Yunus et al., 2017).

2.19.14 Building Information Modelling (BIM)

According to Li et al. (2018), Nasrun et al. (2017) and Wuni & Shen (2020b) utilising Building Information Modelling (BIM) can enhance design sharing, visualization, robustness, flexibility, and system integration, potentially enhancing the overall success of the IBS project. In IBS projects, IPD has been identified as an efficient delivery approach that is most effective when utilised in conjunction with BIM (Whang et al., 2019). Besides that, an effective integration between on-site and off-site trades is essential for the success of these projects, as it greatly improves schedule, time performance (Wuni, Shen, & Osei-Kyei, 2022) and the reduction of defects in IBS projects (Yu et al., 2019). The study done by Ghassemi & Becerik-Gerber (2011) also indicates that true integration occurs when the key project teams can merge their discipline-specific BIM models into a unified model and engage in every stage of the project, from the start of design to construction end.

2.19.15 Internet of Thing (IoT)

Shkundalov & Vilutienė, (2021) states that the Internet of Things (IoT) revolutionises data collection and processing by offering improved performance and results. Abd. Rahsid (2022) and Qi et al. (2021) defined IoT as devices utilise technologies like sensory, communication, and networking to integrate data and

perform analytics, presenting results visually in applications. The IoT implementation in IBS projects utilises a centralised BIM platform to provide real-time visualisation and traceability of prefabricated components, enabling easy access and sharing of location and status information through RFID tags and GPS sensors (Zhou et al., 2021). Besides that, the integration of smartphones with IoT in portable tools has enhanced the efficiency of formation recording during safety inspections (Xu et al., 2019). The IoT is an emerging technology that connects smart devices and things with self-configuration skills to form a worldwide network. Thus, adopting advanced technologies, including the IoT, plays a crucial role, as factory-based IBSs would need more integrated information technology procedures and processes (Al-Aidrous et al., 2022).

2.19.16 Robotic & Automation

The rapid advancements in automation, robotics, and 3D printing are driving the growth of the digitalisation and automation sectors. This trend is attracting more contractors and innovation organisations in the IBS construction sector, accelerating the pace of technological advancements (Kouch et al., 2018). According Akinradewo et al. (2021) and Verma et al. (2006), the construction automation and robotics are assisting the manufacturing industry in the production of IBS components at a constant speed, which makes this technology more advanced because machines are more accurate and assist in planning to avoid wastage of materials. The use of robotics and automation also enhances safety, quality, and productivity, thus improving total construction efficiency (Abd Rashid, 2022). Xu et al. (2021) suggested that the integration of robotic technology, IPD, and BIM can substantially enhance on-site operations, facilitating the just-in-time delivery of prefabricated components. This synergistic combination promotes increased productivity and efficiency through improved collaboration and greater integration. In conclusion, the integration of digital information and automation technologies in IBS construction accelerates decision-making in the planning phase and execution, facilitated by Integrated Project Delivery systems, which integrate diverse expertise, systems, and business practices for optimal project outcomes (García de Soto et al., 2022).

2.19.17 Speed of IBS

IBS significantly shortens construction project durations compared to conventional methods by overlapping site works, such as earthwork or substructure work, concurrently produced (CIDB, 2018b; Musa et al., 2017). IBS-IPD projects have experienced reduced changes, increased speed of performance, and dramatically decreased project delivery time (Kahvandi et al., 2017). IPD is also being implemented efficiently to reduce the duration of project schedules (Kenig & Dorsey, 2011). The statement has been supported by Alinezhad et al. (2020), which concluded that in a comparison between the efficiency and productivity of IBS-IPD projects and non-IBS-IPD projects, the indicators of efficiency and productivity of IBS-IPD projects, including the speed of project delivery, achieved higher values. Thus, the use of new techniques and technology was among the critical factors affecting the speed of IBS in construction projects in Malaysia (Alaghbari et al., 2015).

2.19.18 Availability of Plants

Idoro, (2012) and Yusof et al., (2024) identified that the availability of plants is a factor influencing the adoption of IBS in Malaysia. According to a study conducted by CIDB, (2021), 79.4% of respondents lack access to machinery and equipment at building sites for implementing IBS projects. The added expense of renting special equipment and machinery is one of the top three challenges in implementing an IBS. The IPD's holistic approach addresses fragmentation in construction processes, including transportation and logistics coordination which leads to improved scheduling, reduced wait times, and optimized delivery routes, which ultimately decrease project costs (Lotfi & Karakouzian, 2025). The data presented by CIDB in the IBS Bina Townhall on December 12, 2023, indicates that there are a total of 132 IBS manufacturers for 6 IBS systems, which is still considered low. The data indicated that only five states; Selangor, Negeri Sembilan, Johor, Sarawak, and Sabah had more than ten IBS manufacturers, while three states; Perlis, Kuala Lumpur, and Melaka had none at all. Six states; Kedah, Penang, Perak, Kelantan, Terengganu, and Pahang; had fewer than ten IBS manufacturers. Although the number of IBS manufacturers remains low, their locations extend to other parts of the state, due to the logistical transportation

coverage for IBS, which reaches a maximum of 322 km (Yusof et al., 2023). The availability of plants within a designated covered radius area is essential for minimising transportation expenses. The proximity of the nearest plant to the site yields savings on logistics costs. Therefore, to ensure the successful implementation of IPD in IBS, it is important to have plants, equipment, and machinery available locally within the coverage range of the manufacturing plant.

2.19.19 Computer-Aided Design (CAD)

The construction industry has witnessed the emergence of several technological applications and tools, including Computer-Aided Design (CAD). These tools have proven to be highly beneficial in facilitating effective communication and coordination among different parties involved in IPD (Nawi, 2012). The CAD systems are used for the purpose of generating visual representations of objects, such as the positions of buildings and the arrangements of their layouts. The study conducted by Johnston et al. (1999) highlights the utilisation of CAD in IBS to enhance production. Similarly, Akinradewo et al. (2021) emphasise the importance of CAD in achieving better-quality project delivery and cost-effective life-cycle management, while Verma et al. (2006) also support these benefits. Implementing CAD-based integrated design and production processes, together with interoperability standards, has been shown to result in decreased costs, faster delivery, and greater quality in other industries (Verma et al., 2006). Research conducted by Kiani et al. (2013) indicates that the utilisation of CAD facilitates collaboration among all stakeholders engaged in a project, hence minimising conflicts between design and construction during different stages. Hence, the ideal outcome of IPD collaboration is the eradication of several design alterations and change orders, finally resulting in a project that is completed within the allocated budget and schedule, a feat that is rarely achieved in the construction sector.

2.19.20 Computer-Aided Manufacturing (CAM)

Azhar et al. (2014) stated that to effectively execute Integrated Project Delivery (IPD), a project team must possess specific technologies, collaboration tools, and automation skills. One such capability is Computer-Aided Manufacturing (CAM).

CAM technologies utilise computer software to effectively manage and operate production machines (Abd Rashid, 2022). The integration of CAD-CAM and construction automation in IBS allows for the digitisation of design, delivery, and project management both on-site and off-site. This integration eliminates the need for coordination stages involved in passing over shop drawings to craftsmen, resulting in time and effort savings (Ng & Hall, 2019). This feature also facilitates increased automation throughout the design stage, allowing for the generation of intermediate information products like as drawings, specifications, engineering calculations, and detailing (Peltokorpi et al., 2021). In addition, as stated by Li et al. (2018), the CAD-CAM controlled autonomous manufacturing line effectively utilised a concrete distributor to accurately disperse the appropriate quantity of concrete based on CAD specifications. Furthermore, robots were employed to position the mould and reinforcement materials. Therefore, it can be deduced that CAM simplifies the procedure of product and manufacturing data, minimising manual effort and bridging the divide between construction and manufacture.

2.19.21 Collaboration

According to Kasim et al. (2019), the key management-related factors for successful implementation of IBS projects in Malaysia are the active involvement of all stakeholders to foster strong collaboration. The claim is further supported by a study conducted by Wuni, Shen, & Osei-Kyei (2022), which found that effective collaboration and integration among key stakeholders in an IBS project, through the use of IPD, leads to a better understanding and alignment with the project's planning, objectives, and benefits. This, in turn, reduces disputes and delays. According to Abd. Rashid et al. (2019) and Yunus et al. (2017), effective working collaboration within IPD guarantees a streamlined process sequence at the IBS manufacturing facility and on-site, as well as resolve the issue associated with complex interfacing between systems. A good example of this is the collaboration between manufacturers and the design team (consisting of the architect, structural engineer, and designer) (AIA, 2007). This collaboration enables manufacturers to gain a more accurate comprehension of the intricate working drawings, thereby reducing dimensional tolerances, which reduces delays, disputes, geometric variations, and changes (Wuni et al., 2020). A study

conducted by Saad et al. (2022) found that collaboration is considered one of the most effective strategies in the adoption of IBS, meanwhile Al-Aidrous et al. (2022) found that collaboration is among the top five best practices for IBS. Similarly, a study conducted by Yee et al. (2017) also highlighted collaboration in IPD as a crucial ingredient for carrying out a high-quality IBS project. Therefore, the collaboration functions of IPD throughout the entire IBS process contribute to the success of projects, as IPD demonstrates superior performance compared to projects utilising alternative delivery systems.

2.19.22 Effective Communication

According to Abd. Rashid et al. (2019), communication channels are the means via which information travels both inside and outside of an organisation. The team members who were physically closer together were more successful communicators than those who were further away, and this finding provides support for the idea that physical closeness improves communication (Franz & Roberts, 2022). Kasim et al. (2019), Nduka et al. (2019) and Yusof et al. (2015) stated that it is deemed essential for the stakeholders of the IBS project to have excellent communication in order to coordinate processes and deal with crucial scheduling from the beginning of the project until it is completed. In addition, effective communication across all stages of an IBS project, particularly when addressing specific issues, facilitates the rapid resolution of issues and the achievement of an improved solution (Hamzeh et al., 2019). The IBS project must be continuously managed by providing smooth integration and communication across every stage (Luo et al., 2020). According to research done by Wuni & Shen, (2023) effective communication was assessed as the second most significant determinant of successful IPD in IBS projects. Another study done by Al-Aidrous et al. (2022) identified effective communication as one of top five best practices to implement IBS, and Yu et al. (2019), Nawi (2012) and Franz & Roberts (2022) also identified communication as one of the basic requirements for successful IPD implementation in IBS projects. The aforementioned reviews conclude that efficient communication is crucial for managing IBS stakeholders and members effectively, fostering cooperation to achieve shared benefits and project goals, and indirectly enhancing trust, respect, and knowledge among project team members.

2.19.23 Good Time Management on Design, Manufacture, Transportation and Installation.

Luo et al. (2020) defined IBS as the interconnected processes of production, transportation, and assembly, involving clients, manufacturers, transporters, contractors, and service providers, collaborating to convert resources, products, and components into the final IBS building. Therefore, this process demonstrated that in order to reduce defects and errors, IBS required complete integration of all systems and components into a whole building system utilising industrialised manufacturing, transportation, and assembly techniques (Wuni & Shen, 2020b). In addition, Wuni & Shen, (2020b) find that fourteen out of the fifty-five publications identified effective coordination and management of the IBS as a critical outcome area requiring management support in order to increase the success of IBS initiatives. El-Abidi et al. (2019) highlights the significance of efficient transportation management, which must focus on specifically addressing plan design, site layout, construction timeline, and plant cost. Contractors must also take into account ground conditions, site size, and the most ideal routes for installation. According to Ghanbari et al. (2023) and Walker et al. (2022) effective technology management assistance, such as BIM through IPD in IBS, offers contractors a unique chance to strategically prepare their execution methods and techniques before beginning a project. This system's virtual simulation features allow the entire IBS project team to interact and practice the execution sequence and project site management. Ultimately, the virtual simulation system improves the project's implementation. Discrepancies between the plan and its execution significantly impacted some IBS processes, resulting in unpredictable demand, excessive output, extended production time, disrupted transportation arrangements, and scheduling and cost issues (Luo et al., 2020). Therefore, when choosing IBS, it is critical to understand the substantial management and coordination needed before developing activities, such as coordinating design, transportation, tracking, and installation, in order to guarantee effective execution.

2.19.24 Early Involvement

Integrated Project Delivery (IPD) requires timely collaboration between the owner, designer, and contractor; additional stakeholders may be involved depending on the specific demands of the project (Rodrigues & Lindhard, 2023). According to Whang et al. (2019), the development of the IPD relied on the assumption that individual construction components would collaborate as an integrated unit from the outset of a single project, and its effectiveness is significantly more likely in a fully developed and experienced constructed environment. Research by AIA (2007) supports the above statement, demonstrating that involving critical stakeholders from the earliest stages of an integrated project enhances decision-making by leveraging the collective knowledge and expertise of all entities, particularly in the initial stages when well-informed choices yield the most significant outcomes. For example, in the context of IBS, it is critical to develop a detailed unit as soon as possible with all parties involved (Nduka et al., 2019). This process is done to minimise the chances of generating models that cannot be constructed effectively, thereby lowering the need for design modifications, enhancing the project timeline, and achieving cost savings in construction (Nawi, Lee, et al., 2014; Rashid et al., 2019). Wuni & Shen (2020b) and Al-Aidrous et al. (2022) highlight the significance of early project management in the IBS project life cycle, given that empirical data suggest that initial choices often determine the project's ultimate outcome. Thus, given early involvement from critical stakeholders and a concurrent approach to developing IPD contracts for IBS projects, ensuring a smoother and more efficient process is critical.

2.19.25 Planning and Schedule

The IPD method acknowledges that more planning effort leads to higher executional efficiency and cost savings (AIA, 2007). As a result, the goal is to significantly improve design outcomes rather than minimise design work, which expedites and shortens the much more costly building process through superior planning and shared risks and rewards (AIA, 2007; Ghanbari et al., 2023). According to Wuni & Shen (2023), through detailed planning and scheduling, the construction companies are able to forecast forthcoming project necessities, including inventory

management, resources, failure points, module demand, and production rate, through the use of detailed planning and scheduling. This procedure aids in the early reduction of supply chain waste, vulnerabilities, and risk sources, thereby averting substantial threats to the successful completion of the IBS project. The aforementioned claim is supported by a study conducted by Whang et al. (2019), which found that early project-stage intensive planning and scheduling improved supply chain management plans among important parties and identified design modifications and contentious aspects. This finding also aligns with other prior research conducted by Yu et al. (2019), Franz & Roberts (2022), Orozco et al. (2023), Al-Aidrous et al. (2022) and Rashid et al. (2019) which highlighted the significance of planning and scheduling in achieving effective Integrated Project Delivery (IPD) in IBS projects. Hence, strategic planning and scheduling in the first phases of a project are crucial, and it is clear that improvisation in IBS is not possible without substantial planning and scheduling.

2.19.26 Procurement Method

Wuni & Shen (2020b) and Abd. Rashid et al. (2019), emphasise that the procurement strategy is an essential factor to consider while implementing Industrialised Building Systems (IBS). Implementing IBS involves improving procurement management throughout the whole IBS process due to its divergence from traditional techniques, which require participation from all stakeholders from the beginning (Baharuddin et al., 2019; Kasim et al., 2019; Saad et al., 2022) The use of IPD procurement facilitated enhanced collaboration among project stakeholders and the seamless integration of manufacturers and suppliers into the project's decision-making process (Kahvandi et al., 2023; Wuni & Shen, 2020b). This IPD procurement technique also fosters a cooperative team capable of problem-solving, allowing collaboration between the team and the owner from the initial design phase to the project's successful completion, enhancing the project's progression, productivity, and efficacy. The study conducted by Yu et al. (2019) affirms that IPD is crucial for the success of a project as it establishes a contractual framework that guarantees mutual respect and trust. This finding supports the suggestion made by Nawi et al. (2019) that stakeholders should carefully choose the appropriate procurement type, such as IPD procurement, to be used throughout the IBS project. Whang et al. (2019) also found that IPD is the second most

important factor influencing IPD effectiveness, and recent research by Assaf et al. (2023) revealed that IPD ranked first among other procurement methods used in IIBS projects. Therefore, it is unsurprising that 13 papers referenced enhanced procurement techniques as a recommended approach for executing IBS projects, as shown in Table 2.8.

2.19.27 Standardisation

Standardisation can refer to components or products that are meticulously recorded in a methodical manner to guarantee consistent repetition throughout installation (Kasim et al., 2019). IBS becomes more intricate and challenging when the manufacturer does not implement standardisation of the IBS components (Jamalluddin et al., 2022). According to Nawi (2012) and Jabar et al. (2013), standardisation is a crucial factor in the successful implementation of IBS, as it ensures that the components are uniform and consistent. This is due to the fact that standard plans and component drawings are necessary for modular coordination to ensure the standardisation of all components, thereby facilitating the production process (Nawi, 2012). The aforementioned assertion was substantiated by Nduka et al. (2019) study, which revealed that design standardisation is a key determinant of success in the field of IBS. The reason for standardisation is a best practice in IBS is that it can enhance the productivity and proficiency of workers while simultaneously reducing costs (Abd. Rahsid, 2022; Al-Aidrous et al., 2022; L. Li et al., 2018; Saad et al., 2022). Scott et al. (2013) stated that the adoption of IPD in IBS led to the establishment of a standardised construction process for the project. This approach, which involves the active participation of the customer, designer, and contractor, has proven to be very efficient, particularly when combined with an off-site construction technique. When examining ways to promote integration inside an organisation, standardisation may play a crucial role by focusing on enhancing procedures and all aspects linked to them, such as communication and information exchange (Engebø et al., 2020). Integration among participants in a building project becomes much more complex when there is a lack of established protocols. Therefore, implementing standardisation in IBS projects improves project efficiency and promotes collaboration among construction stakeholders, leading to enhanced productivity and seamless team integration.

Standardisation is an essential factor that inevitably leads to prefabrication and mechanisation, eventually resulting in industrialisation and accelerated construction.

2.19.28 Teamwork

According to Alawag et al. (2023), teamwork is essential in the IBS construction project, as it improves project results, cultivates a positive attitude, and encourages good IBS implementation among team members. Employee integration relies on the essential elements of teamwork and dedication, which are vital for developing trust and effectively using relevant technologies (Yunus et al., 2017). Incorporating production core values into a team charter ensures that these values are in line with the team's objectives. This alignment facilitates faster decision-making and has the potential to enhance productivity (Abd Rashid, 2022; El-Abidi et al., 2019). For Mohsen Alawag et al. (2022), effective collaboration among team members is essential in construction projects, since it necessitates many exchanges and ensures effective teamwork. The significance of exceptional teamwork in fostering trust among team members, resulting in enduring and successful business partnerships. According to Kahvandi et al. (2020), Alinezhad et al. (2020) and Manata et al. (2018), successful teamwork is a fundamental element in IPD and implementing IPD strategies in IBS improves relationships by fostering more reliability, cooperation, and mutual respect (Whang et al., 2019). Teamwork in IPD provides many advantages to IBS, such as reduced communication obstacles, the establishment of a project culture based on relationships, and enhanced oversight of the team's tasks (Franz & Roberts, 2022). In conclusion, a lack of teamwork can result in project failures in the construction sector, demonstrating that teamwork is essential for improving construction quality, minimising resource waste, expediting project deadlines, and increasing customer satisfaction.

2.19.29 Supply Chain Management

Improving the supply chain management strategy among key partners in IBS from the design phase is crucial for successfully delivering IBS (Luo et al., 2020) (Whang et al., 2019). The successful completion of IBS projects faces challenges in collaborating with elements throughout the supply chain, potentially impacting project

implementation and delivery. A strategic integration among IBS stakeholders has been adopted to address the fragmented supply chain problem, potentially enhancing project implementation and delivery (El-Abidi et al., 2019). The integration of the supply chain by aligning with mutually agreed goals leads to the development of trust, the implementation of collaborative methods, the empowerment of participants, and the stimulation of learning (Engebø et al., 2020; Wisetsri et al., 2022). According to Wuni & Shen (2023), in order for IPD to be effective in IBS projects, it is crucial that all the interrelated activities of supply chain management be seamlessly integrated and coordinated. The key factors included in this list are: streamlined communication, cooperative procurement methods, enduring relationships, confidence among all parties involved in the supply chain, efficient utilisation of information and communication technologies, and centralised coordination via distributed task management. Nduka et al. (2019) and Wuni, Shen, & Osei-Kyei (2022) substantiated the aforementioned assertion, revealing that the supply chain is a key determinant of success in the field of IBS. The study emphasizes the importance of integrating IPD strategies for optimal performance in IBS construction projects due to their collaborative nature in the supply chain.

2.19.30 Better Coordination

The research conducted by Yunus et al. (2017) and Nduka et al. (2019) highlighted the significance of improved coordination as a crucial aspect in enhancing productivity in the manufacture of building components in the context of Industrialised Building Systems (IBS). The IBS project encompasses a wide range of stakeholders, including architects, designers, engineers, building authorities, manufacturers, suppliers, contractors, project managers, developers, and clients (Abd Rashid, 2022; Wuni, Shen, & Osei-Kyei, 2022) The efficacy of IPD in IBS depends on the efficient coordination and administration of all IBS stakeholders (Mohsen Alawag et al., 2022). BIM was utilised to coordinate activities in IPD for IBS projects (Yu et al., 2019). The implementation of BIM provides several benefits, including enabling practical cooperation and well-informed decision-making by using 3D modelling, resulting in financial savings and enhanced coordination (Ghanbari et al., 2023). García de Soto et al. (2022) stated that the various teams can also hold frequent meetings, whether online

or in person, to ensure effective coordination. By fostering advancement and minimising the number of corrective iterations, the improved coordination in IPD proved to be beneficial in terms of improving the overall performance of the IBS project.

2.19.31 Owner Competent

The IBS project owner's lack of competent, well-informed, and fair criteria may hinder the IBS project team's engagement, and in order to actively engage in project decision-making, the owner must possess a thorough understanding of the design and construction processes (Allison et al., 2018). Inexperienced owners might seek the guidance of consultants who have the necessary views and knowledge. Inexperienced IBS owners may seek the help of consultants in order to pick a team of competent, motivated, and aligned project participants for the Integrated Project Delivery (IPD) process. According to research by Pal & Nassarudin (2020) and Roy et al. (2018), the client must be willing to take risks and demonstrate competence. This allows the client to make adequate progress by taking appropriate actions at the right times (Erdem, 2021). An additional study conducted by Franz & Roberts (2022) indicated that the IBS client must possess competence in the distribution method, be knowledgeable about their preferences, exhibit action, and autonomously make any decisions. Franz & Roberts' (2022) additional study revealed that the owner must be proficient in the procurement method, have a clear understanding of their preferences, take action, and independently make all decisions. Hence, enhancing efficiency throughout the IPD-IBS procedure necessitates client competence, the use of a competent expert management team, efficient guidance from a specialist main contractor, and competent project participants.

2.19.32 Efficient and Experience Workforce

IPD is a method used in the construction industry that integrates people, systems, expertise, and past experiences to execute projects (Alinezhad et al., 2020), promotes the early sharing of knowledge and experience, and mandates active participation from IBS key stakeholders (Jayasena & Senevirathna, 2012). The selection

process for IBS stakeholders was based solely on the team's qualifications and experience, which included individuals with IBS and IPD experience (Al-Aidrous et al., 2022; Franz et al., 2017; Ghassemi & Becerik-Gerber, 2011). For example, manufacturers' involvement in IBS projects goes beyond product manufacture to project planning, design, management, and implementation, resulting in substantial knowledge and expertise when compared to the entire implementation required for IBS (El-Abidi et al., 2019). This meticulous method ensures the efficient and correct installation of components. Previous studies by Wuni & Shen (2023) also highlighted the necessity for construction organisations to enhance their production in the IBS process through an experienced workforce and technical capability. As a result, the client's role in improving the IBS entails hiring an experienced construction team, leveraging their experience in the construction phase, and employing external experts for both in-person and virtual IPD implementation.

2.19.33 Project Manager Leadership & Attitude

In the context of IPD, the project team operates as a distinct entity, comprised of individuals fully committed to accomplishing the team's goals and upholding its principles (Jayasena & Senevirathna, 2012). The most proficient team member often takes on the role of project manager, ensuring open communication and risk-taking without creating unnecessary obstacles (AIA, 2007). The IBS project manager is responsible for organising both on-site and off-site activities and successfully achieving project goals. In addition, the project manager must also oversee the overall construction schedule and shorten the duration of subsequent tasks (Li et al., 2018). Ghassemi & Becerik-Gerber (2011) stated that the majority of IBS stakeholders had assistance from their organisation and experienced robust guidance from their project manager's leadership during their construction phase. In addition, Larsen et al. (2016) found that the project manager's leadership style significantly affected the project's performance. According to Whang et al. (2019) research, if a project manager has both authorised leadership and a successful reference model, the project could succeed by using the IPD model in the construction sector within a short timeframe. Research done by Yee et al. (2017), Li et al. (2018), Yu et al. (2019), Nguyen (2019) and Franz & Roberts (2022) have also underscored the importance of project manager leadership in

the implementation of IPD in IBS. Therefore, it is crucial for a project manager to possess a positive attitude and demonstrate leadership skills in order to effectively make decisions and develop strategies that lead to exceptional performance on IBS projects.

2.19.34 Staff Qualification

According to Wuni, Shen, & Osei-Kyei (2022), success in a project including IBS depends upon the presence of adequate qualifications, specialised skills, and capacities among the interdisciplinary participants. For instance, a study conducted by Li et al. (2018) revealed that designers with sufficient qualifications in design standardisation can enhance both project constructability and construction speed. Similarly, research conducted by Zakaria et al. (2018) found that adequate qualifications and the industry experience of project leaders have a notable impact on project performance, owing to their superior decision-making abilities. In IBS, Integrated Project Delivery (IPD) allows architects, engineers, owners, and other stakeholders to collaborate effectively by combining their qualifications and actively engaging in all stages of the project in a coordinated manner (Ghanbari et al., 2023) and By using various management tools, IPD has the ability to include diverse forms of information, work processes, and activities within integrated project boundaries (Whang et al., 2019). Researchers Al-Aidrous et al. (2022), Baharuddin et al. (2019), El-Abidi et al. (2019), Perera et al. (2021) and Wuni & Shen (2020b) have also identified adequate qualification as an important factor for best practice in IPD for the IBS project. Therefore, the key project participants need to possess adequate qualifications and extensive expertise in order to successfully execute the IBS project with minimal faults.

2.19.35 Training and Education

IBS requires a greater degree of mechanisation both on and off-site, which in turn demands a higher level of education and training compared to traditional construction methods. Al-Aidrous et al. (2022) emphasised the need for comprehensive training to address the shortage of skilled IBS professionals. Government institutions primarily attribute this shortage to the insufficient duration and quality of their courses and training. The training of working groups is crucial for integrated project delivery

implementation (Kahvandi et al., 2020), and the project team must receive training on IBS before implementing it (Jing Le & Zainal, 2021) . The team gets ongoing training and development opportunities to keep up with the newest techniques and technology (Capuyan & Jocson, 2024). This intensive and constant training ensures that personnel comprehend new procedures and technology. It is also essential to emphasise continual development and provide training programmes to help workers improve their abilities in IPD and IBS practices (Kahvandi et al., 2023; Whang et al., 2019). A lack of monitoring proficiency would pose a threat to the IBS project and impede efforts to counteract it (Jamalluddin et al., 2022). A strong education and training program is essential, where continuous staff training helps solve problems and eliminate human error-related instructions. Lastly, such training and education may also assist professionals in adapting to broad changes, maximising opportunities, and appreciating their professional competence.

2.19.36 Continuous Improvement

According to Capuyan & Jocson (2024), the organisation is constantly improving its structure and implementing it in new initiatives, as well as recording best practices and lessons learned. The organisation integrates IPD concepts into standard operating procedures by applying the improved framework to new IBS projects, and the staff can stay up-to-date on the newest procedures through ongoing training and development opportunities. The establishment of continuous improvement in the administration of daily tasks is essential for personnel who are working towards the organisation's success, as it has the potential to result in increases in relationships with customers, innovation, and development in organisations (Alawag et al., 2022). El-Abidi et al. (2019) and Wuni, Shen, & Osei-Kyei (2022) have conducted research that demonstrates the high effectiveness of continuous improvement and learning as a best practice for IPD in IBS. Team members are required to actively engage in the continuous improvement process by implementing multiple small-scale improvements in their work area and improving the conditions of the building site using IPD in IBS (Le & Nguyen, 2022). This process should begin from the initial stage of the project (Whang et al., 2019). In order to guide the IBS project towards significant achievements, team members must incorporate the information they have obtained from

their continuous efforts to improve performance. This helps build a balanced approach to implementing IPD for IBS in terms of management and technology.

2.19.37 Personnel Working Attitude

Othman et al. (2016) states that an individual's personal working attitude refers to their level of preference or dislike towards work, and this characteristic has been recognised as a crucial element in establishing a completely integrated team in a construction project. A positive attitude has a substantial impact on decision-making and strategy development, leading to improved project performance (Zakaria et al., 2018) due to its influence on the characteristics of project tasks and the management of risks. A great personal working attitude in IBS projects involves team members who possess a strong commitment, motivation, and continuity (Yunus et al., 2017). It also requires a culture of openness to learn and a positive self-improvement attitude among project stakeholders (Nawi, 2012). The research conducted by Nasrun et al. (2017) shown that personal working attitudes play a crucial role in achieving effective IPD in IBS projects. As a result, all team members must prioritise maintaining a positive working attitude in order to mitigate the risk of project failure and avoid disputes among team members.

2.19.38 Key Decision

The strategy of IPD promotes the early involvement of IBS team members in collaborative key decision-making, target development and validation (Saad et al., 2022; Yu et al., 2019). This approach supports risk-sharing and the waiving of obligation among team members (Le & Nguyen, 2022). This factor has the advantage of instilling a sense of individual dedication to the project, which aids in fulfilling both task and team requirements (Engebø et al., 2020; Hamzeh et al., 2019). For example, the IBS team members actively engaged in the project at the earliest opportunity to facilitate efficient decision-making. They promptly resolved issues without any delay and implemented a systematic approach for managing change orders (Wuni & Shen, 2023; Yu et al., 2019). Both Kahvandi et al. (2023) and Whang et al. (2019) have mentioned that the process of making key decisions via collaborative discussion is an

essential factor in IBS project management. As a result of the key decisions made correctly by IBS stakeholders in the early phases of the IBS project, which can ultimately result in outcomes that are efficient in terms of time, quality, and cost.

2.19.39 Customer focus

The client plays a vital role in enabling the transformation of the construction sector via collaborative models or by establishing new IBS project and product needs (Mohsen Alawag et al., 2022; Peltokorpi et al., 2021). Rashidian et al. (2023) emphasise the importance of adaptability within the IBS team members in IPD to address client needs and potential modifications, such as having a team with different skills to create multiple alternative ideas in IBS projects, allowing the team to adjust to client expectations. Evans & Farrell (2023) outlined four essential elements for establishing robust customer relationships and providing solutions that are client-focused. These include: conducting thorough inquiries to accurately discern customer needs, organising tasks based on customer requests, following up with customers to ensure prompt resolution of issues, evaluating customer feedback and satisfaction against industry standards, and lastly, offering innovative ideas to meet future customer requirements. Through the study that Franz & Roberts (2022) and Yunus et al., (2017) has conducted, it has been determined that one of the best practices that must be taken into consideration in the IBS project is the customer's needs. Therefore, there is a need to change the use of outdated business models that don't incorporate customer-focused services. Due to its reliance on outdated financing mechanisms and asset dependence, this model leads to a lack of understanding of the customer's needs and goals.

2.19.40 Mutual Respect and Trust

IPD involves the collaboration of all project stakeholders, such as owners, designers, consultants, contractors, subcontractors, and suppliers, who work together to prioritise the project's success (AIA, 2007). Respect is a vital component of collaboration, as it promotes mutual respect and appreciation for each professional's contributions in situations where roles are not rigidly defined but rather assigned to the most qualified individual. Trust is also crucial for effective collaboration, and it is

nurtured through shared experiences and deliberate decision-making (AIA, 2014). According to Nawi et al. (2017), the establishment of a foundation of mutual respect and understanding throughout the project is a potent motivator for team members to fulfil their obligations. In an effort to cultivate a collaborative atmosphere that is predicated on shared values, expectations, and objectives, the IPD team has implemented an open mutual respect and trust for project finance, cost estimates, and accounting records (Nguyen, 2019; Yu et al., 2019) This mutual respect and trust in communication foster a collaborative work environment that enables disagreements to be resolved without confrontation among team members working on a project (Nawi, 2012). The integration centres on the empowerment of the IPD, a crucial step in fostering mutual respect and trust within the project team (Kahvandi et al., 2023). This mutual process at the project's inception serves as evidence that employer support can improve the quality of collaboration (Alinezhad et al., 2020). This best practice factor aims to enhance problem-solving by fostering transparency, mutual respect, and trust among employees, thereby minimising field coordination and construction time by promoting team collaboration and eliminating unnecessary work.

2.19.41 Close Relationship

The main advantage of IPD is its capacity to cultivate closer relationships among stakeholders, such as owners, designers, and contractors, therefore promoting long-term collaboration (Alinezhad et al., 2020; Ghassemi & Becerik-Gerber, 2011). De Marco & Karzouna (2018) and Nawi et al. (2017) concurred with the statement above, asserting that the Integrated Project Delivery (IPD) strategy is increasingly acknowledged as an effective approach that can reduce disputes among the stakeholders involved in construction projects, as compared to traditional contracting methods, and enhance the overall success of building projects. In addition, the close relationship between the effectiveness of an integrated team and team members' views of the work is crucial and significantly influences the team's growth process (Nawi, 2012). IBS necessitates a strong and close relationship with all parties involved from the first stage of project sequencing (Yusof et al., 2015), and by including all parties involved throughout every stage, it provides them with the chance to develop a relationship with the design prior to the actual engineering and manufacture of the IBS components (Wuni & Shen, 2023).

Nduka et al. (2019) and Wuni & Shen (2023) have also conducted research that demonstrates the close relationship among all parties as one of the best practices for IPD in IBS. Hence, establishing a close relationship is crucial in fostering trust and assurance among all parties in a project, ultimately resulting in enduring and successful business relationships.

2.20 Project Performance Factors

Anantatmula (2015) mention that to enhance project success, and it is crucial to establish a standard frame of reference for understanding project performance success. Different stakeholders may define project performance success differently, as each has unique criteria for what they consider success. This perception of success varies among individuals (Freeman & Beale, 1992) and across industries (Hartman & Ashrafi 1996). According to Vahidi & Greenwood (2009), the iron triangle concept, which comprises time, cost, and quality, is a valuable model for illustrating the implications of change for key project stakeholders. Furthermore, Fewings & Henjewele (2019) also stated that the essential elements of project performance, as defined by the International Project Management Association and the Chartered Institute of Building, include time, cost, and quality. These three elements are interconnected; changes to one can impact the others and affect overall project performance (Ibrahim et al., 2024).

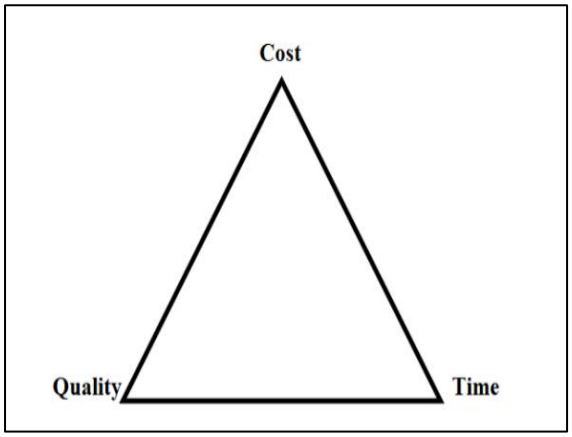


Figure 2.6 Iron Triangle by Fewings & Henjewele (2019)

Nevertheless, dependence exclusively on these factors has been inadequate for comprehensively encapsulating projects' complex nature and multifaceted dimensions (Głodziński, 2019; Ibrahim et al., 2024). Although cost, time, and quality are

traditionally referred to as the “iron triangle,” (Figure 2.6) numerous efforts have been undertaken to broaden this concept by incorporating additional elements, including environmental sustainability, customer satisfaction, integration, market-entry, safety, and benefits to the organization and stakeholders (De Carvalho & Rabechini Junior, 2015; Lindhard & Jesper, 2016; Williams et al., 2015). Project success is acknowledged as a complex condition, with different stakeholder groups often having varying perspectives on what constitutes success (Davis, 2014). Frequently, these additional elements aim to support long-term objectives that go beyond the immediate success of the current project or are naturally linked to one of the original elements. Therefore, this study uses project performance success measures, including time, cost, quality, and an additional element: integration. The selection of the integration element is based on the IPD concept, which integrates people, practices, strategy, and technology. This integration element assesses how the change impacts the relationship among the four key components of IPD.

2.20.1 Time

According to Aggor et al. (2019), project time is an essential factor in project performance, and it relates to the scheduling and timeline of a project, typically constrained by a defined completion date agenda. One of the most essential advantages of IBS construction methods is the reduction in construction time. Finishing projects more quickly speeds up the availability of essential housing units, lowers expenses, and enables developers to react to market demands more swiftly demands (Adeyemi et al., 2024). Ling (2004) identifies three key aspects of project time: enhancing construction speed, increasing delivery speed, and reducing schedule expansion. Project time overrun refers to the increase in the time required to complete a project compared to the initially planned timeline (Anuar & Ng, 2011). Generally, delays in recognising discrepancies in a project can lead to more severe consequences, making it more complicated and expensive to rectify the issues at hand. Masrom et al. (2013) also emphasised that alterations in design, materials, and the scope of work may constitute significant factors leading to time overruns. Parker & Skitmore (2005) suggest that shorter-duration projects can really benefit project managers. By leading and managing these projects from start to finish, they can help minimise performance impacts.

Kamaruddin et al., (2016) and Rahim et al., (2020) conducted a study proposing that implementing IBS would significantly reduce overall costs, substantially save time, and improve quality. IBS is becoming favoured over traditional site-based construction methods for many construction project categories. When conditions are favourable, effectively leveraging IBS can significantly improve project performance regarding time, cost, quality, safety, and sustainability (Wuni et al., 2020).

2.20.2 Cost

A cost budget must be set for every project. The variance between this budget and the project's actual cost is known as cost performance, a crucial element in project management (Park, 2009). Aggor et al. (2019) also, mention that a project's cost indicates the budget and resources allocated for its execution. This cost is typically constrained by the timeline associated with anticipated and delineated expenditures. Performance based on cost is crucial for clients and contractors because a project exceeding budget can diminish all parties' satisfaction (Masrom et al., 2013). One of the key advantages of IBS is its ability to lower overall costs significantly (CIDB, 2021b) and the cost-efficiency of these methods arises from several factors, including material savings, labour efficiencies, and the ability to streamline the construction process (Adeyemi et al., 2024). Labour efficiencies also significantly contribute to cost savings linked to IBS by transferring labour intensive tasks to a factory environment, enabling automation and streamlined processes (Subramanya et al., 2020). A study conducted by Kamaruddin et al., (2016), Rahim et al., (2020) and El-Abidi et al., (2019) has demonstrated that implementing an IBS would significantly reduce overall costs, save time, improve quality, and improve efficiency and long-term sustainability in maintenance.

2.20.3 Quality

While the success of project management is primarily centred on the processes involved and the achievement of financial and temporal objectives, product success pertains to the quality of the project's final deliverable and the quality objectives established for the project (Anuar & Ng, 2011). According to Ibrahim et al. (2024)

quality indicates the degree of excellence or compliance with the specifications anticipated from the project's deliverables. Research conducted by Ali et al., (2013) and Demirkesen & Ozorhon, (2017) underscored that the quality of work is one of the most critical attributes for measuring project performance. The final product's quality affects both client and contractor satisfaction. Construction projects are typically regarded as successful when finished to a satisfactory quality standard (Masrom et al., 2013). It was stated by Rahim et al., (2020), the primary potential enhancements stemming from adopting IBS include increased productivity and improved quality in construction projects. This is because the IBS component is manufactured in a controlled environment, at the site or factory.

2.20.4 Integration

In recent years, consumer satisfaction and integration among construction stakeholders have become additional factors for evaluating project success (Williams et al., 2015). In their study, Cserháti & Szabó (2014) concluded that the factors contributing to successful integration encompassed communication, collaboration, and project leadership. Furthermore, Mir & Pinnington (2014) identified that inter-organisational integration served as a significant determinant of success in numerous projects. Likewise, Zou et al. (2014) determined that effective management of client integration leads to enhanced project performance, despite variations in the relationship between the client and the project throughout its stages. The integration of IBS stakeholders into the project unites diverse skills and expertise, breaking down conventional barriers between design and construction responsibilities, which enhances effective and efficient project delivery (Jaffar & Lee, 2020). The integration of IPD in IBS enables all construction parties to collaborate and coordinate from design to construction (Liyana et al., 2018). Additionally, modern technologies like BIM can enhance collaboration among IBS stakeholders and facilitate the discovery of project solutions to minimise the risk from the problem rise in future (Durdyev et al., 2020). Finally, several research papers have examined process integration and emphasised its value in enhancing project management effectiveness (Demirkesen & Ozorhon, 2017; Enberg, 2012).

2.21 Chapter Summary

IBS, which was introduced long ago into the Malaysian construction industry, is still regarded as unsuccessful in terms of its implementation. The most prevalent choice of IBS components, precast concrete systems, has been utilised in Malaysia since the 1960s. Consequently, the Malaysian government, through the Construction Industry Development Board (CIDB), has exerted significant efforts to improve the adoption of IBS within the construction sector. However, one of the key barriers to the poor implementation of IBS in the Malaysian construction industry has been identified as integration issues. These barriers are not limited to contractors alone but also involve IBS manufacturers, suppliers, clients, and consultants. IPD was introduced by the American Institute of Architects (AIA) in 2007 as a project delivery method that integrates people, systems, business structures, and practices into a collaborative process that optimises efficiency throughout all phases of design, fabrication, and construction. Implementing the IPD approach has fostered a positive work environment built on collaboration, trust, and respect. This shift has improved problem-solving and reduced a culture that focuses on blame. Collaboration is further strengthened by focusing on shared project goals rather than individual achievements. In this study, the forty-one (41) best practices were identified as the minimum required for IPD in IBS. The list was then filtered based on frequency of occurrence, with all items listed in Table 2.6 selected for further investigation. The IBS project performances, which include time, cost, quality, and integration, were also assessed in this study.

Figure 2.7 displays the items of IPD best practices and the IBS project performance. The next chapter, Chapter 3, outlines the research conceptual framework and hypotheses for this study.

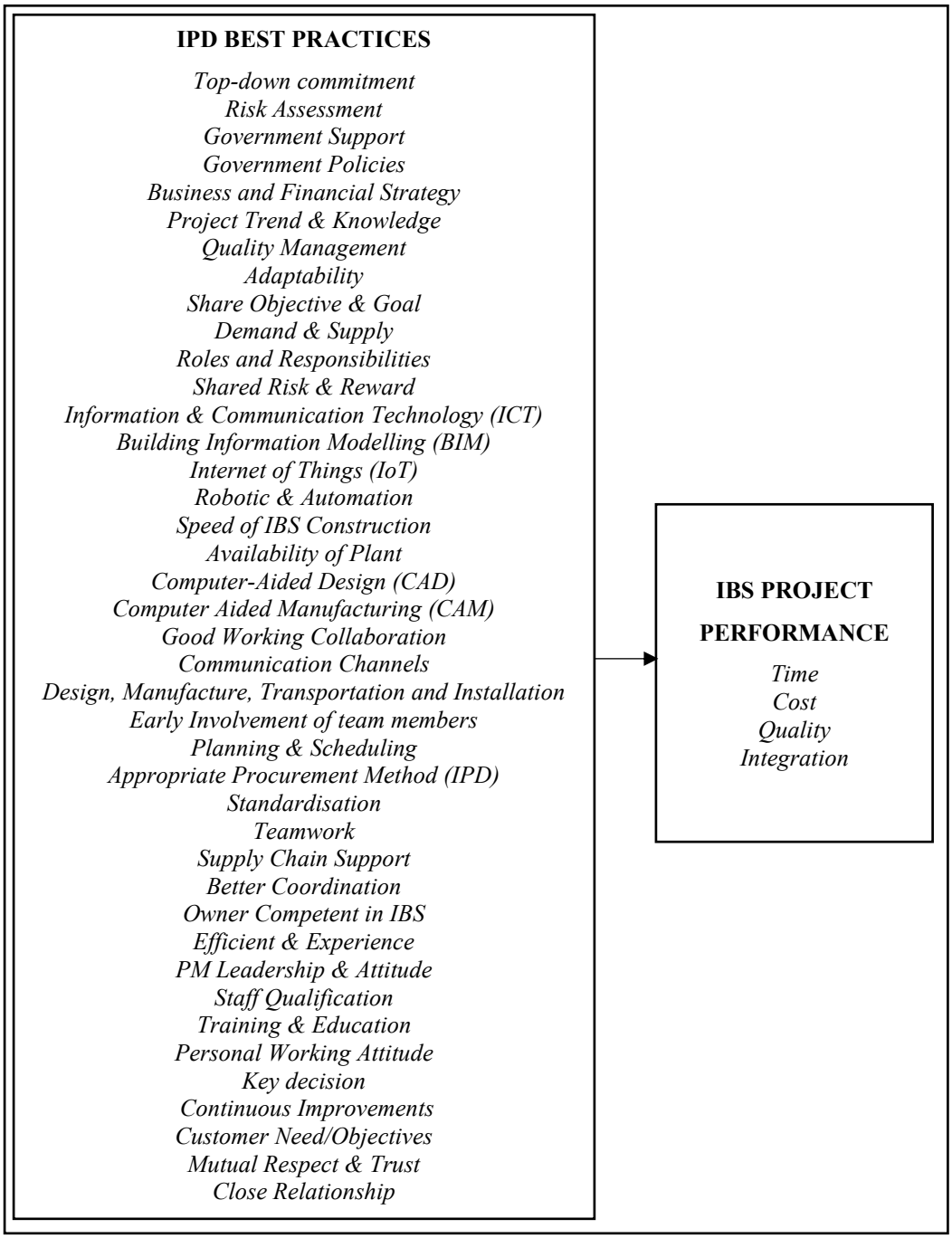


Figure 2.7 IPD Best Practices and The IBS Project Performance

CHAPTER 3
RESEARCH CONCEPTUAL FRAMEWORK AND HYPOTHESIS

3.1 Introduction

This chapter provides an overview of the theories and topics that are examined throughout the study. The purpose of the discussion in this chapter is to provide evidence and justification for the conceptual framework and hypotheses. The research's conceptual framework revealed that the IPD BPs influenced the project performance in IBS. The construction of this conceptual framework was founded upon a modified version of Leavitt's Diamond Theory (1965). Therefore, four relationships have been identified, comprising four primary relationships. A summary is provided at the conclusion of the chapter.

3.2 Underpinning Theory

According to Iyamu (2013) the underpinning theories provide guidance for researchers throughout the process of collecting and analysing data, ensuring thoroughness and preventing mistakes. By offering a symmetrical sequence, they ensure a comprehensive and gap-free study, therefore enhancing the overall quality of the research. The underpinning theories also help researchers identify the factors that have an impact on either development or implementation in their study (Mkhomazi & Iyamu, 2013). As a result, the theories that underpin studies do not make predictions about the outcomes of the studies; rather, they improve our understanding of the situations by providing reasons for why things are happening in a certain way.

A change management model serves as a compass that can facilitate or lead change efforts by determining the specific processes and steps to follow, by illustrating the various factors influencing change, or by determining the levers used to succeed in the change management process (Errida & Lotfi, 2021; Parry et al., 2014; Stouten & Rousseau, 2018).

Scholars have developed multiple organisational design frameworks to help managers with the task of organisational analysis. With regards to this study, three underpinning theories were evaluated to identify the suitability of the research context

due to the researcher's conceptual framework based on change management models that outline the variables and success factors/best practices that impact organisational performance and the success of organisational change projects. There are Burke-Litwin Causal Model (Burke & Litwin, 1992), Nadler and Tushman's congruence model (Nadler & Tushman, 1980), McKinsey 7-S framework (Waterman & Peters, 1980), and Leavitt's Diamond Theory (Leavitt, 1965).

3.2.1 Burke-Litwin Causal Model

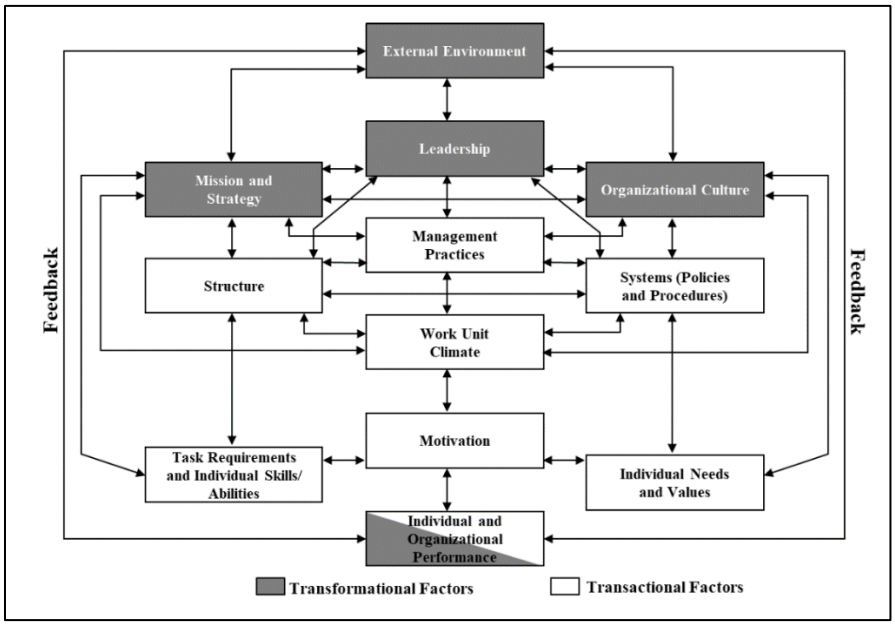


Figure 3.1 Burke-Litwin Model by Hilling (2020)

The Burke-Litwin model (Figure 3.1), also referred to as the Causal Model of Organisational Change and Performance, is a comprehensive framework that elucidates the emergence and progression of change within an organisation (Burke & Litwin, 1992). It accomplishes this by analysing the interplay between various factors and their impact on generating change (Archibong & Ibrahim, 2021; Soyka, 2023), as well as the manner in which change permeates throughout the organisation (Erdem, 2021). The Burke-Litwin model comprises twelve boxes, each containing a factor that facilitates the comprehension and planning of organisational change (Figure 3.1). The eleven factors encompass the external environment, strategy and mission, organisational culture, leadership, organisational structure, management practices, systems, work unit

climate, task and individual skills, individual needs and values, and motivation. These factors have a substantial impact on the final factor, which is both individual and organisational performance. According to Figure 3.1, the model integrates the transformational elements of change in the top section of the graph and the transactional elements of change in the lower section of the graph (Burke & Litwin, 1992). The upper section of the model emphasises leadership, whereas the lower section mainly encompasses management (Burke, 2008; Erdem, 2021). Transactional change necessitates managers to enhance the organisation, but transformational change necessitates leaders to integrate their mission as leaders in change with the organisation's mission (Burke, 2008). The elements of the external environment, including consumer behaviour, market conditions, political situations, and the international economy, contribute to the organisation's input, and on the other hand, the organisation's performance is represented by its output (Burke, 2008; Burke & Litwin, 1992). The feedback loop in the illustration demonstrates a constant interaction between the input and output components. The model is adorned with arrows on both ends of the lines to symbolise the two-direction connection, and the reciprocal nature of this connection implies that any alteration in a single factor ultimately impacts the entirety of the organisation (Hilling, 2020). Therefore, the Burke-Litwin model underlines the significance of transformational factors positioned at the uppermost level of the model, such as mission and strategy, leadership, and organisational culture. These factors need thorough preparation and integration since they have a significant impact on transactional factors and individual and organisational performance.

3.2.2 Nadler and Tushman's Congruence Model

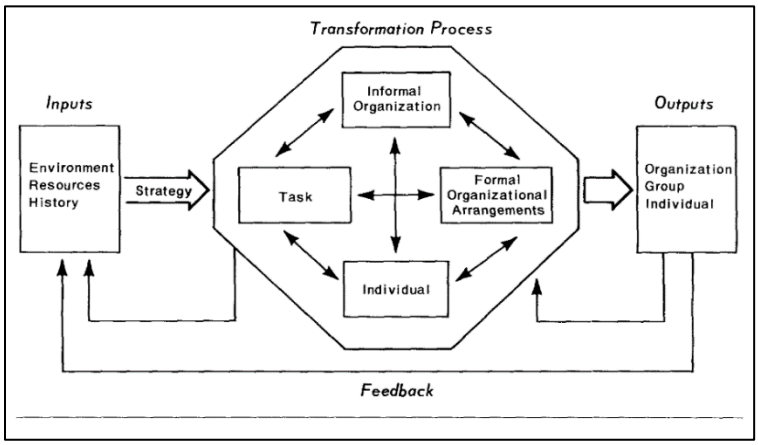


Figure 3.2The Congruence Model by Nadler & Tushman (1980)

According to Nadler & Tushman (1980, 1989), congruence is 'the degree to which the needs, demands, goals, objectives, and/or structures of one component are consistent with those of the other'. The model (Figure 3.2) elucidates the process by which both internal and external inputs are converted into outputs, with particular emphasis on the unique circumstances of an organisation (Pin & Shavarebi, 2021). According to Nadler & Tushman (1980), Leavitt's Diamond Theory's four main components form the foundation of this model. The identification of the model in figure 3.2 showed that it comprises two fundamental components, namely strategy and organisation. The strategy aims to achieve external congruence by creating a plan that aligns with the evolving external environment over time (Ando, 2023; Bezboruah, 2008) and an organisation enables the transformation of strategy into evident outcomes (Ando, 2023). An organisation comprises four core elements encompasses four key elements: work, individuals, formal organisation (structures), and informal organisation (culture). Organisational transformation is essential when there are substantial discrepancies between external and internal congruences among the four key elements, prompting management to investigate the underlying causes and propose new options for resolution to achieve desired outcomes (Ando, 2023; Bezboruah, 2008; Errida & Lotfi, 2021; Nadler & Tushman, 1980, 1989; Pin & Shavarebi, 2021) Thus, the higher the level of congruence among these key elements, the greater the organisational performance, as they are all dependent upon each other.

3.2.3 McKinsey 7Ss Model

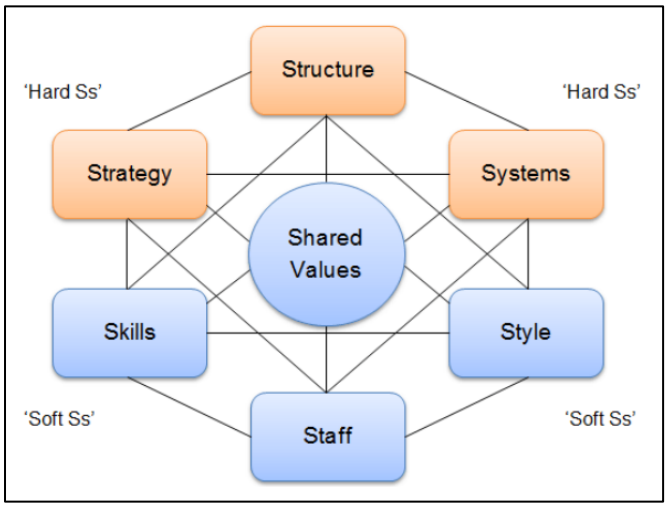


Figure 3.3 McKinsey 7Ss Model by Ravanfar, (2015)

The McKinsey 7Ss Model (Figure 3.3), developed by Waterman et al. (1980), is a model for assessing organisational effectiveness by examining seven interconnected elements: strategy, structure, systems, staff, style, skills, and shared values (Errida & Lotfi, 2021; Salvarli & Kayiskan, 2018). The first element is strategy, a carefully devised plan created by a company to attain long-term competitive advantage and effectively compete in the market; structure refers to the arrangement of company divisions and units; systems refer to the established methods and protocols that a corporation follows in its operations; skills refer to the actual expertise and capabilities possessed by the people employed by the organisation; staff refers to the different kinds of individuals within an organisation; style refers to the management style and culture of the organisation, and the last one is shared values are the underlying set of values that are generally shared within the organisation and act as guiding principles for what is considered important (Chong & Preece, 2014; Kaplan, 2005; Meijuan & Jiangdi, 2020; Ravanfar, 2015). The model highlights the significance of shared values in the central as the basis for all organisational operations, emphasising the interdependence of all elements (Demir & Kocaoglu, 2019; Keček et al., 2023). According to Crespo, (2018) the seven elements can be categorised into hard Ss and soft Ss, with hard elements being strategy, structure, and system, and soft elements consisting of common values, skills, staff, and style. Both hard and soft Ss are equally vital to organisations, and only when these elements are successfully integrated with each other can

organisations achieve growth and achievements. Therefore, the alteration of each element must be properly strategised as it results in a modification of all remaining elements.

3.2.4 Leavitt's Diamond Theory

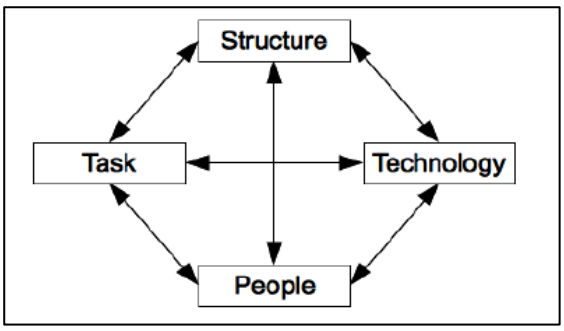


Figure 3.4 Leavitt's Diamond Model by Leavitt (1965)

Implementing change in an organisation necessitates an integrated approach because of its interrelated nature, which can result in both anticipated and unanticipated effects (Coffie et al., 2018). Therefore, careful consideration of all areas is essential to ensure successful implementation. Leavitt's diamond model (Figure 3.4) was established in 1965 by Harold J. Leavitt to examine the comprehensive impacts on an organisation when changes occur (Liao & Teo, 2019). His model, often referred to as Leavitt's Alignment Model or Leavitt's System Model, emphasises the symbiotic relationship among these components, asserting that one modification inevitably precipitates adjustments in the others (Aristovnik et al., 2024).

According to Hau & Chang (2021) Leavitt's diamond model is a commonly employed theoretical framework for examining the influence of new change on an organisation. It does so by assessing how the change affects the interconnections among the organisation's four key elements: technology, people, structure, and task. The Leavitt's diamond model consists of four elements: structure, tasks, technology, and people. Hupperz et al. (2021) and Liao & Teo (2019) indication that structure refers to the authority system, communication systems, and task composition. Tasks encompass all functions that generate value, while technology includes hardware and applications (Coffie et al., 2018). People refer to human resources within an organisation who perform tasks (Hau & Chang, 2021). The diamond configuration of the model is shown

in Figure 3.4 highlights the interconnectedness among the four elements, wherein alterations in one element have an impact on the other elements and consequently on the organisation (Aristovnik et al., 2024; Coffie et al., 2018; Havířová, 2021; Liao & Teo, 2019; Yousefzadeh et al., 2023). Hence, in accordance with Leavitt's diamond model, the project team needs to recognise that greater organisational change success could be achieved through the interaction and integration of the four critical elements, as opposed to their separation.

Lyytinen & Newman (2008) asserted that Leavitt's model's four-element categorisation is commendable due to its simplicity, comprehensiveness, and clear definition. This model embodies a comprehensive approach to accomplishing systematic or organisational shifts spanning many different areas (Yousefzadeh et al., 2023). For example, Ivanov, (2024) improved the theory with the management, scope and modelling element; while other studies have also included cost and factory element (Musa, Mohammad, et al., 2016). Over time, Leavitt's Diamond Theory has been widely recognised and applied in previous studies on IBS (Abd Rashid, 2022; Hamid et al., 2011; Haron, 2013; Kamar, 2011; Musa et al., 2017; Musa, Mohammad, et al., 2016; Nawi, 2012; Ruikar et al., 2006) in novel and critical ways. The alterations made to the terminology of key elements (refer to Table 3.1) were perceived as revisions to Leavitt's theory that incorporated modern concepts, rather than as modifications to the original theory's meaning.

Table 3.1
Terminology of Key Elements for Leavitt's Diamond, Modified Leavitt's Diamond and IPD.

Leavitt's Diamond Model	**Modified Leavitt's Diamond Model**	**Integrated Project Delivery**
People	People	People
Task	Practice	Practice
Structure	Strategy	Business Structure
Technology	Technology	System

Consequently, this study used the terminology of key elements: people, practice, strategy, and technology. This study is supported by a model of Leavitt's Diamond Theory, as numerous prior studies have utilised the diamond model as the foundational

framework for their investigations on IBS. Additionally, IPD is a project delivery method that integrates peoples, practices, business structures, and systems throughout the entirety of the design, fabrication, and construction processes. This is comparable to the four key elements of Leavitt's diamond model: people, task, structure, and technology. It has also been discovered that Leavitt's diamond model serves as a foundational model for other well-known models or theories of change management, such as the Congruence Model (Nadler & Tushman, 1980), McKinsey 7Ss Model, and the Burke-Litwin Model (Vrcelj & Karabašević, 2022). This model asserts that every alteration in one element has a ripple effect on all other elements, necessitating equilibrium among every key element in the model. Therefore, Leavitt's diamond model, a long-standing framework that has been in existence for over six decades, is selected due to its strong basis for analysing the correlation between the best practices of IPD in the field of IBS and project performances.

3.3 The Development of Conceptual Framework

According to Tamene (2016), a conceptual framework is a set of interconnected assumptions, expectations, and ideas that serves as a guiding structure for research and plays a crucial role in study design. It serves as a guiding tool for both the researcher and the reader, offering a valuable understanding of the research process and its results. For Varpio et al. (2020), the conceptual framework is a study that describes the current state of knowledge, identifies gaps in understanding a phenomenon or problem, and outlines the methodology of the research project. Therefore, a conceptual framework is developed from the ideas or notions that the researcher has regarding the current topic. Maxwell (2013) stated that the conceptual framework integrates elements derived from external sources, but the researcher is responsible for constructing the overall structure and coherence, rather than relying on an already existing framework. For the reader, a conceptual framework facilitates readers' comprehension of a researcher's rationale for exploring a particular subject, underlying assumptions, methodology, engagement with other scholars, and divergences from existing viewpoints (Tamene, 2016).

This research examines the current literature review in IPD and IBS, including theories, concepts, and methodologies. It identifies the important best practices for IPD and IBS, focusing on four key elements: strategy, practice, people and technology based

on the Leavitt diamond model (Figure 3.4). In this research, the term "strategy" pertains to the fundamental framework of an organisation. The strategy encompasses decision-making, direction of organisation, various levels of organisational structure, multiple divisions, designated positions and duties, the organisation's/project's objectives, and the business/financial strategy (Coffie et al., 2018; Mani et al., 2024). Regarding the "practices", it refers to the actions being carried out by team members to complete the works (Hau & Chang, 2021). Furthermore, the process encompasses procurement, coordination among team members, project operations, and other related activities. The term "people" in this study encompasses personnel and human aspects, including work attitude, accountability, organisation, and leadership (Hupperz et al., 2021). The composition of a project team is contingent upon the capabilities, performance, expertise, and proficiencies of its employees. Finally, the implementation of best practices must be accompanied by the utilisation of advanced "technology". Technology enhances the performance of team members and practices in task execution (Aristovnik et al., 2024; Liao & Teo, 2019). Technology is considered a suitable medium or tool for enhancing team integration, facilitating the coordination of all project information and operations as an integrated team.

These key elements are aligned with the IPD definition that integrates peoples, systems, business structures, and practices to collectively utilise the skills and knowledge of all participants in order to optimise project outcomes, enhance value for the owner, minimise inefficiencies, and maximise efficiency throughout the design, fabrication, and construction stages (AIA, 2007). Table 3.2 below lists several researchers who have incorporated the best practices elements of people, technology, strategy/structure, practice/process, and others into their studies. Previous outcomes of best practices from past researchers served as a guide for this study to categorise the best practices within each element, and were validated by an expert panel. After evaluating several previous literature studies on best practice elements, a novel conceptual framework was developed, as illustrated in Figure 3.5 below.

Table 3.2
Best Practice Elements

No.	Author/Year	Best Practice Elements						
		Structure/ Strategy	People	Process/ Practice	Technology	Cost	Factory	Project
1	(Ruikar et al., 2006)	x	x	x	x			
2	(Nadim & Goulding, 2011)		x	x	x			
3	(Kamar, 2011)	x	x	x	x			
4	(Hamid et al., 2011)	x	x	x				
5	(Nawi, 2012)		x	x	x			
6	(Haron, 2013)	x	x	x	x			
7	(Musa, Mohammad, et al., 2016)	x	x	x	x	x	x	
8	(Musa et al., 2017)		x	x	x			
9	(Kouch et al., 2018)	x	x	x	x			
10	(Akunyumu et al., 2021)		x	x	x			x

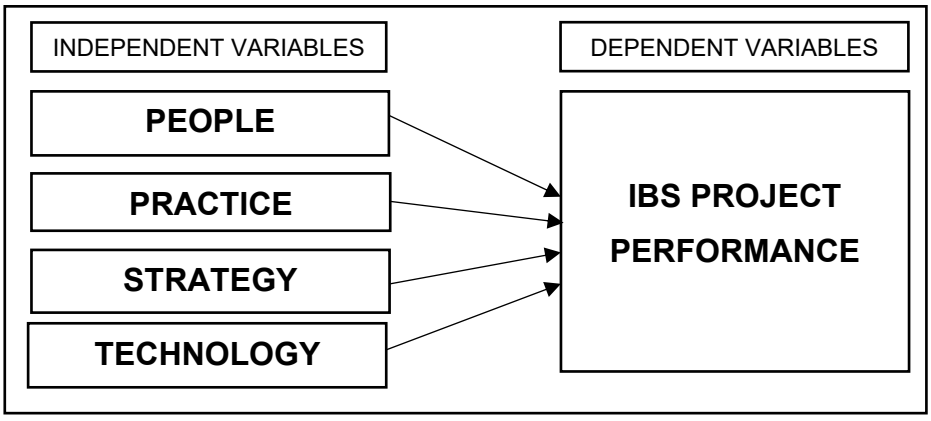


Figure 3.5 Proposed Conceptual Framework

3.4 Proposed Research Hypothesis Development

This study used a proposed conceptual framework, as illustrated in Figure 3.6, to investigate the influence of four key elements of best practice (referred to as BPs) on the conceptual models. The framework's critical independent variables (IV) are the strategy, technology, practice, and people. The dependent variable (DV) refers to the measure of project performance in the field of IBS. To evaluate this study model, the researcher created and verified measuring instruments for four key elements and forty-three sub-elements. The sub-elements were divided into four main elements based on previous research and validated by expert panels during the pretesting stage before the questionnaire was distributed to respondents. Table 3.3 presents the key elements and number of items measured for this study, as outlined in the conceptual framework.

Table 3.3
The Number of Items Measured for Each Construct

Code	Name of Element	Variable Type	Number of Items Measured
H	People	IV	11
P	Practice	IV	11
S	Strategy	IV	12
T	Technology	IV	9
PM	Project Performance	DV	4

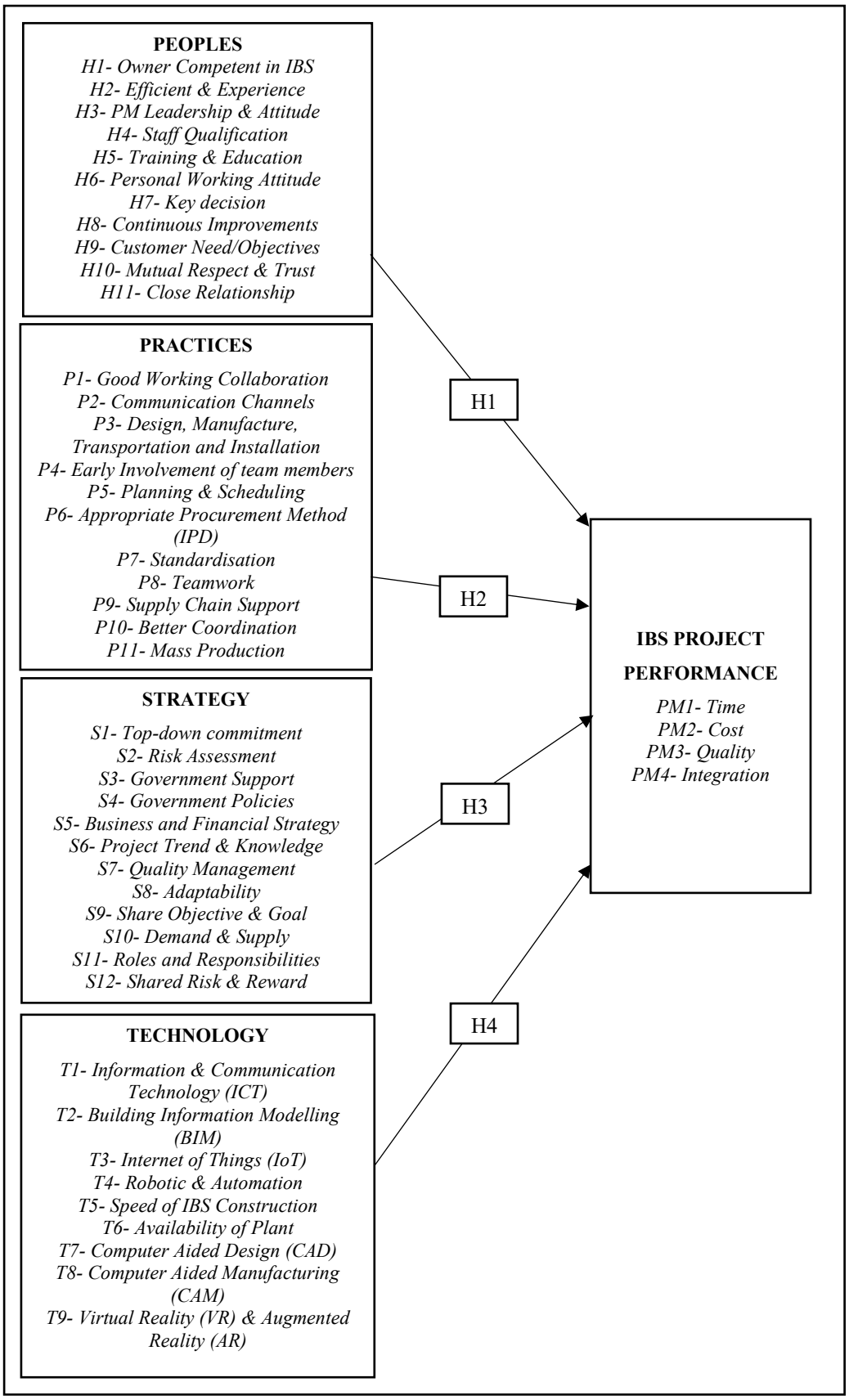


Figure 3.6 Proposed Conceptual Framework and Hypothesis Relationship

Additionally, this research proposes four research hypotheses to investigate the causal relationships within the research framework.

3.4.1 Hypothesis 1 – People and IBS Project Performance

As mentioned previously, this study suggests that a stronger emphasis on people has a more substantial impact on IBS's project performance. Consequently, research by Pal & Nassarudin (2020) and Roy et al. (2018) mentions that the clients must take risks and demonstrate competence. This allows the clients to progress effectively by taking appropriate actions at the right times (Erdem, 2021). The selection process for IBS stakeholders was based solely on the team's qualifications and experience, which included individuals with IBS and IPD experience (Al-Aidrous et al., 2022; Franz et al., 2017; Ghassemi & Becerik-Gerber, 2011). For example, manufacturers' involvement in IBS projects goes beyond product manufacture to project planning, design, management, and implementation, resulting in substantial knowledge and expertise compared to the implementation required for IBS (El-Abidi et al., 2019). In addition, Larsen et al. (2016) found that the project manager's leadership style had a significant impact on the project's performance. According to research by Whang et al. (2019), if a project manager has both authorised leadership and a successful reference model, the project could succeed using the IPD model in the construction sector within a short timeframe. Additionally, in IPD, architects, engineers, owners, and other stakeholders can collaborate effectively by combining their expertise and actively engaging in all project stages in a coordinated manner (Ghanbari et al., 2023). Using various management tools, IPD can include diverse forms of information, work processes, and activities within integrated project boundaries (Whang et al., 2019). It is also essential to emphasise continual development and provide training programmes to help workers improve their abilities in IPD and IBS practices (Kahvandi et al., 2023; Whang et al., 2019). El-Abidi et al. (2019) and Wuni, Shen, and Osei-Kyei (2022) have conducted research demonstrating the high effectiveness of continuous improvement and learning as a best practice for IPD in IBS. Nevertheless, a positive attitude has a substantial impact on decision-making and strategy development, leading to improved project performance (Zakaria et al., 2018). Kahvandi et al. (2023) and Whang et al. (2019) have mentioned that making key decisions via collaborative discussion is essential to IBS

project management. Through the studies by Franz & Roberts (2022) and Yunus et al. (2017), it has been determined that one of the best practices to consider in the IBS project is meeting the customer's needs. According to Nasrun et al. (2017), establishing a foundation of mutual respect and understanding throughout the project is a potent motivator for team members to fulfil their obligations. De Marco & Karzouna (2018) and Nawi et al. (2017) assert that the IPD strategy is increasingly acknowledged as a practical approach that can reduce disputes among the stakeholders involved in construction projects, as compared to traditional contracting methods, and enhance the overall success of building projects. Therefore, as stipulated in past studies, a similar finding is expected to happen in the relationship between people and performances in the present research context. Thus, it is hypothesised that:

H1: There is a significant positive relationship between people and the IBS project performance.

3.4.2 Hypothesis 2 – Practice and IBS Project Performance

A study conducted by Wuni, Shen, and Osei-Kyei (2022) found that effective collaboration and integration among key stakeholders in an IBS project, facilitated through IPD, lead to a better understanding and alignment with the project's planning, objectives, and benefits. Effective communication, as assessed by Wuni & Shen (2023), was found to be the second most significant determinant of successful IPD in IBS projects (Wuni & Shen, 2023). It plays a crucial role in avoiding mismatches between the plan and its implementation, which can lead to uncertain demand for IBS components, overproduction, long lead times in the factory, disrupted transportation schemes, and schedule and cost problems (Luo et al., 2020). In the context of IBS, early planning is critical. As Nduka et al. (2019) suggest, it is essential to develop a detailed unit as soon as possible, with all parties involved. The IPD model also emphasises early planning and design to address potential challenges and optimise project performance proactively (Ghanbari et al., 2023). Furthermore, using IPD procurement facilitated enhanced collaboration and performance among project stakeholders, as well as the seamless integration of manufacturers and suppliers into the project's decision-making process (Kahvandi et al., 2023; Wuni & Shen, 2020b). Scott et al. (2013) stated that adopting IPD in IBS established a standardised project construction process. This

approach, which involves the active participation of the customer, designer, and contractor, has proven to be very efficient, particularly when combined with an off-site construction technique. Teamwork is a well-known factor for the success of projects and organisations. In the context of IBS construction projects, it is essential. As Alawag et al. (2023) point out, teamwork among IPD stakeholders contributes significantly to improving project outcomes, fostering the correct mindset, and inspiring each team member to ensure effective IBS adoption. According to Capuyan and Jocson (2024), the collaborative nature of IPD contributes to enhanced supply chain effectiveness, resulting in improved project performance. This finding highlights the crucial role of the supply chain in IPD in achieving optimal performance in IBS projects. Therefore, to successfully implement IPD in IBS, careful attention to detail for each practice's best practices is necessary. Concerning the above argument, the following hypothesis is proposed:

H2: There is a significant positive relationship between practice and the IBS project performance.

3.4.3 Hypothesis 3 – Strategy and IBS Project Performances

Previous studies have found significant empirical strategies and IBS performances. For instance, El-Abidi et al. (2019) stated that top management support needs to be obtained by contractors, and their business model must aligned with the companies' vision and mission related to IBS. Identifying the risks and their potential effects of using IPD in constructing industrialised buildings can help practitioners adopt adequate risk management methods to respond to risks and assist the organisation in developing a suitable strategy that can enhance the widespread use of IPD in IBS (Abd Rashid, 2022). Additionally, the government's role as a major client in the construction industry makes government policy a significant factor in driving the adoption of new techniques and goods in this sector (El-Abidi et al., 2019; Lou & Kamar, 2012). According to the findings of Hall et al. (2022), if these construction organisations can achieve greater efficiency by adopting IBS and IPD business structure models, they have the potential to progress from lower-value projects to more complex projects. Furthermore, Wuni & Shen (2020) mention that understanding changing project trends and knowledge is required for the adoption of IBS and IPD to maintain the viability of

organisations in the industry. The quality management system in IPD can also be utilised to integrate construction professionals and government agencies into the process of identifying key areas where the quality of an IBS project may be affected (Mohsen Alawag et al., 2022). Other than that, the adaptability of IPD in the context of IBS is crucial for organisational business structures to maintain resilience in a construction market filled with uncertainty (Orozco et al., 2023). IPD engaged all levels of project parties in IBS to establish a shared understanding of objectives and goals within the team and committed to the project (Franz et al., 2017; Franz & Roberts, 2022; Wuni, Shen, & Darko, 2022). The key parties in IPD play essential roles that impact the IBS project's relational capability, as well as its stability and relational depth (Steinhardt et al., 2020). One of the best practices for achieving success in IPD is implementing a "shared reward and risk". Thus, an effectively designed risk and reward strategy in a business structure is crucial for promoting collaboration among the involved IBS parties, regardless of whether the project is on or exceeds the goal cost (Hamzeh et al., 2019). Therefore, to successfully implement IPD in IBS, careful attention to detail is necessary to ensure each strategy's best practices are followed. Concerning the above argument, the following hypothesis is proposed:

H3: There is a significant positive relationship between strategy and the IBS project performance.

3.4.4 Hypothesis 4 – Technology and IBS Project Performances

The relationship between technology and IBS performance has shown significant findings. According to Li et al. (2018), Nasrun et al. (2017), and Wuni & Shen (2020b), utilising Building Information Modelling (BIM) can enhance design sharing, visualisation, robustness, flexibility, and system integration, potentially enhancing the overall success of the IBS project. The synergy of BIM and IoT is beneficial and efficient because it extends the traditional methods of gathering and mapping data from a construction project into the BIM model. This integration should include not only the visualisation of semantic information within the BIM model but also its analysis in the context of existing objects, including mechanisms (Shkundalov & Vilutienė, 2021). Additionally, the various ICT management solutions for IPD within IBS integrate diverse information, work processes, and activities (Whang et al., 2019).

The current technology in IBS, utilising robotics and automation, also enhances safety, quality, and productivity, thereby improving overall construction efficiency (Abd. Rashid, 2022). IBS-IPD projects have experienced reduced changes, increased speed of performance, and dramatically decreased project delivery time (Kahvandi et al., 2017). According to Akinradewo et al. (2021), the importance of CAD in achieving better-quality project delivery and cost-effective life-cycle management is emphasised, while Verma et al. (2006) also support these benefits. The integration of technology through CAD and CAM and construction automation in IBS enables the digitisation of design, delivery, and project management, both on-site and off-site. This integration eliminates the need for coordination stages involved in passing over shop drawings to craftsmen, resulting in time and effort savings (M. S. Ng & Hall, 2019). Wuni, Shen, and Darko (2022) stated that utilising technologies like VR and AR can enable collaborative IBS team members and key stakeholders to access accurate and interactive digital representations of the project, thereby improving decision-making processes in IPD (Hwang et al., 2020). To successfully implement IPD in IBS, it is crucial to pay close attention to detail, ensuring that the best practices of each technology are followed. Based on this argument, the following hypothesis is proposed:

H4: There is a significant positive relationship between technology and the IBS project performance.

3.5 Chapter Summary

This chapter explores the research framework, underlying theory, and development of related hypotheses. This research presents a conceptual framework, as illustrated in Figure 3.6, to assess the impact of four key elements on the performance of the IBS project. Consequently, four hypotheses are proposed to investigate the significant relationships between these constructs. Each construct is represented by its respective indicator, as detailed in subsections 3.4.1 through 3.4.4. Given that few studies have examined the relationship between IPD in IBS and IBS project performance, discovering a significant relationship can enhance the novelty of this study. The conclusions drawn from the interactions among these four relationships could provide valuable insights for IBS implementation within our construction

industry. The subsequent chapter outlines the methodology employed for the empirical testing of the proposed hypotheses.

CHAPTER 4
RESEARCH METHODOLOGY

4.1 Introduction

The previous chapter discussed the research basis and the development of the research model. In that model, two main variables; independent and dependent variables are essential elements in the study. Then, several items were created to support the variables that were built. After a thorough examination on the variables and their items, were then theoretically described. The next step is to identify suitable techniques for measuring the items within those variables. This chapter details the study's methodological approach to ensure it aligns with the objectives established at the outset of the study. The study methodology is crucial to ensure that the research questions are answered and the study objectives are successfully achieved by the end of this study. Generally, there are various methods or analyses for making measurements. Therefore, the selection of an appropriate method or analysis needs to be clearly understood before application to ensure that the measurements taken can produce the necessary study findings. The discussion in this chapter further covers the study model, study design, study sample, measurement instruments used, instrument validity and reliability, data collection procedures, and study analysis.

4.2 The Research Paradigm

Research paradigms are significant as they establish the fundamental beliefs and guidelines that influence researchers within a specific field regarding the matters to investigate, the methodologies to be employed, and the interpretation of study results (Kivunja & Kuyini, 2017). Guba & Lincoln (1994) define a paradigm as a core set of ideas or a worldview that guides research activities or investigations. Furthermore, Denzin & Lincoln (2000) mention paradigms as human constructs that address fundamental principles or ultimate concerns, indicating the researcher's perspective to facilitate the construction of meaning embedded within data.

According to Creswell (2009), a paradigm consists of four elements: epistemology, ontology, methodology, and axiology. Epistemology defines how we

ascertain truth or reality, and it investigates the nature, forms, acquisition, and dissemination of knowledge (Kivunja & Kuyini, 2017). Additionally, it scrutinises human understanding, which may be acquired through scholarly research or personal insight, with the intention of broadening and deepening one's subject of inquiry. When employing facts derived from experts, literature, and business leaders, one's epistemology is deemed authoritative. Rationalist epistemology, or logical knowledge, underscores reason as the most reliable means of discerning the truth. Conversely, empirical epistemology emphasises that knowledge is acquired through sensory experiences and objective facts. Epistemology is important because it helps establish the faith you place in your data (Kivunja & Kuyini, 2017).

Ontological assumptions relate to the nature of reality, specifically, what exists, and researchers must adopt an approach to their interpretations of reality and functionality (Scotland, 2012). The ontology concepts assist in guiding your thought process regarding the research problem, its importance, and the methodologies you may employ to address it, thereby facilitating the answering of your research question, comprehending the investigated issue, and contributing to its resolution (Kivunja & Kuyini, 2017). Both ontology and epistemology shape the researcher’s approach to acquiring knowledge (Vengirasamy, 2024). This encompasses the integration of the theoretical perspective and methodology that establishes the framework and strategy for executing the research (Leavy, 2017).

In addition to methodological aspects, ethical considerations are also important when conducting research. Axiology is the philosophical term that encompasses ethical considerations. According to Kivunja & Kuyini (2017), axiology entails the definition, evaluation, and comprehension of concepts relating to morally correct and incorrect conduct in the context of research. It takes into account the significance assigned to different components of our research, including the participants, the data, and the audience of the results. All these philosophical ideas form the research paradigm, which influences the researcher's selections regarding the research topic, interpretation of the results, and how they are communicated (Leavy, 2017).

Inductive and deductive are two common research approaches. The inductive approach is often associated with developing a theory or knowledge based on observations from real life. On the other hand, the deductive approach employs a study strategy specifically designed to test a theoretical proposition (Saunders et al., 2012).

The four main paradigms that dominate in research are positivism, constructionism, pragmatism, and critical realism. Vengirasamy (2024) states that positivism is a worldview grounded in the idea that science and scientific research are the primary methods for discovering objective truth. Research performed in this manner employs deductive reasoning, involving the creation of hypotheses, their testing, and the use of operational definitions, mathematical equations, calculations, extrapolations, and expressions to draw valid conclusions (Kivunja & Kuyini, 2017; Sekaran & Bougie, 2020). Additionally, the positivist paradigm advocates the use of quantitative research as its primary research methodology. Constructionism emphasises phenomenological studies aimed at observing individuals within their natural environments. It explores how individuals construct and maintain the social world through interactions with others within their respective contexts (Neuman, 2014; Sekaran & Bougie, 2020). Rather than beginning with a predetermined theory, a constructionist employs an inductive method to formulate a theory (Creswell, 2014). For critical realism, or pragmatism, lies between the two extremes of positivism and constructionism (Sekaran & Bougie, 2020). In this type of research paradigm, both theory and practice are important (Vengirasamy, 2024). Pragmatism underscores the importance of comprehending the world and addressing its issues through the utilisation of both subjective and objective methodologies (Elgeddawy & Abouraia, 2024). Pragmatist researchers demonstrate flexibility and practicality in identifying feasible solutions to the phenomena under investigation.

This study examines the impact of IPD best practices on the performance of IBS projects. It employs a modified Leavitt Diamond theory to examine relationships between constructs and consider cause-and-effect links, aligning with the positivist paradigm. A research model and hypotheses were developed and tested using quantitative data from a survey, following a deductive approach. This approach is consistent with the existing literature, where the positivist paradigm is commonly used to test theories and hypotheses with objective measures, thereby ensuring reliable results.

4.3 Research Process

This section outlines the plan for conducting the current research. The first step in the research process was to thoroughly understand the study's context, ensuring that the research was necessary and defining the research problem. The problem statement was strengthened through interviews conducted with an expert panel from the industry, particularly within the IBS sector. This step was undertaken with sufficient care and effort to ensure that the current research makes significant contributions to practice. Having identified the problem, a comprehensive review of the literature and relevant theories was undertaken. Guided by the identified underlying theory, a comprehensive research model was developed, laying a foundation for the study.

After determining what needed to be studied, the research problem was transformed into research questions and objectives. This made it possible to formulate hypotheses. Following this, a suitable research process with a quantitative approach was selected based on the research paradigm. All aspects of the research were taken into consideration when developing the research process. This included determining how to operationalise the key constructs and measurements, expert panel view, developing the questionnaire, selecting the unit of analysis, designing the sampling method, conducting pretesting and expert validation. The sampling design includes both determining the sample size and selecting the sampling methods. The questionnaire was validated through pretesting to identify any issues prior to distribution to respondents.

Upon the completion of data collection, the Statistical Package for the Social Sciences (SPSS) version 28 software was employed to examine the data meticulously. Subsequently, the PLS-SEM version 4 was used to test the research hypotheses. The results of the analysis were thoroughly explained, discussed, reviewed by expert panels and concluded, with every step documented. Figure 4.1 visually represents how these processes seamlessly integrate to ensure the robustness of the study's findings.

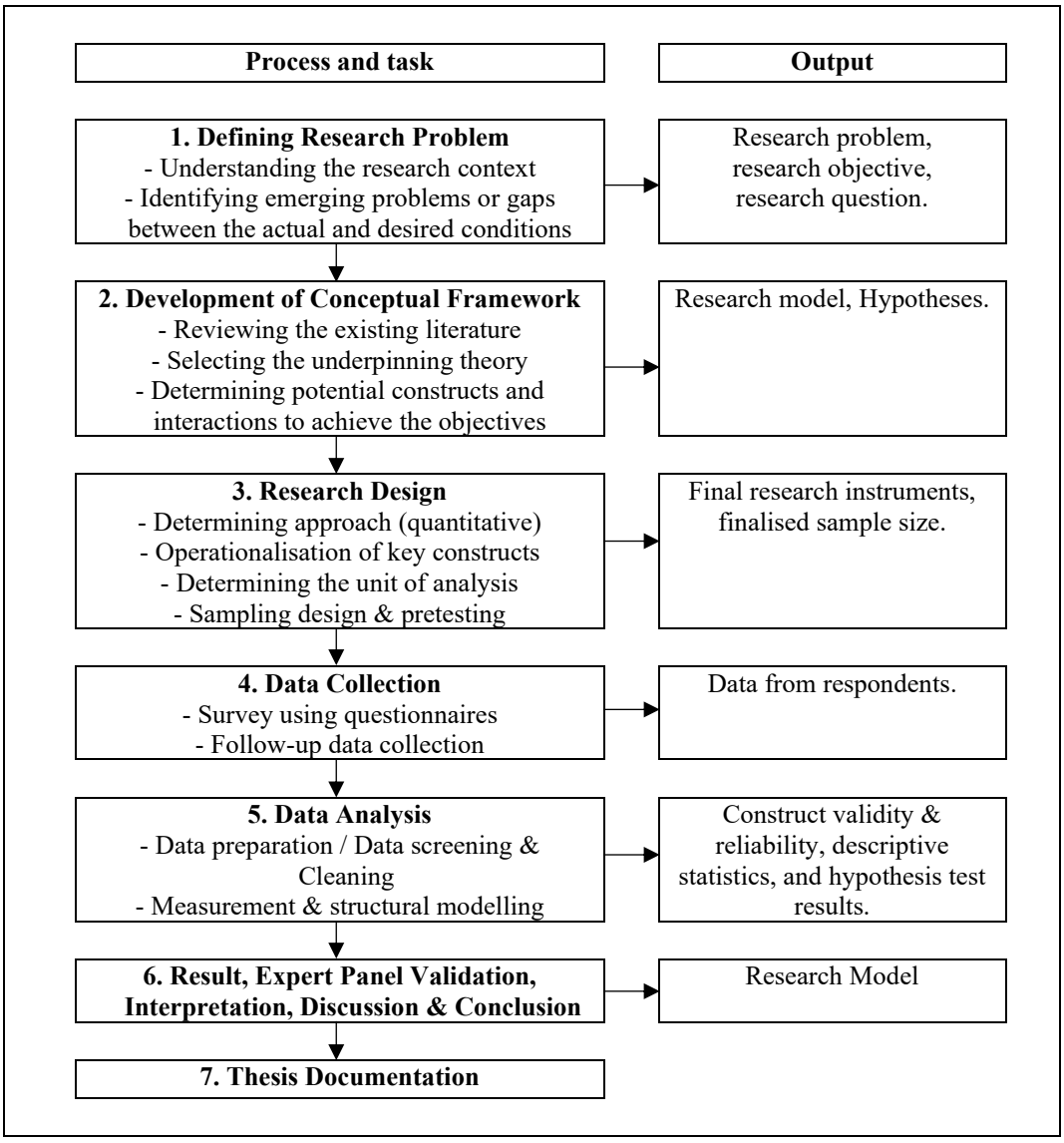


Figure 4.1 Research Process. Adapted from Vengirasamy (2024)

4.4 Research Design

Research design establishes the fundamental framework and guidance necessary for conducting scholarly investigation. Sekaran & Bougie (2020) characterised research design as a "blueprint or plan for the collection, measurement and analysis of data created to answer the research empirical questions. " The careful selection of an appropriate research design is crucial, as it enables the researcher to acquire pertinent information efficiently, thereby facilitating the achievement of research objectives (J. F. Hair et al., 2019b). This study employed a survey research methodology to generate standardised data suitable for examining the relationships between the constructs. These methods are often cost-effective and allow quick responses and higher control over the

respondents (Seman, 2020). Furthermore, prior studies of IBS have also employed the survey method. Some examples of prior studies that have deployed the survey method are Abdullah & Nasir (2024), Alawag et al. (2025), Hashim et al. (2024), Shamsuddin et al. (2021), Mohamed (2021) and Abd. Rahsid (2022). Therefore, these studies supported the utilisation of the survey method in the current research.

4.5 Research Technique

This subsection discusses three main research techniques used to complete the study, focusing on justifying the choice of each method. These techniques are interconnected and include the literature review, preliminary study, questionnaire survey, and expert validation.

4.5.1 Literature Review

The literature review aims to identify existing problems in the construction industry, determine the research issues, and then develop the research questions, goals, and objectives (Mohamed, 2021). Previous researchers' academic works were assessed and synthesised to develop a conceptual framework (Saunders et al., 2012). For this study, a literature review was conducted to gather relevant information and develop an understanding of IBS and IPD. This process aimed to identify best practices in IPD that influence IBS project performance and to develop a conceptual framework for this study. The conceptual framework assists the researcher in organising the hypothesis and the methods of data collection by identifying the critical areas that require investigation and analysis, as detailed in Chapters 2 and 3.

4.5.2 Preliminary Survey

A preliminary survey is a crucial step in the early stages of research. The survey provides essential background information regarding your topic, addressing questions such as who, what, when, and where. This survey also helps identify arguments related to your subject and assesses the availability of sufficient sources to ensure comprehensive coverage (Calgary, 2022). The preliminary survey for this research aims to identify the current challenges faced by IBS stakeholders and to strengthen the

problem statements. This is to ensure that the issues are genuine and valid from both the literature review and the industry stakeholders' perspectives. The preliminary survey was conducted through interviews, as the responses from the interviewees establish primary data and provide a more flexible, in-depth, and spontaneous approach to initial information collection. The interviewees were randomly selected from the CIDB list with at least 3 years of experience in managing IBS projects. The results of the preliminary survey are presented in sub-chapter 1.3.5.

4.5.3 Questionnaire Survey

This study utilised the questionnaire survey as the primary data collection method. Both soft-copy and hard-copy questionnaires were distributed to respondents. First, an online questionnaire survey platform was used via Google Form. Respondents received an email invitation with a link to the Google Form for the survey, along with follow-up reminders from early October through the end of November 2023. Hard-copy questionnaires were collected during the Program Jelajah Bina Townhall Se-Malaysia, organised by CIDB at various locations, including the Klang Valley, Johor Bahru, Pulau Pinang, Kelantan, and Sarawak, on designated dates from the end of November 2023 to July 2024. A sequential approach was employed, using different methods for each survey process: initially, a soft-copy questionnaire was sent via email with reminders, and subsequently, hard-copy questionnaires were distributed after the soft-copy method failed to meet the target (Becker, 2022). This method reduces the risk of duplication compared to offering both options simultaneously. The entire data collection process lasted approximately ten months, from October 2023 to July 2024. The questionnaire contents for this study undergo pretesting validation and a pilot survey prior to being distributed to the targeted respondents

4.5.3.1 Questionnaire Design

The design of this questionnaire carefully considered the content and purpose of the questions, as well as the language, wording, and question formats (Sekaran & Bougie, 2020). The wording and language used in the questionnaire were carefully

reviewed to ensure respondents could understand it clearly. Complex wording and unclear questions were avoided to elicit good quality responses.

All construct items were assessed using a Likert scale. Both independent and dependent variable items were measured on a six-point Likert scale. The study's results revealed that a six-point Likert scale tends to yield higher reliability values compared to a five-point Likert scale. To minimise deviation and mitigate risks associated with personal decision-making variability, it is also recommended to adopt the six-point Likert scale rather than the five-point scale (Chomeya, 2010). Finally, the length of the questions or statements was maintained as concise as possible without compromising their intended meanings to enhance respondents' comprehension (Sekaran & Bougie, 2020).

4.5.3.2 Questionnaire Format

A questionnaire consisting of four (4) sections was developed for data collection, as shown in Table 4.1. Section A consisted of general information questions, including the organisation's location, primary business, respondent's job title, years of experience, stakeholders involved in the respondent's IBS project, the type of IBS project background, and the location of the respondent's IBS project. Section B incorporated the questions on IPD best practices that influence the IBS project performance. The respondents must indicate their opinion of the 43 IPD best practices (independent variables), which have been grouped into four elements: strategy, technology, practice, and people. This aims to forecast the relationship of IPD best practices to IBS project performance. A six-point Likert scale was used to measure all variables, ranging from 1=strongly disagree to 6=strongly agree. Section C measured the IBS project performance (dependent variables). This section also uses a six-point Likert scale. In the final section D, respondents are allowed to provide open-ended comments, thus offering qualitative inputs that enrich the depth and detail of the questionnaires.

Table 4.1
Questionnaire Format

Part	Description	Purpose	Number of Questions
A	General Information	Profile of respondents and their organisations	7
B	IPD Best Practice		
	B1- Strategy	IV	12
	B2 - Technology	IV	9
	B3 - Practice	IV	11
	B4 - People	IV	11
C	IBS Project Performance	DV	4
D	Comments	Comments from the respondent	1

4.5.3.3 Measurement of Variables

The measurement of variables comprises forty-seven (47) survey items; of these, forty-three (43) items are distributed across four (4) independent variables (IV), while four (4) items pertain to the dependent variable (DV). All items were sourced from the literature review outlined in Chapter 2. The variable items are as follows:

i) Strategy

The survey questions aimed to assess the level of agreement or disagreement with the items of the strategy for IPD best practices.

No.	B1 The **strategies** to implement Integrated Project Delivery (IPD) in IBS projects, I believe that.../	Strongly Disagree					Strongly Agree
		1	2	3	4	5	6
1	...the **top-down commitment** was efficiently implemented.						
2	...the **risk assessment** was properly recognized.						
3	...the **government support** were fully applied. Example IBS levy exemption, IBS exhibition etc.						
4	...the **government policies** were properly recognized. Example IBS Score mandatory, tax incentives etc.						
5	...**business and financial** approach been applied.						
6	...**project trend & knowledge** were with the times.						
7	...the **quality management** were fully implemented during component manufacturing and installation stage.						
8	...the **adaptability** to IBS system were reached.						
9	...**share objective and goal** were achieved.						
10	...the **demand & supply** factor was appropriately identified.						
11	...**roles and responsibilities** each parties was appropriately identified.						
12	... **the shared risk and reward** are determined fairly.						

Figure 4.2 Strategy Items for IPD Best Practices

ii) Technology

The survey questions aimed to assess the level of agreement or disagreement with the items of the technology for IPD best practices.

No.	B2 The **technologies** to implement Integrated Project Delivery (IPD) in IBS projects, I believe that…/	Strongly Disagree					Strongly Agree
		1	2	3	4	5	6
1	…**information and communication technology (ICT)** was extensively used.						
2	…**Building Information Modeling (BIM)** was successfully implemented.						
3	…the **internet of things (IoT)** was applied accordingly.						
4	…**robotic and automation** were appropriately introduced.						
5	…**speed of IBS construction** was acceptable.						
6	…**availability of plant** were sufficient.						
7	…**Computer Aided Design (CAD)** was extensively practiced.						
8	…**Computer Aided Manufacturing (CAM)** was effectively used.						
9	…**3D printing** were appropriately introduced.						
10	…**Virtual Reality (VR) and Augmented Reality (AR)** has been satisfactorily introduced.						

Figure 4.3 Technology Items for IPD Best Practices

iii) Practice

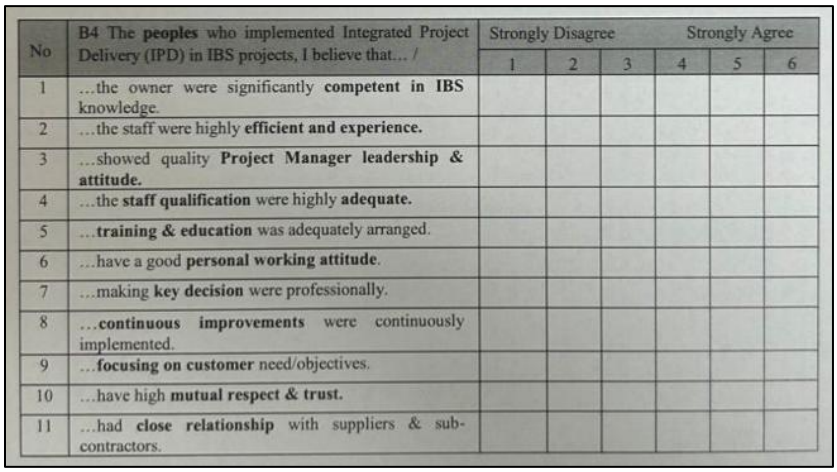
The survey questions aimed to assess the level of agreement or disagreement with the items of the practice for IPD best practices.

No	B3 The **practices** to implement Integrated Project Delivery (IPD) in IBS projects, I believe that…	Strongly Disagree					Strongly Agree
		1	2	3	4	5	6
1	…a **good working collaboration** was effectively achieved.						
2	…the **communication channels** were efficient / saluran komunikasi adalah cekap.						
3	…the **design, manufacture, transportation and installation** were extensively coordinated.						
4	…the **involvement during the design process** from all the team members was sufficiently achieved.						
5	…the **planning and scheduling** were extensively carried out.						
6	…**appropriate procurement method** were used such as integrated project delivery (IPD).						
7	…**compensation structure** was considered accordingly.						
8	…**standardisation** was effectivelyimplemented.						
9	…**teamwork** was strongly implemented.						
10	…**supply chain support** was sufficiently identified.						
11	...**better coordination** was effectively implemented.						
12	…**early involvement of team members** was fully supported.						
13	…**mass production** were fully achieved.						

Figure 4.4 Practice Items for IPD Best Practices

iv) People

The survey questions aimed to assess the level of agreement or disagreement with the items of the people for IPD best practices.



No	B4 The **peoples** who implemented Integrated Project Delivery (IPD) in IBS projects, I believe that... /	Strongly Disagree					Strongly Agree
		1	2	3	4	5	6
1	...the owner were significantly **competent in IBS** knowledge.						
2	...the staff were highly **efficient and experience.**						
3	...showed quality **Project Manager leadership & attitude.**						
4	...the **staff qualification** were highly **adequate.**						
5	...**training & education** was adequately arranged.						
6	...have a good **personal working attitude**.						
7	...making **key decision** were professionally.						
8	...**continuous improvements** were continuously implemented.						
9	...**focusing on customer** need/objectives.						
10	...have high **mutual respect & trust.**						
11	...had **close relationship** with suppliers & sub-contractors.						

Figure 4.5 People Items for IPD Best Practices

4.5.4 Pretesting of Questionnaire (Validity Test)

Pretesting is typically conducted before the pilot study. According to Sekaran & Bougie (2020), pretesting aims to evaluate whether the questions are suitable, understandable to respondents, and elicit consistent responses. The pretest aids the researcher in obtaining feedback on the instructions, format, phrasing, clarity of language, redundancy of questions, and general structure of the questionnaire to enable appropriate modifications before the real survey (Sekaran & Bougie, 2020). Creswell (2009) states that to validate an instrument's content, the required number of experts ranges from 5 to 25; hence, the number used in this research is sufficient. The pretest took place from 1st to 30th August 2023, as shown in Table 4.2, which presents the profile of the experts who validated the instrument. During the interviews, the questionnaires were distributed as hard copies to the experts. The experts' comments, insights, and feedback were utilised to enhance the questionnaire's quality. Several item modifications, based on their suggestions, are summarised in Table 4.3.

Table 4.2
Expert Panel's Profile

Expert Panel	Designation	Organisation	Experience
A	Production Manager	IBS Manufacturer	10 years
B	Project Director	IBS Contractor & Manufacturer	25 years
C	Architect	IBS Consultant	15 years
D	Project Manager	IBS Contractor	13 years
E	Manager	Local Authorities (CIDB)	10 years

Table 4.3
Expert Panel's Comments

Expert Panel	Comments	Adjustment made
Expert Panel A	The researcher needs to add the item, mass production, under the Practice element.	The expert panel's suggested items have been incorporated into the questionnaire.
Expert Panel B	The researcher needs to add the items, Virtual Reality (VR) and Augmented Reality (AR), under the Technology element.	The expert panel's suggested items have been incorporated into the questionnaire.
Expert Panel C	The bilingual questionnaire is too lengthy. Please use only English since your target respondents are accustomed to English, as it is widely used for communication in Malaysia's construction sector. Please check the questionnaire grammar.	The questionnaire has been modified to be in English only. The questionnaire was grammar-checked with Grammarly.
Expert Panel D	The researcher needs to check the spelling and grammar in the questionnaire before distributing it.	The questionnaire was checked with Grammarly for spelling and grammar correction.
Expert Panel E	Good questionnaire. The items in the questionnaire cover essentially all IPD best practices that IBS stakeholders need to consider. Easy to understand the questionnaire.	No adjustments were made following the expert panel's comments.

Following the pretesting validity assessment conducted with five IBS experts, all feedback from the expert panel was addressed and incorporated. Additionally, two new items; i) mass production; ii) virtual reality (VR) and augmented reality (AR) were introduced to the questionnaire based on the feedback received from expert panels A and D.

i) Mass Production

The fundamental principle of IBS is based on mass production, which can lead to reduced production costs and increased affordability (Khalili-Araghi & Kolarevic, 2018). The consistent and repetitive design, as well as the fabrication of modular

components, offer advantages such as minimising on-site errors and enhancing productivity in IBS projects. The IPD method is a strategic approach that fosters the collaborative integration of IBS project teams (Khalili-Araghi & Kolarevic, 2018), and to improve communication, clarity, and results, IBS parties should prioritise involvement in the mass production stage as early as possible (Lopez et al., 2022).

ii) Virtual Reality (VR) and Augmented Reality (AR)

Virtual Reality (VR), for instance, provides a natural platform for building design by simulating various phases of the construction process and enabling collaborative exploration of design options through real-time manipulation of three-dimensional visuals (Al-Ansi et al., 2023; Bouchlaghem et al., 2005). While, augmented reality (AR) is a technology that overlays computer-generated information over the user's real-world vision, creating a blended experience (Albahbah et al., 2021; Chi et al., 2013).

4.5.5 Pilot Study (Reliability Test)

Bryman (2012) emphasises the importance of conducting a pilot study prior to managing a self-completion questionnaire. The primary benefit of executing a pilot study lies in providing a preliminary trial of the questionnaire before its final dissemination to respondents. Importantly, Bryman (2012) advocates for the assessment of each question's 'internal reliability' utilising 'Cronbach's Alpha', and the recommended Cronbach's Alpha value must be greater than 0.7. A pilot study was carried out from 1st to 25th September 2023, involving 30 respondents selected at random. This approach aligns with the recommendation by Johanson & Brooks (2010), which suggests that approximately 30 participants, representing the population, constitute a practical minimum sample size for a pilot study. This study found that Cronbach's Alpha values exceeded the standard threshold, with values greater than 0.70, as shown in Table 4.4.

Table 4.4
Results of Cronbach's Alpha for Pilot Study

No.	Construct	Variable	Number of Items Measured	Cronbach's Alpha
1	People	IV	11	0.963
2	Practice	IV	11	0.977
3	Strategy	IV	12	0.934
4	Technology	IV	9	0.928
5	Performance	DV	4	0.881

4.5.6 Final Survey

The final survey encompassed the collection of data from respondents through both online and physical distribution of hardcopy questionnaires. The questionnaire employed in the final survey is appended in Appendix A. The use of online surveys and hardcopy questionnaires was anticipated to optimise response rates and enhance the efficiency of the data collection process. The survey was conducted from October 2023 to July 2024.

4.6 Research Setting

This study selected the IBS construction industry in Malaysia as the research setting. The IBS sector has grown dramatically and emerged as one of the construction techniques used in Malaysia. This is due to the government mandating the use of IBS in government projects worth RM10 million and above to achieve a minimum IBS score of 70. Since 2018, the Ministry of Housing and Local Government has mandated the adoption of IBS in private projects worth RM 50 million and above to achieve a minimum IBS score of 50. This progressive increase in the adoption of IBS is evidenced by the rise from 8 projects in 2008 to 175 projects in 2019, according to the CIDB technical report issued in 2021. Additionally, the government's support for promoting IBS in Malaysia's construction industry is evident through several strategic initiatives: the IBS Strategic Plan 1999, the IBS Roadmap 2003-2010, the IBS Roadmap 2011-2015, the Construction Industry Transformation Plan (CITP) 2016-2020, and the Construction 4.0 Strategic Plan 2020-2025. This scenario offered an ideal context for the present research to examine the best practices that affected the IBS project

performance. This study's setting included IBS stakeholders across all states and federal territories of Malaysia.

4.7 Sample Design

Samples were chosen from the population for data collection. A sample is a smaller group selected from the entire population (Sekaran & Bougie, 2020). Sampling involves choosing appropriate elements to represent the population accurately (Vengirasamy, 2024) and requires careful planning of the sampling design and sample size (Sekaran & Bougie, 2020). The present study employed a probability sampling technique, particularly a stratified sampling for data collection. In adopting this sampling approach, this study focuses on IBS contractors with a grade G7 specialised in B01-Precast Concrete System. According to the Construction Industry Development Board (2021), most IBS systems use a precast concrete system. Furthermore, the circular issued by the government mandates the utilisation of IBS in government projects valued at RM10 million or more to attain a minimum IBS score of 70. Specifically, IBS contractors classified as G7 must handle projects exceeding RM10 million in size, which results in them automatically being required to use IBS. Besides that, the sample also consists of IBS consultants, IBS precast system clients, IBS precast manufacturers, and suppliers. The overall process yielded a total of 1,037 firms to form the population, all of which were registered with CIDB, as listed in the Orange Book 2019 & 2023, the IBS in Malaysia 2008-2013 book, and the IBS in Malaysia 2014-2018 (see Table 4.5).

Table 4.5
Size of Research Sample

Number	IBS Stakeholders	Total
1	IBS Contractors G7 Precast	867
2	IBS Precast Manufacturers	62
3	IBS Consultants	48
4	IBS Clients	60
	Total	**1,037**

4.8 Unit of Analysis

The unit of analysis is defined as “the level at which information is analysed and conclusions are drawn." (Sekaran & Bougie, 2020). According to Creswell & Clark (2017), the units of analysis in management are typically categorised as individual, organisation, and group. This study's unit of analysis is an organisation company, involving respondents such as owners, managers, directors, engineers, architects, quantity surveyors, and others who typically know the IBS in Malaysia.

4.9 Sample Size

G*Power is a standalone power analysis software used for various statistical tests frequently employed within the social, behavioural, and biomedical sciences (Erdfelder et al., 2009). The G*Power software facilitates sample size and power calculations across a range of statistical methods, including F, t, $\chi 2$, z, and exact tests (Kang, 2021). Its user-friendly graphical interface and free availability further enhance its accessibility and practical utility. The minimum sample size required for this research was determined through power analysis using the G*Power software version 3.1.9.7. This study employed F-test and A-priori power analysis in G*power to determine the necessary sample size, with effect size, alpha value, and power set at 0.15, 0.05, and 0.95, respectively. The number of predictors was set as 4 based on the maximum arrows pointing to a construct in the research model. Consequently, G*Power indicated a minimum required sample size of 129 for the current study (see Figure 4.6). Nonetheless, questionnaires were disseminated to all 1,037 qualified IBS stakeholders in order to maximise the response rate.

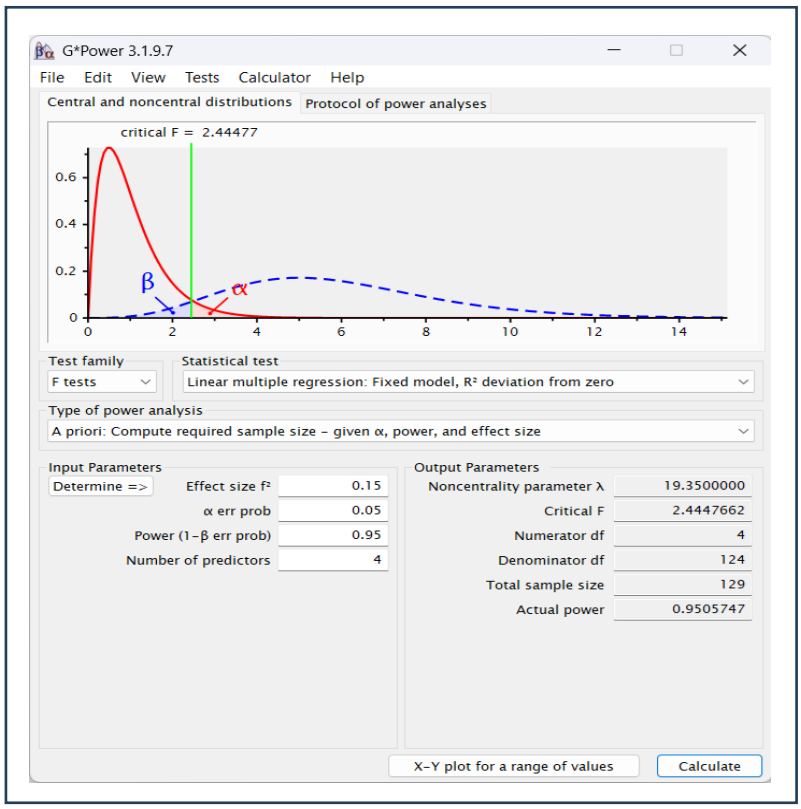


Figure 4.6 Sample Size of Research Study

4.10 Preliminary Data Analysis

Preliminary data analysis involves data screening, normality testing, and assessing common method bias. Data screening includes reviewing collection forms for missing information, editing errors, and correct classification. This process also involves transforming data into a coding system within SPSS version 28, where each item is assigned a specific numerical value (Aljuboori et al., 2022). The normality test is a distributional assumption for data based on symmetrical and peak intensity distributions. Examining multivariate skewness and kurtosis is also part of the procedure for directing the appropriate data analysis tool. The common method bias (CMB) occurs when data are collected simultaneously for both dependent and independent variables (Aljuboori et al., 2022). Furthermore, full collinearity testing is another method to evaluate CMB, using a threshold value for the variance inflation factor (VIF) of no more than 10 (Kock, 2024). Once the data is decent, the SPSS version 28 software was used to run some descriptive analysis. In descriptive analysis, the independent and dependent variables were examined, detailing their mean, mode,

median, and standard deviation. The software also reveals the demographic profile of the respondents.

4.11 Statistical Analysis using Structural Equation Modelling (SEM)

There are two primary methods for conducting SEM: covariance-based SEM (CB-SEM) and partial least squares SEM (PLS-SEM). According to Hair & Alamer (2022), CB-SEM is primarily intended for the testing of theory, the confirmation of theoretical frameworks, or the comparison of alternative theories. Conversely, PLS-SEM is employed for predicting or explaining key target constructs, as well as identifying key target constructs. Additionally, PLS-SEM can be utilised to investigate the theoretical extensions of existing structural theories. Table 4.6 illustrates several rules of thumb for choosing between CB-SEM and PLS-SEM techniques.

Table 4.6
Rules of Thumb for Choosing Between CB-SEM and PLS-SEM

No.	Criteria	CB-SEM	PLS-SEM
1	**Research Goals**		
	a. Predicting key target constructs or identifying key "driver" constructs.		√
	b. Theory testing, theory confirmation, or comparison of alternative theories.	√	
2	**Measurement Model Specification**		
	a. If formative constructs are part of the structural model.		√
	b. If error terms require additional specification, such as covariation.	√	
3	**Structural Model**		
	a. If the structural model is complex (many constructs and many indicators).		√
	b. If the model is nonrecursive.	√	
4	**Data Characteristics and Algorithm**		
	a. The data meet the minimum sample size and the distributional assumptions.		√

	b. The data do not meet the minimum sample size and the distributional assumptions.	√	
	c. The sample size is relatively low.		√
	d. The sample size is large.	√	√
	e. The data distribution is nonnormal.		√
	f. The data distribution is normal.	√	√
5	**Model Evaluation**		
	a. Latent variable scores in subsequent analyses.		√
	b. Requires a global goodness-of-fit criterion.	√	
	c. Need to test for measurement model invariance.	√	

Source: Adapted from Hair et al. (2011)

4.12 Justification for Selecting PLS-SEM

PLS-SEM was selected for this study following the rules of thumb between CB-SEM and PLS-SEM. The first reason for the study is to test new assumptions against existing theories, aiming to explore the relationship between IPD best practices and IBS project performance, which aligns with the use of the PLS-SEM technique. Secondly, this study employed a reflective measurement model with a high level of structural complexity. Therefore, PLS-SEM is suitable for the present model, which contains many variables and direct structural paths. Third, the PLS-SEM analysis required either a small or a large sample size to conduct the test. This provides an advantage to researchers, as there may be limitations in the number of respondents available for this research. Fourth, data that do not follow a normal distribution are common in social science research, including this study, which makes PLS-SEM a suitable choice.

4.13 Assessment of Measurement Model

The analysis of the Reflective Measurement Model in this study encompasses four principal steps. Firstly, the investigation considers the indicator or outer loading (Indicator Reliability), with a threshold set at greater than 0.50 (Hair et al., 2019; Ramayah et al., 2018). The second step involves internal consistency reliability testing,

which includes Cronbach's Alpha (CA) and composite reliability (CR), with established standards of acceptability at 0.60-0.70, satisfactory levels at 0.70-0.90, and higher thresholds exceeding 0.95 (Hair et al., 2019). The third step entails assessing the convergent validity of each construct using the Average Variance Extracted (AVE) metric. For an AVE to be considered valid, the construct must account for at least 50% of the item variance, establishing the minimum AVE threshold at 0.50. (Hair et al., 2019; Ramayah et al., 2018). The fourth step to evaluate involves the assessment of discriminant validity, employing the heterotrait-monotrait (HTMT) ratio and cross-loading metrics. HTMT values exceeding 0.90 for similar constructs and above 0.85 for dissimilar constructs indicate a potential deficiency in discriminant validity. (Franke & Sarstedt, 2019). The cross-loading measure, as indicated by the loading of its constructs, should exceed that of other constructs. In conclusion, Table 4.7 provides a summary of the threshold values used in the reflective measurement model analysis within this study.

Table 4.7
Guidelines for Assessing Measurement Model

No	Type	Name of Index	Guidelines
1	Indicator reliability/ Factor loadings	Indicator loadings	It should be higher than 0.50 or 0.708. If the average variance extracted (AVE) value is satisfactory, the lower loading is acceptable.
2	Internal Consistency	Composite Reliability (CR)	Acceptable: 0.60-0.70 Satisfactory:0.70-0.90
		Cronbach Alpha (CA)	Higher: >0.95
3	Convergent validity	Average Variance Extracted (AVE)	AVE > 0.50
4	Discriminant validity	HTMT Criterion	HTMT 0.85 (conceptually dissimilar construct) HTMT 0.90 (conceptually similar construct)
		Cross-Loading	The loading of its own constructs should be higher than that of other constructs.

Source: Adapted from Ramayah et al. (2018)

4.14 Assessment of Structural Model

The analysis of the structural model aims to evaluate the significant direct and indirect effects of hypotheses based on a specific procedure. Initially, detecting collinearity is crucial to prevent bias in path coefficients, which is assessed using the Variance Inflation Factor (VIF) metric by identifying potential bias when its value exceeds 5 (Hair et al., 2017).

Subsequently, a structural model analysis can be conducted to evaluate both direct and indirect effects, employing a designated set of criteria. The standard criteria to be demonstrated include path coefficient (standard beta, t-values, and p-values), coefficient of determination (R^2), effect size (f^2), and other measures of predictive relevance such as Q^2 (Hair et al., 2019b). The importance of the p-value and t-value can be understood by examining their direct and indirect role effects. Ramayah et al. (2018) specify guidelines that values for a one-tailed test are 2.33 at the 1% significance level ($\alpha = 0.01$), 1.645 at the 5% level ($\alpha = 0.05$), and 1.28 at the 10% level ($\alpha = 0.1$).

The threshold for R^2 varies based on the study's context and the number of constructs in the model (Hair et al., 2019b). Chin (1998) stated that an R^2 of 0.67 is substantial, 0.33 is moderate, and 0.19 is weak. The f^2 metric measures the relative influence of a predictor construct on endogenous constructs. Cohen (2013) provided a guideline for assessing effect size, where values of 0.02, 0.15, and 0.35 denote small, medium, and large effect sizes, respectively. The blindfolding procedure, as suggested by Hair et al. (2017) was used to assess the predictive relevance (Q^2) of the model, and if $Q^2 > 0$, then the model has sufficient predictive relevance. In conclusion, Table 4.8 provides a summary of the threshold values used in the reflective measurement model analysis within this study.

Table 4.8
Guidelines for Assessing Structural Model

No	Type	Name of Index	Guidelines	Sources
1	Lateral Collinearity	Variance Inflation Factor (VIF)	VIF ≤ 3.3	(Diamantopoulos & Siguaw, 2006)
			VIF ≤ 5.0	(Hair et al., 2017)
2	Path Coefficient	Path Coefficient	p value < 0.01 t value > 2.58 (two-tailed) t value > 2.33 (one-tailed)	(Hair et al., 2017)
			p value < 0.05 t value > 1.96 (two-tailed) t value > 1.645 (one-tailed)	(Hair et al., 2017)
			p value < 0.10 t value > 1.645 (two-tailed) t value > 1.28 (one-tailed)	(Hair et al., 2017)
3	R^2	Coefficient of determination	0.26 – Substantial 0.13 – Moderate 0.02 – Weak	(Cohen, 2013)
			0.67 – Substantial 0.33 – Moderate 0.19 – Weak	(Chin, 1998b)
			0.75 – Substantial 0.50 – Moderate 0.25 – Weak	(Hair et al., 2017)
4	f^2	Effect size to R^2	0.35 – Substantial effect size 0.15 – Medium effect size 0.02 – Small effect size	(Cohen, 2013)
5	PLS-predict	Q^2 predict	Q^2 predict >0	(Hair et al., 2017)

4.15 Validation of the Model

The validity of the findings was validated by experts in the construction industry to solicit their feedback on opinions and comments concerning the structural model of the IPD best practices model, with particular emphasis on its appropriateness, content,

acceptance, and feasibility within Malaysia. The expert panel's feedback should focus on the approval level of the structural model, which includes determinant factors for the IPD best practices and the analysis of the research. Providing an explanation of the concept of IPD to expert panels prior to the interview session is essential to ensure their comprehension of the IPD-IBS conceptual model. The validation of the proposed research model involved structured interviews with the expert panels.

The number of expert panels in this study is based on Creswell (2009) recommendation, which suggests a range of 5 to 25 individuals. The criteria for selecting the experts are specified as follows: 1) Working experience: This includes experts and government officials with more than five years of professional experience in the field of IBS; 2) Position: The experts should have held management-level positions in IBS projects; and 3) Knowledge: The experts are required to possess relevant knowledge and skills in IBS. Consequently, the criteria for expert validation are clearly defined within this research.

4.16 Ethical Consideration

Ethical considerations were prioritised in the conduct of this research. Throughout the data collection process, all respondents were informed that their participation in the survey was entirely voluntary, and they received clear information regarding the survey's objectives. Furthermore, participants were assured that their anonymity would be preserved and that principles of privacy and confidentiality would be strictly followed. As a result, the names and details of their organisations remain undisclosed in any publications or reports.

4.17 Chapter Summary

This chapter outlines the research methodology employed in the present study. It encompasses details pertaining to the research paradigm, research process, research techniques, research setting, population, sampling methods, questionnaire development, pretesting procedures, pilot study, and data collection methods. Additionally, the chapter discusses the statistical techniques employed for hypothesis testing and addresses the ethical considerations involved in the study. Given that PLS-SEM was utilised for data analysis, both the measurement model and structural path model were

evaluated concurrently. The assessment of the measurement model included tests of validity and reliability, whereas the evaluation of the structural model concentrated on hypothesis testing. Furthermore, validation by expert panels was incorporated to ensure the robustness of the study's results. The outcomes of these assessments are presented in the subsequent chapter. Table 4.9 below delineates the research methods corresponding to each research objective to be accomplished.

Table 4.9
Research Relationship Between Research Question, Objectives and Aim

Research Questions	Research Objectives	Methods	Research Aim
1. What are the best practices of IPD in the IBS project?	1. To identify Integrated Project Delivery (IPD) best practices in the Industrialised Building System (IBS) project.	Literature review Expert Validation	To propose an Integrated Project Delivery (IPD) Best Practices (IPD-BP) Model for Industrialised Building System (IBS) performance in Malaysia
2. What are the elements for the IBS project performance?	2. To identify the performance elements of the Industrialised Building System (IBS) project. .	Literature review Expert Validation	
3. What is the relationship between IPD best practices and IBS project performance?	3. To analyse the relationship between Integrated Project Delivery (IPD) best practices and the Industrialised Building System (IBS) project performance.	Questionnaire Survey SPSS PLS-SEM analysis (Hypothesis testing)	
4. How would the model be developed to improve the integration among IBS stakeholders for successful IBS project delivery?	4. To develop an Integrated Project Delivery Best Practice (IPD-BP) Model for Industrialised Building System Performance in Malaysia.	PLS-SEM (Model) Expert validation	

CHAPTER 5
DATA ANALYSIS, RESULTS AND DISCUSSION

5.1 Introduction

This chapter presents the results, conducts statistical analyses, and discusses the findings of this research. It begins with data screening and preparation, then presenting the descriptive statistics on the respondents' profiles. Subsequently, a preliminary examination is conducted to test the underlying assumptions of multivariate analysis. Since this research employed the PLS-SEM technique, the measurement and structural path model analyses were performed and reported accordingly. The chapter concludes with a summary of the data analysis and results (see Figure 5.1).

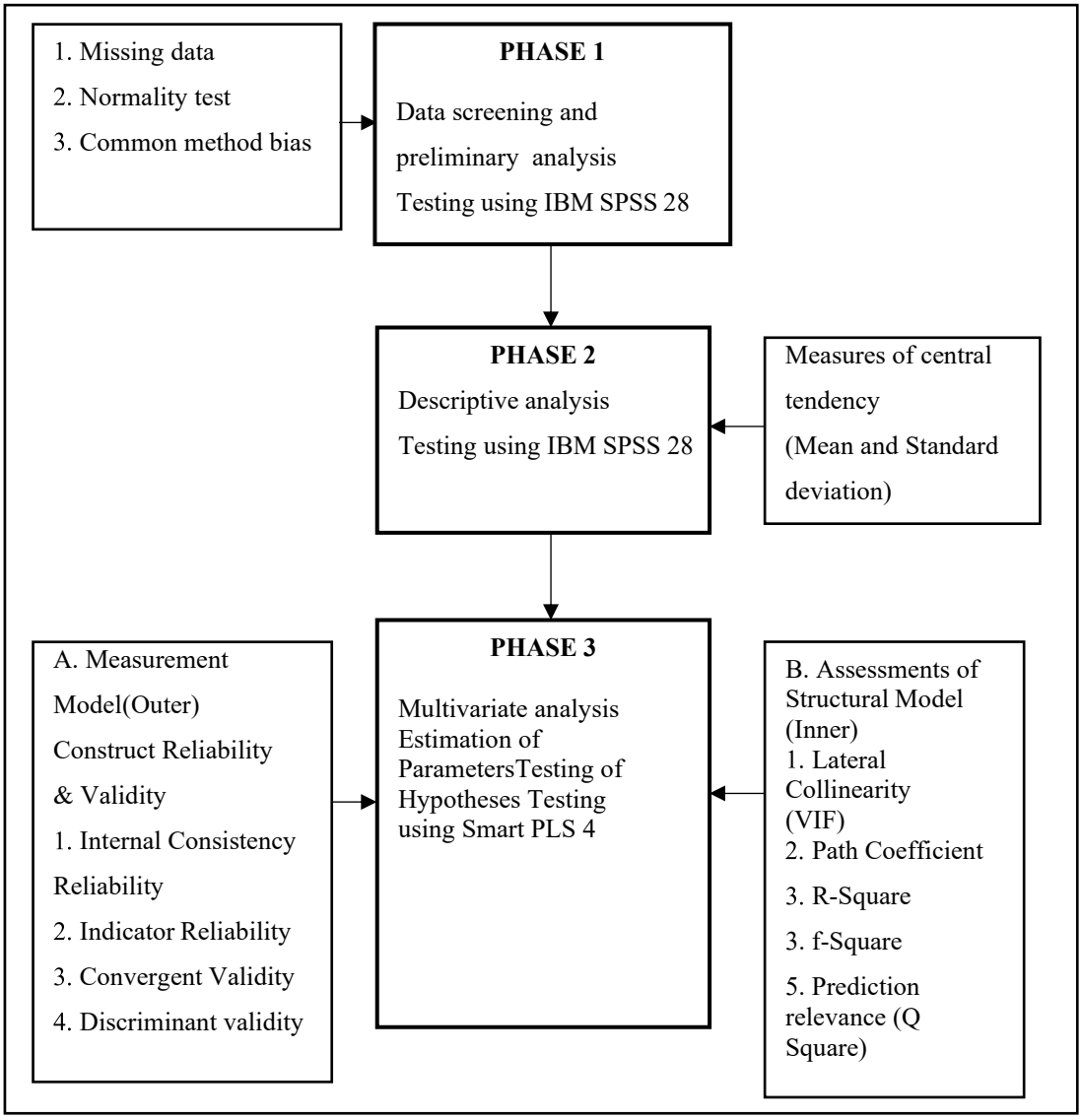


Figure 5.1 Main Data Analysis, Source: adapted from Mohamed (2021)

5.2 Response Rates

The response rate is calculated by dividing the number of completed and returned questionnaires by the total number of eligible survey participants (Frohlich, 2002). Achieving a higher response rate is contingent upon respondents' willingness to complete the administered questionnaires. This study utilised an online survey using Google Forms that was forwarded to the respondents via email, and a hardcopy questionnaire distributed by hand to the respondents. At the end of the data collection, a follow-up reminder was also carried out through phone calls to the targeted organizations. A total of 1037 questionnaires were disseminated for ten months, commencing in early October 2023 and concluding at the end of July 2024.

However, as illustrated in Table 5.1, a total of 259 questionnaires were acknowledged and retained for analysis, in contrast to the overall total of 1037 responses distributed. Invalid and incomplete responses constituted the primary reasons for excluding eight responses. Further, the results presented in Table 5.1 indicate that the G*Power version 3.1 software recommends a minimum sample size exceeding 129 to conduct multiple regressions for a fixed model. This finding suggests that this study has garnered a substantial number of respondents (N=259), thus permitting the application of Structural Equation Modelling (SEM) utilising Smart PLS version 4.

Table 5.1
Questionnaire Distribution and Decisions

Items	Frequency	Percentage (%)
Questionnaires given out	1037	100
Questionnaires returned	259	25

5.3 Data Screening/ Data Preparation

The data obtained from the distribution of questionnaires can be analysed in two ways: to identify missing data and to assess normality.

5.3.1 Missing Data

Missing data or blank responses can arise from several factors, such as errors in data entry, issues in data collection, or respondents skipping specific questions (Hair et al., 2018). According to Kang, (2013), the absence of data diminishes the efficacy of a dataset analysis. The present study used Google Forms to distribute the online questionnaire to the participants, with each section designated as mandatory. Regarding the hardcopy questionnaires distributed, eight (8) were excluded due to invalid or incomplete responses, which was the primary rationale for their exclusion. Therefore, 251 questionnaires were acknowledged and retained for the present study (Table 5.2).

Table 5.2
Total Number of Questionnaires

Items	Frequency	Percentage (%)
Questionnaires returned	259	100
Questionnaires excluded	8	3
Usable questionnaires	251	97

5.3.2 Normality

The data distribution's normality was evaluated using multivariate skewness and kurtosis, as recommended by Hair et al., (2022). The Mardia techniques were employed in this study to assess data normality. Mardia's coefficient helped verify normality, specifying skewness (±3) and kurtosis (±20) thresholds (Cain et al., 2017). A WebPower, an online statistics software, evaluated the data's normality.

This test was performed via a web application at: https://webpower.psychstat.org/models/kurtosis/.odels/kurtosis/. Consequently, the data exhibited a non-normal distribution, as indicated by the skewness ($\beta = 7.993$, $p < 0.01$) and kurtosis ($\beta = 65.953$, $p < 0.01$), both surpassing the established thresholds (see Figure 5.2). This information is crucial for identifying optimal approaches for data analysis, as every dataset, regardless of its distribution, requires a specific method and an appropriate tool. Thus, Smart-PLS is suggested as the preferred tool for analysing the study data (refer Table 4.6).

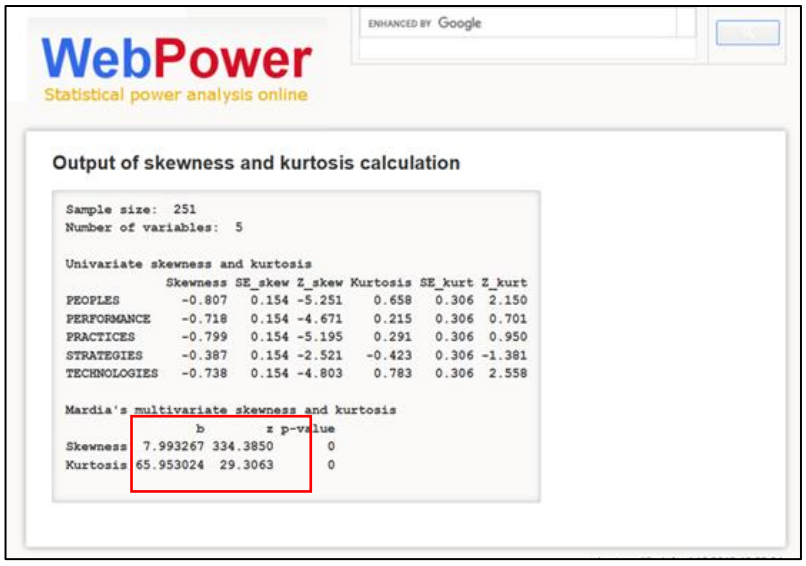


Figure 5.2 Normality Test of Mardia's

5.3.3 Common Method Bias (CMB)

Data collection for this study employed a single source and consistent methodology, making it essential to investigate for systematic bias, commonly referred to as common method bias (CMB). Kock et al. (2021) have pointed out that common method bias can adversely affect the validity of a study. This study evaluates common method bias by applying a full collinearity test and analysing full collinearity utilising Smart-PLS 4. All variables regressed against the common variable up to a threshold variance inflation factor (VIF) value of 10 (Kock, 2024) and the current study found that the VIF values do not exceed the threshold value of 10, as illustrated in Table 5.3. Ultimately, common method bias does not pose a significant concern in this study, as evidenced by the test. This suggests that the data gathered from a single source was not biased.

Table 5.3
Full Collinearity Testing Result

Item	Variance Inflation Factor (VIF)
People	4.575
Practice	5.621
Strategy	4.178
Technology	3.627
Average VIF	4.500

5.4 Descriptive Demographic Profile

This study describes the demographics of the respondents using eight elements: location of the respondents' organisations, the primary type of business, designations of respondents, education level, respondents' experience in IBS, types of stakeholders, type of IBS projects, and location of IBS projects (Table 5.4). The highest location of respondents who answered the survey was in Selangor, which accounted for 41.04% of the total. The second highest is Pulau Pinang, which accounts for 15.54%. Third is Kuala Lumpur with 8.37%, followed by other states: Kedah (7.17%), Sarawak (5.98%), Perak (5.18%), Johor (4.78%), Perlis (3.19%), Negeri Sembilan (2.39%), Kelantan (1.99%), Sabah (1.59%), Melaka (1.20%), Pahang (0.80%), and Terengganu (0.80%).

Only 70.12% of respondents are from contractor organisations, 9.16% from manufacturers, and 7.57% from consultants. This is followed by 4.78% from developers/clients/ project owners, 5.18% from government agencies, and 3.19% from IBS suppliers. For job designations, 28.69% are owners or directors of companies, 19.52% are civil or structural engineers, 17.13% are project managers, and 9.56% are quantity surveyors. Additionally, 6.37% are site supervisors. Both site managers and project supervisors account for 3.19% each. Architects comprise 2.79%, while construction managers represent 1.20%. Planners, QAQC engineers, and sales and marketing executives each constitute 1.60%, and mechanical and electrical engineers make up 0.40%. Finally, project coordinators, senior executive business development professionals, assistant production managers, logistics supervisors, yard supervisors, and occupational safety and health officers each represent 0.40%.

Among the respondents' education levels, 85.66% hold a degree, followed by 11.16% with a master's degree, 2.39% with a diploma, and 0.40% each with a Ph.D. and certification. In addition, most respondents have participated in IBS projects for less than five years, accounting for 57.37%. Only 26.29% of the respondents have worked in the construction industry for 6 to 10 years. Meanwhile, 7.97% of respondents have been in the construction industry for 11 to 15 years, and 5.18% have 16 to 20 years of experience in IBS. The remaining respondents, 3.19%, have over 20 years of experience. Concerning the type of stakeholders, only 26.29% of the project types involved stakeholders from the government, and 37.05% involved private stakeholders. Additionally, 36.65% represent private and government stakeholders for whom respondents have worked. The respondents indicated that utilising IBS in residential projects accounts for 38.65%, while non-residential projects contribute 22.31%. Furthermore, a balance of 39.04% exists for projects encompassing both types of IBS. Regarding the geographical distribution of IBS projects, the predominant concentration is in urban areas, comprising 43.43%. This is followed by a combined category of all locations, encompassing urban, suburban, and rural settings, at 24.70%. Suburban areas account for 22.31%, while rural regions represent the smallest percentage, at 9.56%.

Table 5.4
Demographic Profile

Description	Frequency	Percent (%)
Location of the respondent's organisation		
Selangor	103	41.04
Kuala Lumpur	21	8.37
Perak	13	5.18
Kedah	18	7.17
Pulau Pinang	39	15.54
Perlis	8	3.19
Kelantan	5	1.99
Terengganu	2	0.80
Negeri Sembilan	6	2.39
Melaka	3	1.20
Johor	12	4.78
Pahang	2	0.80
Sabah	4	1.59
Sarawak	15	5.98
Total	251	100.00
The primary type of business of the respondents' organisation		
Contractor	176	70.12
Developer/Client/ Project Owner	12	4.78
Consultant	19	7.57
Manufacturer	23	9.16
Supplier/ Installer	8	3.19
Government Agency	13	5.18
Total	251	100.00
Designation of respondents		
Owner / CEO / Managing Director / Director	72	28.69
Project Manager	43	17.13
Site Manager	8	3.19
Architect	7	2.79
Quantity Surveyor	24	9.56
Civil/ Structure Engineer	49	19.52
Site Supervisor	16	6.37
Others		
a - Planner	3	1.20
b - Project Coordinator	1	0.40
c - Senior Executive Business Development	1	0.40
d - QAQC Engineer	3	1.20
e - Sales & Marketing Executive	3	1.20

f - Project Supervisor	8	3.19
g - Construction Manager	5	1.99
h - OSH	1	0.40
i - Assistant Production Manager	1	0.40
j - Logistics Supervisor	1	0.40
k - M&E Engineer	4	1.60
l - Yard Supervisor	1	0.40
Total	251	100.00
Education level		
Diploma	6	2.39
Degree	215	85.66
Master	28	11.16
PhD	1	0.40
Others		
a- Certification	1	0.40
Total	251	100.00
Respondents' experience in IBS projects		
Less than 5 years	144	57.37
6 to 10 years	66	26.29
11 to 15 years	20	7.97
16 to 20 years	13	5.18
more than 20 years	8	3.19
Total	251	100.00
Stakeholders that being involved in the respondents' IBS projects		
Government	66	26.29
Private	93	37.05
Both	92	36.65
Total	251	100.00
Type of IBS projects		
Residential Project	97	38.65
Non-residential Project	56	22.31
Both	98	39.04
Total	251	100.00
The area of the IBS project has been constructed		
Urban	109	43.43
Sub-urban	56	22.31
Rural	24	9.56

All above		62	24.70
	Total	251	100.00

5.5 Mean Rating Analysis

This section identifies the best practices of IPD in IBS. It analyses survey results in response to objective two of this study, highlighting the most significant IPD best practices for IBS. The forty-three best practices mentioned in section 2.15 were incorporated into subsequent questionnaire sections. Respondents evaluated their agreement with each factor on a scale from 1 (strongly disagree) to 6 (strongly agree). This section emphasises IPD best practices in IBS construction, utilising SPSS version 28 for analysis. Summative results from descriptive statistics, including mean ratings, were determined by categorising and ranking the IPD best practices from the perspective of 251 respondents.

5.5.1 Mean Rating Analysis for IPD Best Practices for Strategy

The IPD best practices for "Strategy" element comprised twelve best practices: (i) top-down commitment; (ii) risk assessment; (iii) government support; (iv) government policies; (v) business and financial aspects; (vi) project trends and knowledge; (vii) quality management; (viii) adaptability to IBS; (ix) shared objectives and goals; (x) demand and supply; (xi) roles and responsibilities; (xii) shared risk and reward. As shown in the analysis below in Table 5.5, the results indicate that quality management has the highest mean (M= 4.84), followed by business and financial aspects (M= 4.79), government support (M= 4.78), project trends and knowledge (M= 4.78), roles and responsibilities (M= 4.71), risk assessment (M= 4.71), top-down commitment (M= 4.71), shared objectives and goals (M= 4.71), government policies (M= 4.70), adaptability to IBS (M= 4.63), demand and supply (M= 4.61), and shared risks and rewards (M= 4.57). Cross-checking with median and mode values revealed no outliers, as the median value was consistently five, with mode values of five and six across all components in the strategy group. The average mean value is 4.71, suggesting that all IPD best practices are vital to the strategy group for IBS.

Table 5.5
Mean Analysis for Strategy

Label	IPD Best Practices (BP) for IBS for Strategy	Mean	Mode	Median	Std. Deviation	Ranking
S1	Top-Down Commitment	4.71	5.00	5.00	1.008	7
S2	Risk Assessment	4.71	5.00	5.00	1.023	6
S3	Government Support	4.78	6.00	5.00	1.076	3
S4	Government Policies	4.70	5.00	5.00	1.049	9
S5	Business and Financial	4.79	5.00	5.00	0.966	2
S6	Project Trend and Knowledge	4.78	5.00	5.00	0.953	4
S7	Quality Management	4.84	6.00	5.00	1.041	1
S8	Adaptability to IBS	4.63	5.00	5.00	1.040	10
S9	Share Objectives & Goals	4.71	5.00	5.00	0.999	8
S10	Demand and Supply	4.61	5.00	5.00	1.109	11
S11	Roles and Responsibilities	4.71	5.00	5.00	1.058	5
S12	Shared Risks and Rewards	4.57	5.00	5.00	1.050	12
	Average Mean Score	*4.71*				

5.5.2 Mean Rating Analysis for IPD Best Practices in Technology

The IPD best practices for "Technology" included nine best practices: (i) information and communication technology (ICT); (ii) building information modelling (BIM); (iii) internet of things; (iv) robotics and automation; (v) IBS speed; (vi) plant availability; (vii) Computer Aided Design (CAD); (viii) Computer Aided Manufacturing (CAM); and (ix) virtual reality (VR) and augmented reality (AR). The analysis below (Table 5.6) shows that computer-aided design (CAD) has the highest mean score (M= 4.92), followed closely by the speed of IBS (M= 4.84), computer-aided manufacturing (CAM) (M= 4.67), building information modeling (BIM) (M= 4.59), information and communication technology (M= 4.59), plant availability (M= 4.55), the internet of things (M= 4.45), and robotic automation (M= 3.83), with virtual reality (VR) and augmented reality (AR) (M= 3.72). Cross-checking the median and mode values showed no outliers; the median values were four and five, while the mode values also reflected four and five across all best practices in technology groups. The mean

value averages at 4.39, indicating that all IPD best practices are essential to the technology group for IBS.

Table 5.6
Mean Analysis for Technology

Label	IPD Best Practices (BP) for IBS for Technology	Mean	Mode	Median	Std. Deviation	Ranking
T1	Information and Communication Technology (ICT)	4.59	5.00	5.00	1.033	5
T2	Building Information Modelling (BIM)	4.59	5.00	5.00	1.150	4
T3	Internet of Things (IoT)	4.45	4.00	4.00	1.110	7
T4	Robotic and Automation	3.83	4.00	4.00	1.329	8
T5	Speed of IBS	4.84	5.00	5.00	1.040	2
T6	Availability of Plant	4.55	5.00	5.00	1.190	6
T7	Computer Aided Design (CAD)	4.92	5.00	5.00	1.031	1
T8	Computer Aided Manufacturing (CAM)	4.67	5.00	5.00	1.077	3
T9	Virtual Reality (VR) and Augmented Reality (AR)	3.72	4.00	4.00	1.416	9
	Average Mean Score	*4.39*				

5.5.3 Mean Rating Analysis for IPD Best Practices in Practice

The IPD best practices for the element concerning "Practice" consist of eleven best practices approaches: (i) good working collaboration; (ii) established communication channels; (iii) comprehensive design, manufacturing, transportation, and installation; (iv) meticulous planning and scheduling; (v) appropriate procurement methods; (vi) standardisation; (vii) teamwork; (viii) supply chain support; (ix) better coordination; (x) early involvement of team members; (xi) mass production. The analysis in Table 5.7 below reveals that teamwork has the highest mean score (M= 4.90), followed closely by early involvement of team members (M= 4.85) and better coordination (M= 4.85). Other noteworthy aspects include design, manufacture, transportation, and installation (M= 4.84), appropriate procurement method (IPD) (M= 4.83), planning and scheduling (M= 4.83), good working collaboration (M= 4.83),

communication channels (M= 4.81), standardisation (M= 4.81), mass production (M= 4.79), and supply chain support (M= 4.79). The process of cross-referencing median and mode values indicated the absence of outliers, as the median value consistently registered at five, with mode values of five and six being observed across all components within the practice group. The computed average mean value is 4.83, implying that all IPD best practices are essential to the practice group dedicated to IBS.

Table 5.7
Mean Analysis for Practice

Label	IPD Best Practices (BP) for IBS for Practice	Mean	Mode	Median	Std. Deviation	Ranking
P1	Good Working Collaboration	4.83	5.00	5.00	1.027	7
P2	Communication Channels	4.81	6.00	5.00	1.077	8
P3	Design, Manufacture, Transportation and Installation	4.84	5.00	5.00	1.049	4
P4	Planning and Scheduling	4.83	5.00	5.00	1.045	6
P5	Appropriate Procurement Method (IPD)	4.83	6.00	5.00	1.112	5
P6	Standardisation	4.81	5.00	5.00	1.040	9
P7	Teamwork	4.90	5.00	5.00	1.013	1
P8	Supply Chain Support	4.79	5.00	5.00	1.022	11
P9	Better Coordination	4.85	5.00	5.00	1.016	3
P10	Early Involvement of Team Members	4.85	6.00	5.00	1.070	2
P11	Mass Production	4.79	5.00	5.00	1.049	10
	Average Mean Score	*4.83*				

5.5.4 Mean Rating Analysis for IPD Best Practices in People

The IPD best practices for “People" element identified by eleven best practices: (i) owner competent in IBS; (ii) staff efficiency and expertise; (iii) leadership and attitude of the project manager; (iv) adequate staff qualifications; (v) ongoing training and education; (vi) personal work attitude; (vii) key decision making; (viii) continuous improvement; (ix) focus with customer objectives; (x) mutual respect and trust; (xi) close relationships. The analysis below in Table 5.8 reveals that the close relationship item has the highest mean score (M= 4.95), followed by mutual respect and trust (M=

4.95), key decision making (M= 4.90), focus with customer objectives (M= 4.89), a personal work attitude (M= 4.88), commitment to continuous improvement (M= 4.87), project manager leadership and attitude (M= 4.84), training and education initiatives (M= 4.74), adequate staff qualifications (M= 4.71), staff efficiency and experience (M= 4.70), and owner competence in IBS (M= 4.62). Reviewing the median and mode values showed no outliers; the median remained at five, with mode values of five and six for all components in the practice group. The average mean value of 4.82 indicates that all IPD best practices are essential for the people group.

Table 5.8
Mean Analysis for People

Label	IPD Best Practices (BP) for IBS for People	Mean	Mode	Median	Std. Deviation	Ranking
H1	Owner Competent in IBS	4.62	4.00	5.00	1.041	11
H2	Staff Efficiency and Experience	4.70	5.00	5.00	1.079	10
H3	Project Manager Leadership and Attitude	4.84	5.00	5.00	0.993	7
H4	Adequate in Staff Qualification	4.71	5.00	5.00	1.043	9
H5	Training and Education	4.74	5.00	5.00	1.071	8
H6	Good Personal Working Attitude	4.88	5.00	5.00	1.026	5
H7	Key decision	4.90	5.00	5.00	0.983	3
H8	Continuous Improvement	4.87	5.00	5.00	1.043	6
H9	Focus on Customer Objectives	4.89	5.00	5.00	0.977	4
H10	Mutual Respect and Trust	4.95	5.00	5.00	0.958	2
H11	Close Relationship	4.95	6.00	5.00	1.009	1
	Average Mean Score	*4.82*				

5.5.5 Mean Rating Analysis for IBS Project Performance

The IBS project performance consists of four items: (i) cost; (ii) time; (iii) quality; and (iv) integration. The analysis below in Table 5.9 reveals that the time has the highest mean score (M= 5.10), followed by integration (M= 4.86), quality (M=

4.85), and finally, cost (M= 4.70). The average mean value of 4.88 indicates that all IBS project performances are important.

Table 5.9
Mean Analysis for IBS Project Performance

Label	Best Practices (BP) for Integrated Project Delivery (IPD) in IBS	Mean	Mode	Median	Std. Deviation	Ranking
PM1	Cost	4.70	5.00	5.00	1.153	4
PM2	Time	5.10	6.00	5.00	0.985	1
PM3	Quality	4.85	5.00	5.00	1.074	3
PM4	Integration	4.86	5.00	5.00	1.018	2
	Average Mean	4.88				

In summary, participant evaluations of the best practices for Integrated Project Delivery (IPD) in Industrialised Building System (IBS) are consistently favorable. The scores for IPD best practice groups are relatively high, with an average of 4.71 for strategy, 4.39 for technology, 4.83 for practice, and 4.82 for the people group, respectively. Nevertheless, based on Table 5.6 above, the respondents are less confident in assessing the best practice factors in the technology group. The technology group has an average mean score of 4.39, which is significantly lower than the average mean scores of the other group due to the best practices factors for virtual reality and augmented reality (M= 3.72) and robotic and automation (M= 3.83), since their mean scores are significantly lower than all the others. According to an interview with a CIDB officer, it was revealed that robotics, automation, virtual reality, and augmented reality were implemented in July 2016 when Gamuda launched Gamuda Industrialised Building System Sdn. Bhd. (Gamuda IBS). This factory marked Malaysia's first digital IBS facility, utilising digital technology for construction. By the end of 2025, it is expected that no more than five companies have adopted this technology. The average score for the IBS project performance is 4.88, indicating that the variable is suitable for use in the following analysis. In summary, the respondents agree that the IPD best practices and IBS project performance outlined in this study are crucial for enhancing IBS performance.

5.6 Reflective Measurement Model Analysis

The reflective measurement model analysis includes reliability (Indicator and Internal Consistency) and validity (Convergent and Discriminant). The analyses above the minimum required threshold value for all reflective constructs, as shown in Table 5.10 and Figure 5.3.

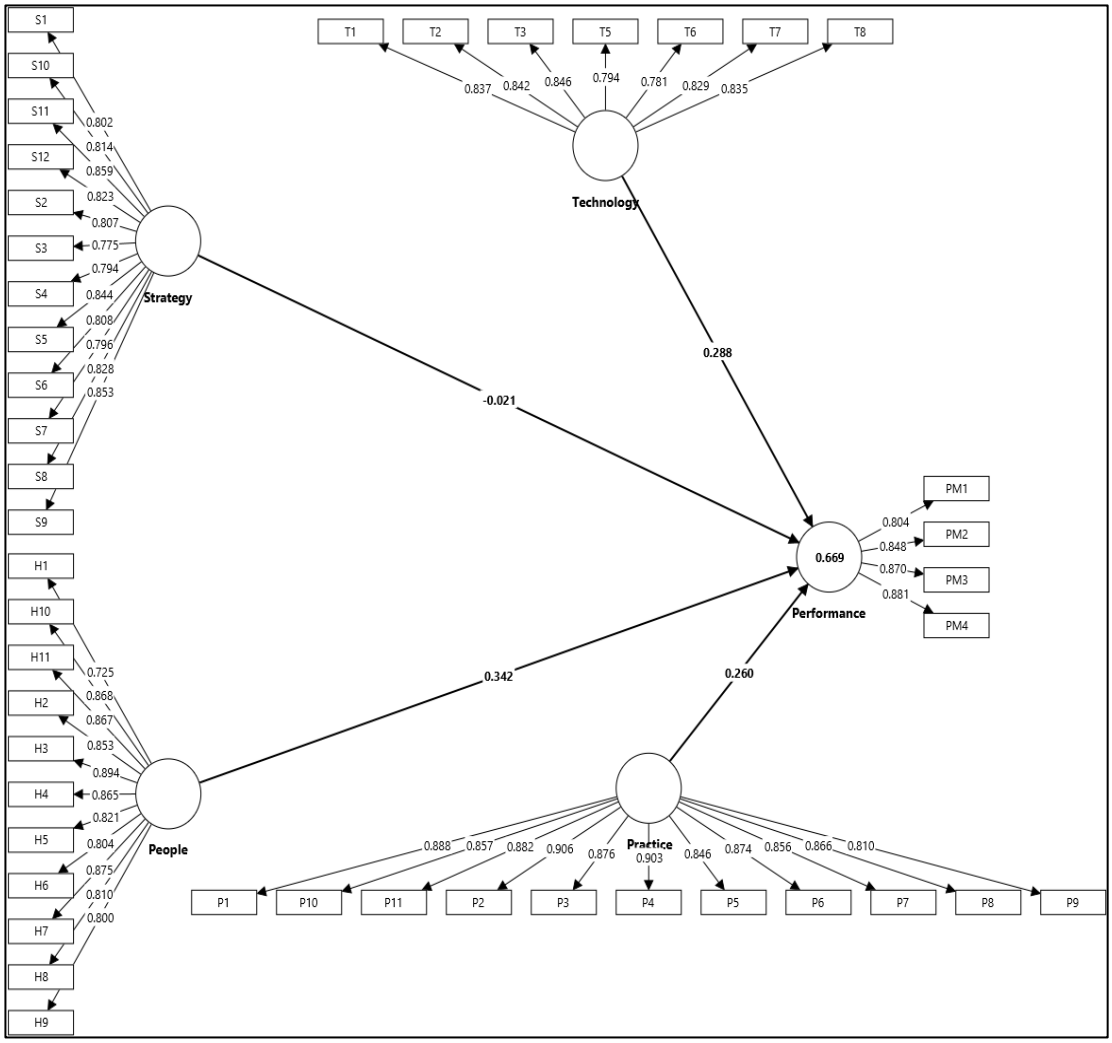


Figure 5.3 The Reflective Measurement Model Analysis

5.6.1 Indicator Consistency

The reliability of each indicator or item can be assessed by examining the individual correlations between the indicators and their theoretically related groups. A satisfactory correlation between the indicators and the respective group (Strategy,

Technology, Practice, People, and Performance) is crucial. The reliability of the individual indicator is assessed by looking at the extent of each load on the group (Hair et al., 2011). Indicators with outer loadings of 0.70 or more are regarded as highly satisfactory (Hair et al., 2019a). The cut-off value decided for outer loading in this study is 0.70 and higher, whereas those less than 0.70 should be removed. In this regard, two indicators (T4 = 0.520 and T9 = 0.434) were omitted due to their lower loading and effect on Composite Realibity (CR) and Average Variance Extraxted (AVE) values. The analysis results for all the indicators have met the criteria with loading values of more than 0.70 in Table 5.10.

5.6.2 Internal Consistency Reliability

The second factor for reliability is the evaluation of two measures which are Composite Reliability (CR) and Cronbach's Alpha (CA). The composite reliability (CR), with defined standards of acceptable (0.60-0.70), satisfactory (0.70-0.90), and higher (>0.95) values (Hair et al., 2019a) indicates that the study's constructs meet those standards. Another metric of internal consistency reliability is Cronbach's alpha (CA), which uses comparable standards. This study found that CA values also exceeded the standards. Table 5.10 shows the values for both CA and CR that are more than 0.70 in the PLS-Algorithm. To summarise, all sets of indicators receive favourable evaluations from their respective groups.

5.6.3 Convergent Validity

Convergent Validity refers to agreement of items that measure the same construct (Sadikoglu & Zehir, 2010). The average of the variants extracted (AVE) is used to evaluate convergent validity (Fauzi, 2023). Hair et al. (2017) recommended that the value of AVE should be at least equal to or greater than the fifty per cent threshold value of the assigned indicators' variance (AVE>0.50) in order to achieve adequate convergent validity. Table 5.10 shows the value of the AVE results, which are more than the threshold value of 0.50, indicating a high level of convergent validity.

Table 5.10
Measurement Model Result

Group	Indicators	Indicator and Internal Consistency Reliability				Convergent Validity
		Loading	Cronbach's Alpha	Composite Reliability (rho_a)	Composite Reliability (rho_c)	Average Variance Extracted (AVE)
People	**H1**	0.725	0.957	0.959	0.962	0.699
	H10	0.868				
	H11	0.867				
	H2	0.853				
	H3	0.894				
	H4	0.865				
	H5	0.821				
	H6	0.804				
	H7	0.875				
	H8	0.810				
	H9	0.800				
Practice	**P1**	0.888	0.968	0.968	0.972	0.756
	P10	0.857				
	P11	0.882				
	P2	0.906				
	P3	0.876				
	P4	0.903				
	P5	0.846				
	P6	0.874				
	P7	0.856				
	P8	0.866				
	P9	0.810				
Performance	**PM1**	0.804	0.873	0.876	0.913	0.724
	PM2	0.848				
	PM3	0.870				
	PM4	0.881				
Strategy	**S1**	0.802	0.955	0.956	0.96	0.668
	S10	0.814				
	S11	0.859				
	S12	0.823				

	S2	0.807				
	S3	0.775				
	S4	0.794				
	S5	0.844				
	S6	0.808				
	S7	0.796				
	S8	0.828				
	S9	0.853				
Technology	**T1**	0.837	0.921	0.921	0.937	0.678
	T2	0.842				
	T3	0.846				
	T5	0.794				
	T6	0.781				
	T7	0.829				
	T8	0.835				

5.7 Discriminant Validity

The discriminant validity can be defined as the extent to which indicators distinguish between constructs by evaluating the relationship among measures that have the potential to overlap (Ahmad, 2023). This research utilised two methods for assessing discriminant validity: the heterotrait-monotrait (HTMT) method and the cross-loading criterion.

5.7.1 The heterotrait-monotrait (HTMT)

The heterotrait-monotrait (HTMT) criterion assessed the measurement model's discriminant validity. HTMT is characterised by two measurement approaches known as stricter (≤0.85) and lenient (≤0.90) (Franke & Sarstedt, 2019; Ringle et al., 2012). Table 5.11 shows that the HTMT values met the criterion (≤0.90) that supports the validity of the construct. Thus conclude the measurement model analysis is recognised as reliable and valid.

Table 5.11
Heterotrait-Monotrait Ratio (HTMT)

	People	Performance	Practice	Strategy	Technology
People					
Performance	0.843				
Process	0.900	0.842			
Strategy	0.853	0.772	0.869		
Technology	0.826	0.836	0.869	0.855	

5.7.2 Cross Loading Criterion

The second assessment for discriminant validity is based on cross loadings. This approach is executed by checking the cross-loading matrix. The loadings of indicators on the allotted construct should be more than the loadings on all other constructs (Hair et al., 2017; Ramayah et al., 2016). This proves that the indicators of the construct successfully measured the targeted construct. Table 5.12 indicates the validation of discriminant validity using the cross-loading technique, and it was clear that all indicator loadings (appearing in bold) loaded higher than the cross loadings on all other constructs. This suggests that the discriminant validity of the outer model is satisfactory.

Table 5.12
Cross Loading Result

	People	Practice	Strategy	Technology	Performance
H1	**0.725**	0.619	0.592	0.576	0.540
H10	**0.868**	0.704	0.671	0.646	0.661
H11	**0.867**	0.727	0.676	0.679	0.687
H2	**0.853**	0.767	0.728	0.669	0.663
H3	**0.894**	0.791	0.772	0.730	0.693
H4	**0.865**	0.772	0.728	0.705	0.662
H5	**0.821**	0.769	0.691	0.644	0.604
H6	**0.804**	0.679	0.662	0.573	0.618
H7	**0.875**	0.765	0.719	0.678	0.720
H8	**0.810**	0.739	0.679	0.638	0.626
H9	**0.800**	0.614	0.580	0.594	0.624
P1	0.736	**0.888**	0.788	0.756	0.696
P10	0.772	**0.857**	0.692	0.721	0.673
P11	0.757	**0.882**	0.718	0.690	0.669
P2	0.771	**0.906**	0.780	0.730	0.681
P3	0.752	**0.876**	0.732	0.755	0.697

P4	0.756	**0.903**	0.752	0.720	0.688
P5	0.737	**0.846**	0.752	0.690	0.626
P6	0.762	**0.874**	0.752	0.752	0.670
P7	0.736	**0.856**	0.690	0.681	0.673
P8	0.751	**0.866**	0.708	0.679	0.673
P9	0.750	**0.810**	0.634	0.686	0.670
S1	0.655	0.662	**0.802**	0.611	0.547
S10	0.667	0.730	**0.814**	0.682	0.562
S11	0.733	0.744	**0.859**	0.692	0.598
S12	0.687	0.716	**0.823**	0.696	0.599
S2	0.675	0.675	**0.807**	0.661	0.553
S3	0.576	0.600	**0.775**	0.547	0.545
S4	0.591	0.626	**0.794**	0.597	0.537
S5	0.695	0.711	**0.844**	0.693	0.634
S6	0.630	0.651	**0.808**	0.663	0.551
S7	0.719	0.696	**0.796**	0.699	0.587
S8	0.659	0.672	**0.828**	0.663	0.589
S9	0.710	0.705	**0.853**	0.659	0.623
T1	0.624	0.660	0.681	**0.837**	0.596
T2	0.615	0.659	0.662	**0.842**	0.606
T3	0.635	0.659	0.663	**0.846**	0.586
T5	0.686	0.663	0.654	**0.794**	0.635
T6	0.678	0.730	0.686	**0.781**	0.642
T7	0.660	0.680	0.660	**0.829**	0.639
T8	0.573	0.681	0.617	**0.835**	0.618
PM1	0.582	0.653	0.595	0.648	**0.804**
PM2	0.623	0.618	0.540	0.607	**0.848**
PM3	0.679	0.641	0.599	0.643	**0.870**
PM4	0.742	0.724	0.668	0.659	**0.881**

5.8 Structural Model Analysis

This study examines structural model analysis. The proposed model comprises four primary hypotheses, which were evaluated through the analysis of path coefficients (standard beta, t-values, and p-values), coefficient of determination (R^2), effect size (f^2), and other measures of predictive relevance (Q^2 predict). The structural model utilised a bootstrapping technique encompassing 10,000 resamples.

5.8.1 Collinearity Assessment

Before proceeding with the analysis of the significance of variable relationships or hypotheses, it is important to address the issue of collinearity within each construct. This final step focuses on assessing and managing collinearity to ensure the reliability and accuracy of the analysis. A collinear model is characterised by a high correlation between the predictor variables and the latent constructs, which can make it difficult to estimate the relationship between the predictor variables and the latent constructs with precision (Hair et al., 2017). This means that collinearity refers to high correlations between predictor variables, which can affect the accuracy of estimating relationships between the predictors and latent constructs. Hence, when there is a high correlation between predictor variables, it can be challenging to accurately estimate the relationship between the predictors and the latent constructs. Therefore, a method for evaluating collinearity is to examine the Variance Inflation Factor (VIF). The average full collinearity VIF (AFVIF), were below 5, suggesting low levels of vertical and lateral collinearity (Hair et al., 2019a), hence demonstrating that collinearity is not a problem (see Table 5.13).

Table 5.13
Collinearity Assessment Results

Index	Value	Interpretation
Average full collinearity VIF (AFVIF)	4.500	Acceptable if ≤5

5.8.2 Path Coefficient

Path coefficients reflect the expected correlations between the constructs, with the suggested standardised value range of -1 to +1 (Hair et al., 2011). For instance, path coefficients near +1 suggest a strong positive relationship (and the opposite is true for negative values) (Hair et al., 2017). The data collected was not normally distributed; therefore, a bootstrapping method using 10,000 bootstrap samples with replacement was employed from the original sample to identify common bootstrapping errors and assess the significance of the path coefficients. A hypothesis is deemed significantly positive when the t-values for one-tailed tests surpass 2.33 at $p<0.01$ or 1.645 at $p<0.05$ (see Figure 5.4 and Table 5.14).

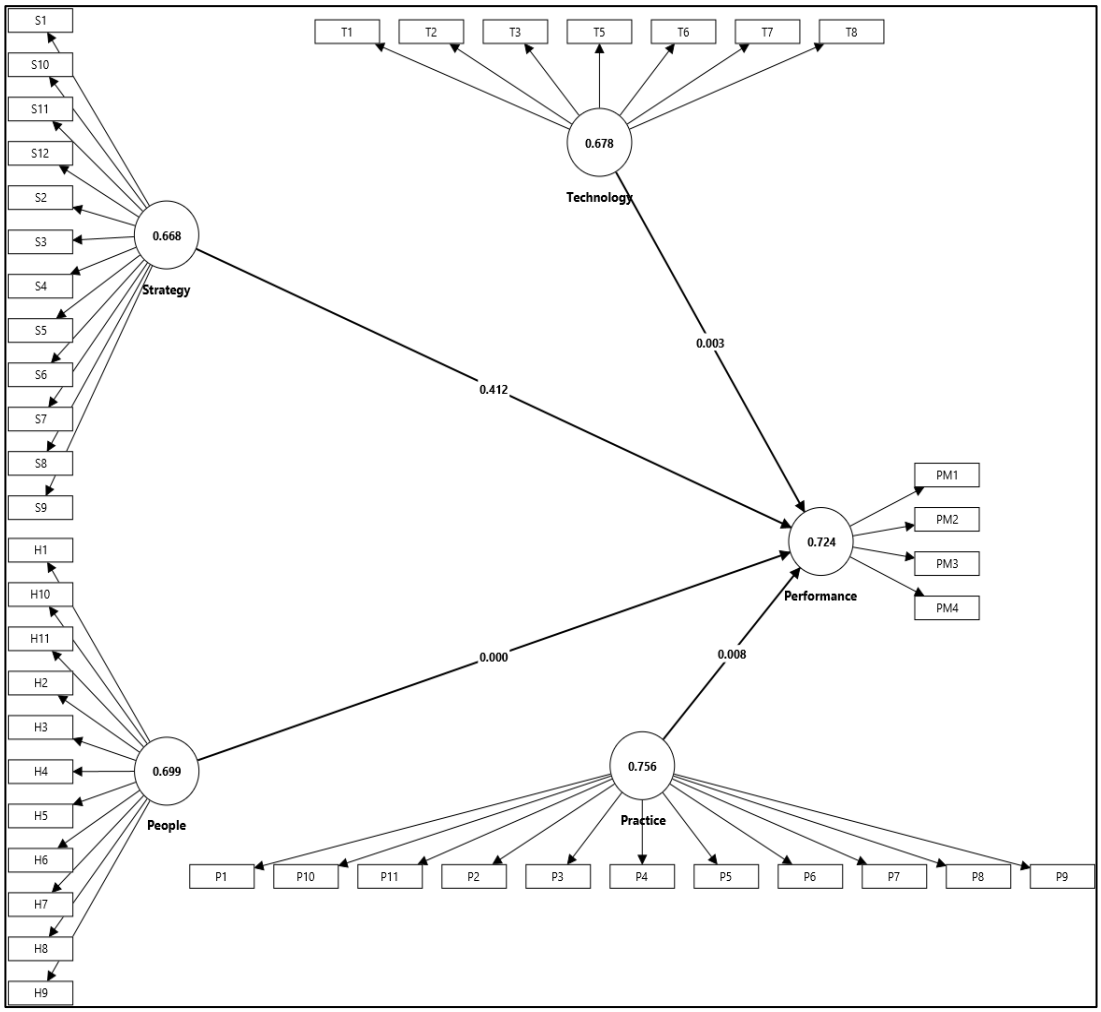


Figure 5.4 The Structural Model Analysis

Table 5.14
Structural Model Assessment Results

Hypothesis	Relationship	Path Coefficient (β)	t-value	p-value	Decision
H1	People ->Performance	0.342	4.016*	0.000	Supported
H2	Practice -> Performance	0.260	2.416*	0.008	Supported
H3	Strategy -> Performance	-0.021	0.223	0.412	Not Supported
H4	Technology -> Performance	0.288	2.787*	0.003	Supported

Note: Significance value: *p<0.05 (t>1.645), **p<0.01 (t>2.33)

According to Figure 5.4 and Table 5.14, the bootstrapping procedure in PLS SEM revealed that the relationships between people and performance (β = 0.342, t-

value = 4.016), practice and performance (β = 0.260, t-value = 2.416), and technology and performance (β = 0.288, t-value = 2.787) were significant at p< 0.05. These results testify that H1, H2, and H4 were supported. On the contrary, the relationships between strategy and performance (β = -0.021, t-value = 0.223) were insignificant; thus, H3 was not supported.

5.8.3 Assessment of R^2 and f^2

R^2 was deployed to assess the model fit. According to Ramayah et al. (2016), R^2 was a gauge of the model's predictive accuracy and was also interpreted as the integrated effect of independent variables and dependent variables. Hair et al. (2017) recommended a value for the R^2 to be as follows: 0.75, which indicated substantial, 0.50 indicated moderate and 0.25 indicated weak. A variable in the structural model can be affected by several different variables (Ahmad, 2023). f^2 assesses the relative impact and how strong an exogenous construct is on an endogenous construct, and the f^2 is classified into three levels, such as weak (> 0.02), moderate (>0.15), and substantial (>0.35) (Cohen, 2013). Removing an exogenous variable can affect the dependent variable. f2 represents the change in R2 when an exogenous variable is removed from the model.

Table 5.15
R^2 and f^2 Result

Hypothesis	Relationship	R^2	f^2
H1	People ->Performance	0.67	0.077
H2	Practice -> Performance	0.67	0.036
H3	Strategy ->Performance	0.67	0.000
H4	Technology ->Performance	0.67	0.069

As shown in Table 5.15, the R^2 value of 0.67 is above 0.25 as suggested by Hair et al. (2017), which indicates a substantial model. f^2 results are 0.077, 0.036, 0.000 and 0.069, respectively. Therefore, in line with the guideline suggested by Cohen (2013), the effect sizes of these four exogenous constructs on endogenous constructs can be

considered as none for strategy and small effect sizes for people, practice, and technology, respectively.

5.8.4 Predictive Relevance of The Model (Q^2)

According to Ramayah et al. (2016) Q^2 value was used to predict the relevance of the model. This assessment was deployed to dependent constructs that have reflective measurement model characteristics. A blindfolding procedure was conducted for this assessment. Hair et al. (2019) mention that if values larger than 0 were present in the results, the independent constructs were proved to have predictive relevance for the dependent construct model. In Table 5.16 below, all the Q^2 values for people (Q^2= 0.432), practice (Q^2= 0.416), strategy (Q^2= 0.475), and technology (Q^2= 0.562) are more than 0, indicating that the model has sufficient predictive relevance.

Table 5.16
Q^2 Result

H1	People -> IBS Project Performance	0.432
H2	Practice -> IBS Project Performance	0.416
H3	Strategy -> IBS Project Performance	0.475
H4	Technology -> IBS Project Performance	0.562

5.8.5 Hypothesis

5.8.5.1 H1: There is a significant positive relationship between people and IBS project performance.

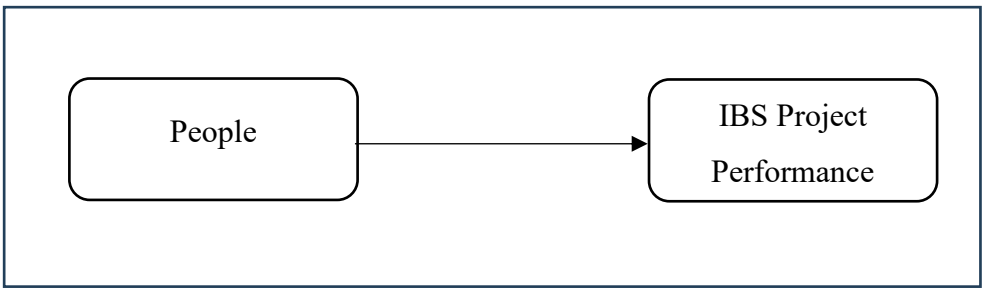


Figure 5.5 The Relationship Between People and IBS Project Performance

The first hypothesis (H1) in this model is that people have a significant positive relationship with performance as exhibited in Figure 5.5. The relationship between people and performances was empirically significant ($\beta = 0.342$, $t = 4.016$), supporting the H1. People were found to have a positive relationship with performance, explaining 67% of its variation ($R^2 = 0.67$). Furthermore, people had an effect size (f^2) of 0.077, indicating a small to moderate effect (>0.15) (Cohen, 2013). The results also showed a predictive relevance value known as Q^2, which was evaluated using the blindfolding technique. H1 discovered that the redundant communality for people (0.432) was more than zero, resulting in the performance prediction capability (Shmueli et al., 2019). In conclusion, significant statistical evidence supported the proposed relationship in this model regarding people and performances.

5.8.5.2 H2: There is a significant positive relationship between practice and IBS project performance.

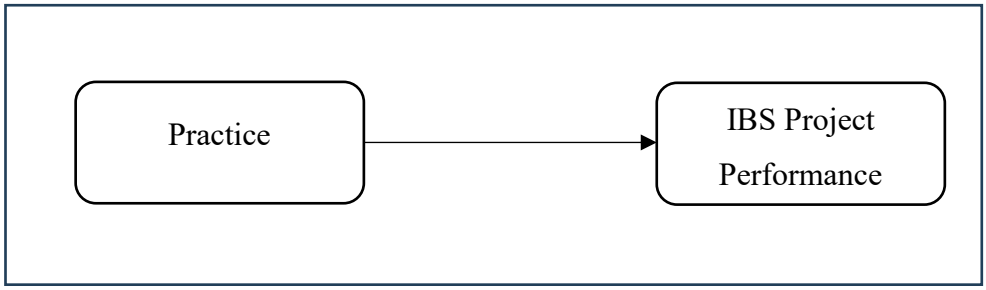


Figure 5.6 The Relationship Between Practice and IBS Project Performance

The model's second hypothesis (H2) is that practice has a significant positive relationship with performance, as illustrated in Figure 5.6. The relationship between practice and performance was determined to offer statistically significant evidence ($\beta = 0.260$, $t = 2.416$) to substantiate H2. The result found that 67 per cent ($R^2 = 0.67$) of practice explained the performance variation deemed acceptable for the coefficient of determinant in this model (Falk & Miller, 1992). Besides that, the practice revealed a substantial effect size ($f^2 = 0.036$) on performance, surpassing the 0.02 small effect size value (Cohen, 2013). The relationship also used the blindfolding technique to evaluate the predictive relevance of Q^2. The results revealed that both values were greater than zero ($Q^2 = 0.416$), proving the strong power of predictive relevance (Shmueli et al.,

2019). In summary, this study discovered that the relationship between practice and performance was strongly justified by empirical scientific evidence.

5.8.5.3 H3: There is a significant positive relationship between strategy and IBS project performance.

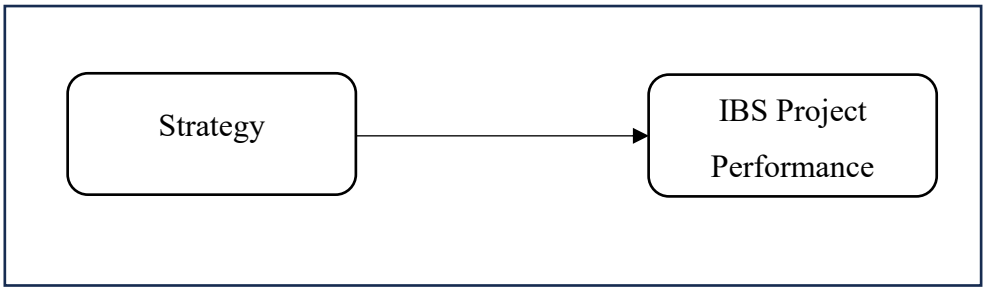


Figure 5.7 The Relationship Between Strategy and IBS Project Performance

The third hypothesis (H3) in this model is a novel proposition: strategy has an insignificant relationship with performance, as demonstrated in Figure 5.7. The strategy was found to be negatively associated with performance, as indicated by path coefficients ($\beta = -0.021$, $t = 0.223$). This is due to the requirement that the t-values must surpass 1.645 at a significance level of $p<0.05$ for the hypothesis to be regarded as significantly positive (Hair et al., 2017). Therefore, there was no significant relationship between strategy and performance.

5.8.5.4 H4: There is a significant positive relationship between technology and IBS project performance.

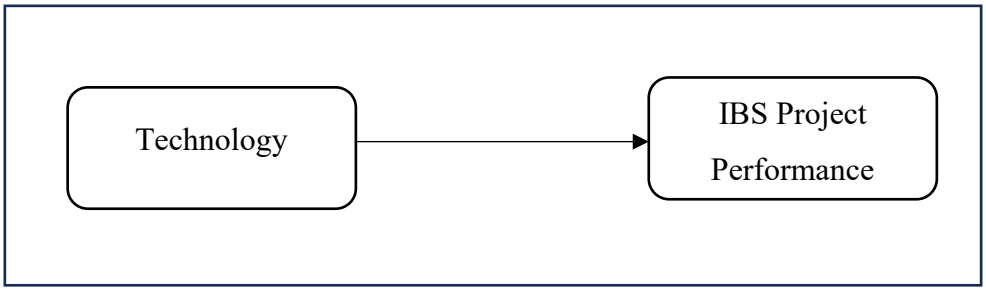


Figure 5.8 The Relationship Between Technology and IBS Project Performance

The fourth hypothesis (H4) in this model is a novel proposition: technology has a substantial positive relationship with performance, as demonstrated in Figure 5.8. The empirical findings validated the concept that technology has a significant influence on performance. First, technology was found to be positively associated with performance by path coefficients ($\beta = 0.288$, $t = 2.787$) result. Second, technology contributed 67 per cent ($R^2 = 0.67$ of the variation in performance that surpassed the 0.33 threshold value, which was considered moderate (Chin, 1998a). Third, the effect size for this relationship was moderate ($f2 = 0.069$), exceeding the 0.02 threshold (Cohen, 2013). Fourth, this relationship's predictive relevance values ($Q^2 = 0.263$) have strong power due to exceeding zero (Shmueli et al., 2019). The results were obtained using the blindfolding technique. The novel proposition of this model that technology correlates with performance is supported by empirical scientific evidence. Correspondingly, technology and performance demonstrated a significant relationship, as found in the prior study.

5.9 Expert Validation for the Results Analysis

To verify the validity of this model for use in the Malaysian construction industry, an expert validation was performed. This validation involved specialists in IBS, who reviewed the results to gather their feedback and insights. The experts focused on two main aspects: 1) the acceptance of the content model (assessment of the measurement model) and 2) the acceptance of the findings within the model (assessment of the structural model). The validation of the proposed research model involved conducting structured interviews with five experts specialising in the field of IBS. The expert validation process was conducted from June 9 to 30, 2025. The model validation was explicitly assessed by respondents who are involved in IBS. Based on the validation conducted, the majority of respondents possess at least 10 years of experience in IBS, while only two respondents have less than 10 years of experience. A comprehensive summary of the respondents' profiles during the expert validation process is provided in Table 5.17, and their feedback on the validation sessions is shown in Table 5.18.

Table 5.17
Respondent Profile in The Validation Process

Expert	Organisation	Position	Experience
Expert 1	Local Authorities	Manager	11-20 years
Expert 2	IBS Consultant	Sr. Engineer	6-10 years
Expert 3	IBS Developer/ Client	Interior Designer	6-10 years
Expert 4	IBS Contractor	Assistant Manager	11-20 years
Expert 5	IBS Manufacturer	Technical Advisor	More than 20 years

Table 5.18
Acceptance Level of PLS-SEM Model by Experts

No.	Relationship	Expert Panels				
		1	2	3	4	5
1	There is a significant positive relationship between people and the IBS project performance.	Agree	Agree	Agree	Agree	Agree
2	There is a significant positive relationship between practice and IBS project performance.	Agree	Agree	Agree	Agree	Agree
3	There is no significant relationship between strategy and IBS project performance.	Agree	Disagree	Disagree	Agree	Agree
4	There is a significant positive relationship between technology and IBS project performance.	Agree	Agree	Agree	Agree	Agree

Expert Panel	Relationship	Comments/ Feedback
Expert Panel 1	People > Performance	• Agreed with the research result. • Based on a research study on IBS in Sabah, training and continuous improvement play a crucial part in enhancing IBS performance.
	Practice > Performance	• Agreed with the research result.

		• Collaboration among IBS is important for the performance of IBS.
	Strategy > Performance	• Agreed with the research result. • Strategy does not impact performance because the government exempts the use of IBS based on several factors.
	Technology > Performance	• Agreed with the research result. • The minimum implementation of technology can deliver good IBS performance.
Expert Panel 2	People > Performance	• Agreed with the research result.
	Practice > Performance	• Agreed with the research result.
	Strategy > Performance	• Disagreed with the research result. • Strategy is essential, and other factors influence the findings. • Other factors like political changes in government, government policies, and the complexity of the projects.
	Technology > Performance	• Agreed with the research result.
Expert Panel 3	People > Performance	• Agreed with the research result. • Training and education played a significant part in the increased IBS players and project performance.
	Practice > Performance	• Agreed with the research result. • Early involvement of IBS players is crucial for IBS performance.
	Strategy > Performance	• Disagreed with the research result. • The complexity of the project can influence the relationship, including

		factors like the availability of time. More time is needed for a more complex IBS project.
	Technology > Performance	• Agreed with the research result. • Technology available is a must-have system to support the IBS project.
Expert Panel 4	People > Performance	• Agreed with the research result.
	Practice > Performance	• Agreed with the research result.
	Strategy > Performance	• Agreed with the research result. • There may be other factors that influence the insignificant relationship, such as the size of the IBS company.
	Technology > Performance	• Agreed with the research result.
Expert Panel 5	People > Performance	• Agreed with the research result. • The project owner must have basic IBS knowledge.
	Practice > Performance	• Agreed with the research result. • The collaboration among IBS players at each phase is essential in the IBS project.
	Strategy > Performance	• Agreed with the research result. • Items under Strategy are suitable for a larger company than typical IBS contractors
	Technology > Performance	• Agreed with the research result. • BIM is a crucial technology for IBS implementation.

Below are the experts' feedback and comments regarding the acceptance level of the proposed model.

a) Expert panel 1

I agree with the relationship between people and IBS project performance. For example, a research study on IBS in Sabah demonstrated a willingness to attend training and improve their competency in IBS. This indicates that training and continuous improvement play a crucial part in enhancing their IBS performance. For relationship practice with the IBS project performance, I also agree. KTI Group has strengthened its relationship as a contractor with the IBS manufacturer and the IBS developer. Collaboration among IBS parties and the supply chain within the IBS circle is crucial to ensure the IBS project runs smoothly. For government projects, based on the Ministry of Finance Circular 1.10, all projects with a value of RM10 million or more are required to use IBS with a minimum score of 70 IBS. Despite the circular, the minister can grant an exemption to use IBS based on several factors. Therefore, I agree that strategy does not affect the performance of IBS. The adoption of technology is also crucial in IBS, as it has a significant impact on the performance of IBS. Based on a case study conducted by CIDB, the minimum implementation of technology can deliver good IBS performance with certain costs involved. The availability of plants is also very crucial in the implementation of IBS projects. For robotics, automation, virtual, and augmented reality, these technologies are still in the early stages of implementation, with only large companies like Gamuda IBS, IJM IBS, and CIBS having adopted them. For regular IBS contractors, they lack the capability to invest in such technologies.

b) Expert panel 2

I disagree that there is no relationship between strategy and IBS project performance. For me, all the best practice factors in strategy are very important. I believe other factors influence the respondent's answers on this hypothesis. Best practice factors, such as government support, played a crucial role in IBS in Malaysia since its introduction in the early 1960s, and possibly political changes in the government and the implementation of government policies influenced the

IBS company's strategy. I think the complexity of the project and the location of the site influence the relationship between strategy and IBS project performance. For example, if the project is located in a remote area and has limited supplies of IBS material, or if IBS material cannot be delivered, the project may use the traditional method due to an exemption granted by the government.

c) Expert Panel 3

For the relationship between people and performance, training and education play a significant positive role in the IBS industry. For optimal performance in IBS, early involvement of team members is crucial to facilitate their effective integration and collaboration. Regarding strategy, the availability of time influences the insignificant relationship due to the project's complexity. For example, additional time is required to complete tasks of greater complexity in IBS project. Other than that, the larger the IBS project, the higher the initial cost for IBS components, which hinders the average IBS contractor from participating in that project. The technology available nowadays is significant for IBS, supporting the continuous improvement project performance.

d) Expert Panel 4

I agree with the researcher's study findings; however, there may be other factors that influence the insignificant relationship between strategy and performance. This may be due to the size of IBS companies themselves, which can affect the strategy. The typical IBS G7 contractor can be considered an average contractor because their main goal is to sustain themselves in the industry, and they target only a small portion of the IBS scope of work. This differs from large IBS stakeholders like Gamuda and IJM, which are willing to invest in IBS by establishing GAMUDA IBS and IJM IBS to secure a larger portion of IBS projects and ensure long-term sustainability in the industry. It also demonstrates that these companies are prepared to follow the project trend and to adopt modern construction methods (IBS), rather than relying solely on traditional methods.

e) Expert Panel 5

I agree that there is a significant relationship between people with IBS and

project performance. For example, the client or project owner must have a basic understanding of IBS so that the project can run smoothly without any delays that may arise from the client's side. Regarding practices, the management of IBS during design, manufacturing, transportation, and installation also plays a crucial part in ensuring the project runs smoothly from the start. I also agree that there is no significant relationship between strategy and IBS project performance. This is because, the items under the strategy are suitable for large companies like Gamuda IBS, IJM IBS, Setia Precast and others, rather than a typical G7 IBS contractor. The typical IBS contractor does not have sufficient funds to make the IBS components themselves. Besides that, the IBS construction in Malaysia is still in close approach implementation. For the final hypothesis, I agree with the outcome that there is a significant relationship between technology and IBS project performance. Nowadays, Building Information Modelling (BIM) is a crucial technology for IBS, especially in the early stages, such as at the design stage.

In conclusion, all expert panels provided highly positive feedback and comments regarding the proposed model. This feedback and comments from the expert panels were incorporated into the discussion of the data analysis results.

5.10 Discussion on the Result of the Hypothesis

The third objective of this study is to analyse the relationship between Integrated Project Delivery (IPD) best practices and the Industrialised Building System (IBS) project performance. Four hypotheses have been proposed to examine the relationship between those constructs. First, this study examined the relationship between people and IBS project performance (H1: There is a significant positive relationship between people and IBS performance). Second, a direct relationship between practice and IBS project performance was tested (H2: There is a significant positive relationship between practice and IBS performance). Third, the direct relationship between strategy and IBS project performance was emphasised (H3: There is a significant positive relationship between strategy and IBS performance). Fourth, this study examined the relationship effect of technology and IBS project performance (H4: There is a significant positive

relationship between technology and IBS performance). Thus, each relationship was deliberated in detail to demonstrate statistically significant evidence to support the arguments.

5.10.1.1 H1: There is a significant positive relationship between people and IBS project performance

Based on hypothesis 1, the high values of composite reliability (0.962) and Cronbach's alpha (0.957) generally indicated a reliable measurement of people in this study. Subsequently, the analysis of the structural model revealed a positive relationship between people and IBS project performance. The strong positive relationship suggests that the people element is a significant influence on the outcome of the IBS project performance. This finding coheres with the existing studies in the literature linking people to project performance in different contexts by Abd Rashid (2022), Akunyumu et al. (2021), Kouch et al. (2018), Musa et al. (2017), Musa et al. (2016), also in line with Nawi (2012), with the identification that an essential element in achieving effective IPD in IBS efforts is the people. Besides that, Musa et al. (2016, 2017) also indicate in their study that people represent an element of the IBS modular system framework aimed at enhancing IBS technology in Malaysia. Nevertheless, IPD teams are structured to be versatile and adaptable; they guarantee that the overall success of the IPD implementation is not jeopardised by the absence of individual practitioners, irrespective of their industry sector (Zadeh et al., 2025). Additionally, projects delivered through IPD have the potential to achieve a higher level of client satisfaction, as research by Ali has highlighted (Zadeh et al., 2025). This suggests that the client's needs or objectives can be more easily met by implementing IPD in IBS.

Based on the results of the best practice elements shown in Table 3.2 in Chapter 3, it has been demonstrated that every previous study has recognised people as one of the research elements. Based on validation by expert panels, all concur that people elements are essential for IPD best practices to enhance IBS project performance. Expert Panel 1 notes that IBS stakeholders are motivated to attend training and develop their skills, highlighting the importance of ongoing training and improvement in boosting their IBS performance (Kahvandi et al., 2023; Whang et al., 2019). Additionally, Expert Panel 5 emphasises that the client or project owner should have a

basic understanding of IBS. This ensures the project proceeds smoothly without delays caused by the client and enables the client to take timely, appropriate actions for effective progress (Erdem, 2021) and this statement aligns with research conducted by Pal & Nassarudin (2020) and Roy et al. (2018). Therefore, accurately identifying IPD best practices in the people elements is vital. In conclusion, the people element has a significant impact on the performance of the IBS project.

5.10.1.2 H2: There is a significant positive relationship between practice and IBS project performance

The evidence from this study suggests that practice could significantly affect the IBS project performance. This result is consistent with most previous studies, which have shown that practice influences the improvement of IBS project performance. Studies on IPD best practices in the element of practice have repeatedly proven how these best practices affect the IBS project performance, particularly in innovative procurement such as IPD (Ahamad et al. (2024), Viana et al., (2020), Hu & Chong, (2020), Liyana et al., (2018) and Nawi et al., (2014), and in collaboration (Al-Aidrous et al., 2022; Rashid et al., 2019; Saad et al., 2022; Wuni, Shen, & Osei-Kyei, 2022; Wuni et al., 2020; Yee et al., 2017; Yunus et al., 2017). The utilised IPD in IBS enhances both horizontal and vertical integration within project management, thereby addressing issues related to fragmentation, sustainability, and circularity (Rankohi et al., 2023).

This study also demonstrated that the practice element in this research model is essential. Based on the results presented in Table 3.2 of Chapter 3, it is evident that all previous studies acknowledged practice as a key element in their research. Additionally, all members of the expert panel agreed with hypothesis no. 2, which states that practice can directly influence the IBS project's performance. According to Expert Panel 1, collaboration among IBS parties and the supply chain within the IBS circle is vital for the smooth progress of the IBS project. Expert Panel 3 also highlights that early involvement of team members is essential to facilitate their effective integration and collaboration. Furthermore, Expert Panel 5 states that the management of IBS during design, manufacturing, transportation, and installation also plays a crucial role in ensuring the project runs smoothly from the outset. Thus, the findings of this study offer

an advanced insight that strengthens the empirical evidence in the existing literature on the relationship between practice and IBS project performance.

5.10.1.3 H3: There is a significant positive relationship between strategy and IBS project performance

Strategy dictates organisational choices and sets the organisation's direction, including the specific supporting strategies the organisation employs or is employing to achieve its core mission (Nadler & Tushman, 1989). This study theorised that strategy can positively affect IBS project performance. The measurement model assessment showed a high reliability of the scales measuring the concept. However, the structural model indicated that there is no significant relationship between the strategy and IBS project performance. Thus, the finding does not align with prior studies connecting the strategy with IBS project performance (Kamar, 2011; Musa et al., 2016).

The samples of the present research comprise IBS stakeholders, including IBS contractor G7, IBS consultant firms, IBS manufacturers and suppliers, and IBS clients registered with CIDB. As such, it is surprising that the strategy does not contribute to IBS project performance in these samples. Perhaps, this phenomenon can be explained by Expert Panel 2, which stated that the complexity of the project, such as the site's location, can influence the relationship between strategy and IBS project performance. For example, if the project is in a remote area and has limited supplies of IBS material or if IBS material cannot be delivered, the project may use the traditional method due to an exemption granted by the government. Expert Panel 3 also notes that as the size of an IBS project is large, the higher the initial cost paid to the manufacturer for IBS components. This cost barrier can prevent average IBS contractors from participating in such projects, leading them to stick to their traditional strategies. Expert Panel 5 disagree with Expert Panels 2 and 3, which suggest that there is no significant relationship between strategy and IBS project performance. Expert Panel 5 explains that the best practice items under the strategy are suitable for large companies, such as Gamuda IBS Sdn. Bhd. and IJM IBS Sdn. Bhd., rather than a normal G7 IBS contractor, because these companies are subsidiaries of the main company. Typically, the IBS contractors often lack sufficient funds to produce the IBS components themselves.

Apart from that, the IBS construction in Malaysia is still in close approach implementation.

Unlike Expert Panels 2 and 3, Expert Panel 4 agrees with Expert Panel 5 that there is no significant relationship between strategy and IBS project performance due to the size of the companies involved. The typical IBS G7 contractor can be viewed as an average contractor because their primary aim is to maintain their position in the industry, and they focus solely on a small part of the IBS scope of work. This contrasts with larger IBS companies, which are willing to invest in IBS by establishing a factory to secure a larger share of IBS projects and ensure long-term sustainability. It also shows that these companies are ready to follow project trends and adopt modern construction methods (IBS). Expert Panel 1 also concurs that there is no relationship between strategy and the IBS project's performance, primarily due to a loophole within government policies on IBS. According to the Ministry of Finance Circular 1.10, all governmental projects valued at RM10 million or above are mandated to utilise IBS and achieve a minimum score of 70 IBS. Nevertheless, notwithstanding this circular, the minister possesses the discretion to grant exemptions from the IBS utilisation requirement based on various considerations, including site location and other factors. However, regarding the private projects referenced in Circular Number 4/2024 issued by the Ministry of Housing and Local Government, the National Council on Local Government has concurred to enforce an IBS score of 70, with a value of RM50 million or more, as well as a minimum gross floor area of 50,000 square meters (538,195.52 square feet), as a mandatory prerequisite for the submission of building plans. Thus, a 16-year gap exists in the exemption from implementing IBS for private projects since the issuance of the Ministry of Finance Circular 1.10 in 2008. This may pertain to a governmental decision associated with a political or construction environment scenario.

In conclusion, external factors that are mentioned by the Expert Panel may influence the relationship between strategy and IBS project performance, including the complexity of the project, the size of the project, the size of the company, and the political or construction environment. The findings of this research are in line with prior studies (e.g., Eresia-Eke & Soriakumar, 2021; Langston & Zhang, 2021; Pheng & Chuan, 2006) which evidenced an effect of strategy on IBS project performance. According to research done by Eresia-Eke & Soriakumar (2021), all public sector organisations encountered substantial bureaucratic processes, excessive policies

imposed by the government, political influences extended beyond election cycles, and occasionally, the appointment of new executives for the organisations, along with stakeholder management challenges. Meanwhile, Langston & Zhang, (2021) research indicates that people tend to be conservative and hesitant to accept new products, technologies, and methodologies. For instance, the prevailing perception of IBS buildings often equates to square structures, signifies the decline of quality architecture, or is viewed as a temporary, low-grade solution. However, this barrier always prevents conventional construction companies from shifting their focus to IBS. The size of a project generally influences its complexity, and the development projects with high complexity tend to experience significant cost and schedule overruns (Pheng & Chuan, 2006). As the project size enlarges, the challenges associated with coordinating subcontractors escalate, thereby impacting the overall strategies of project management. It is recommended that the project team pay particular attention to the size (El-Sayegh et al., 2016) and the complexity of projects (Majeed et al., 2023) when designing their organisational structure, as it significantly influences the performance of the project.

Based on the results presented in Table 3.2 of Chapter 3, it is evident that only six out of ten previous studies recognised strategy as a key element in their research compared to other elements. Based on the research outcomes, supported literature reviews, and expert panel opinions, the strategy does not impact the performance of the IBS project.

Therefore, a moderating element (external factors) might be introduced to enhance the model's relationship, and further research is needed to explore these external factors.

5.10.1.4 H4: There is a significant positive relationship between technology and IBS performance

As expected, this study found a positive effect of technology on IBS project performance. The strong positive relationship suggests that the technology element is a significant influence on the outcome of the IBS project performance. This finding is consistent with the perspective that technology can improve IBS project performance (Kamar, 2011) (Abd Rashid, 2022) (Musa et al., 2017) (Musa, et al., 2016) by providing greater advantages over conventional projects. Various studies in the literature suggest

that technology can be a significant source of IBS project performance and a competitive edge for organisations (Xu et al., 2021) (Alawag et al., 2022). According to research done by (Al-Aidrous et al., 2022) technology is one of the top factors impacting the IBS performance. For example, IPD is recognised as an effective delivery system that works best when paired with BIM, where it can manage rich, object-oriented, intelligent, and parametric digital information for IBS projects (Nawi, Haron, et al., 2014; Whang et al., 2019). The integration of IBS and IPD, along with the associated IBS technology, facilitates efficient knowledge sharing, communication, and productivity monitoring throughout the project (Rankohi et al., 2022). Additionally, it supports a streamlined alignment of tools and techniques with personnel and processes, serving as the foundation for a new integration project management.

According to the best practice elements presented in Table 3.2 of Chapter 3, it has been demonstrated that all prior studies have acknowledged technology as a component of their research, except for the study conducted by Hamid et al. (2011). Nevertheless, the validation by expert panels, all members concur that technology elements are essential to IPD best practices to improve IBS project performance. According to Expert Panel 1, the adoption of technology is crucial in IBS, as it has a significant impact on the performance of IBS. Based on a case study conducted by CIDB, the minimum implementation of technology can deliver good IBS performance at a certain cost. Expert Panel 3 and 5 also notes that technologies like BIM in IPD-IBS are vital and should be used from the outset, especially in the design phase. This aligns with research by Hamzeh et al. (2019), which highlights that BIM is an integrated design sharing platform that aids in transferring information and knowledge between trades, improving communication and cooperation, and reducing misunderstandings and errors. Therefore, accurately identifying best practices in the IPD technology element is essential. In conclusion, the technological element can substantially influence the performance of the IBS project.

5.11 Chapter Summary

In this chapter, the overall measurement models and hypotheses were empirically validated. The chapter begins with data preparation, followed by testing

multivariate regression assumptions and validating measurement and structural models. Overall, three (3) of the four hypotheses tested in this study were supported.

The findings confirmed that best practices for IPD have an influence on IBS performance. Conversely, only one element, strategy, was identified as not being significantly related to IBS performance. This has opened the door for additional research into external factors as a possible moderating element that impacts the non-significant relationship between strategy and IBS performance. The next chapter focuses on discussing the study's findings, its theoretical and practical contributions, limitations, and suggestions for future research.

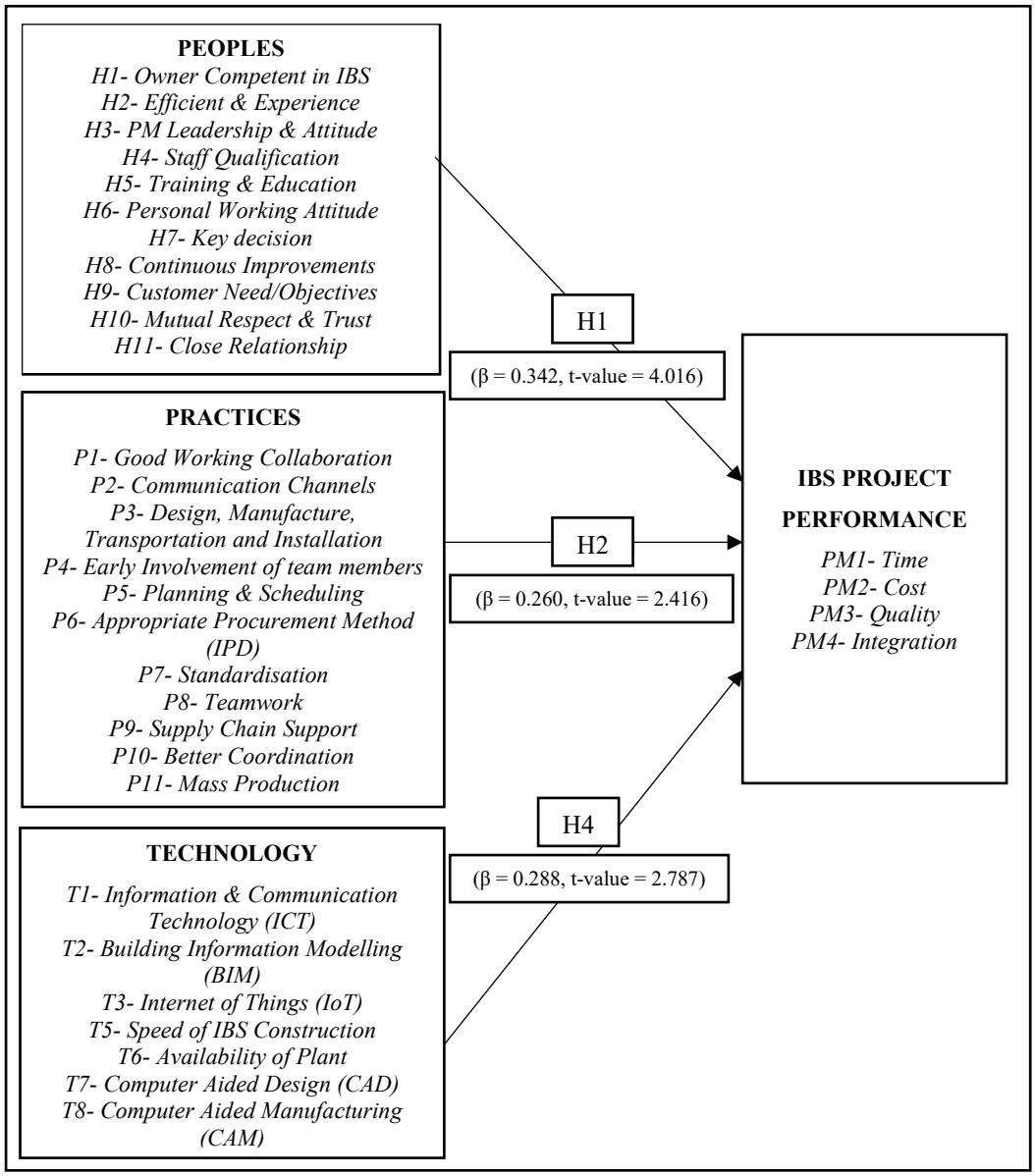


Figure 5.9 IPD Best Practices Model

CHAPTER 6
CONCLUSION AND RECOMMENDATION

6.1 Introduction

The previous chapter concentrated on gathering data to attain substantive statistics and findings. This chapter presents the study's key findings regarding predictors in developing an Integrated Project Delivery (IPD) Best Practices (IPD-BP) Model for Industrialised Building Systems (IBS), supported by significant statistical evidence. It answers the research questions to ensure that the study's objectives are met. The study's theoretical, methodological and practical contributions are then highlighted. Subsequently, this chapter emphasises the study's limitations, including future avenues and recommendations. Finally, a conclusion is provided to encapsulate the overall research and conclude the study.

6.2 Achievement of Objectives

All research questions were successfully answered, and the objectives were fully achieved. The findings of this study are discussed in detail based on the following research objectives as postulated in Chapter 1:

6.2.1 RO 1 - To Identify The IPD Best Practices in The IBS Project.

The first objective is to identify the IPD best practices in the IBS project. Forty-one (41) IPD best practice items have been identified as influencing the IBS project performances. These IPD best practice items were based on a literature review. During the expert review for validation of these IPD best practice items, two (2) new IPD best practices were suggested. The items are Mass Production and Augmented Reality (AR) and Virtual Reality (VR). The total number of items becomes forty-three (43) during the data collection stage. All best practice items are divided into four elements (variables): people, practice, strategy, and technology. These four modified elements (variables) are derived from Leavitt’s diamond model, developed by Leavitt (1965). The Cronbach's Alpha reliability test was conducted to determine the reliability of each

respondent's responses to the best practice items listed in the questionnaire. The results indicate that all items exhibit high reliability, exceeding the predetermined value of 0.70. At measurement model analysis, using Smart PLS-SEM software, two items, Robotic and Automation and Virtual Reality (VR) and Augmented Reality (AR) were omitted due to their lower loading. The cut-off value decided for outer loading in this study is 0.70 and higher, whereas those less than 0.70 should be removed. The mean score for robotics and automation and virtual reality and augmented reality, significantly lower than all the other best practice items. Based on an interview with a CIDB officer, to date, not more than five factories are using this technology. This shows that the implementation of these two technologies is still new for IBS in Malaysia. Finally, the number of IPD best practices items for IBS is forty-one (41). In conclusion, all the IPD best practices for IBS outlined in this study are crucial for enhancing IBS performance.

The IPD best practices for IBS are listed below.

i. People

The people element consists of eleven (11) best practices namely (i) owner competent in IBS; (ii) efficient and experience; (iii) project manager leadership and attitude; (iv) staff qualification; (v) training and education; (vi) personal working attitude; (vii) key decision; (viii) continuous improvement; (ix) customer need objectives; (x) mutual respect and trust; (xi) close relationship.

ii. Practice

The practice element consists of eleven (11) best practices namely (i) good working collaboration; (ii) early involvement of team members; (iii) design, manufacture, transportation and installation; (iv) early involvement of team members; (v) planning and scheduling; (vi) appropriate procurement method; (vii) standardisation; (viii) teamwork; (ix) supply chain support; (x) better coordination; (xi) mass production.

iii. Strategy

The strategy element consists of twelve (12) best practices namely (i) top-down commitment; (ii) risk assessment; (iii) government support; (iv) government

policies; (v) business and financial; (vi) project trend and knowledge; (vii) quality management; (viii) adaptability; (ix) share objective and goal; (x) demand and supply; (xi) roles and responsibilities; (xii) shared risk and reward.

iv. Technology

The technology element consists of seven (7) best practices namely (i) information and communication technology (ICT); (ii) Building Information Modelling (BIM); (iii) Internet of Things (IoT); (iv) Speed of IBS construction; (v) availability of plants; (vi) computer aided design (CAD); (vii) computer aided manufacturing (CAM).

6.2.2 RO 2 – To Identify The Performance Elements of The IBS Project.

The second objective of this research is to identify the performance elements of the Industrialised Building System (IBS) project. All these criteria were based on the literature review and the expert's opinion. Four (4) elements were identified. The first three elements are based on the Iron Triangle model, which includes time, cost, and quality. The fourth is integration. Many efforts have been made to expand this concept by adding extra elements, such as integration. These additional elements aim to support long-term goals that extend beyond the immediate success of the current project or are inherently connected to one of the original elements. Based on the data analysis of the reflective measurement model (Figure 5.3), the integration has the highest loading, compared to the other three elements: quality, time, and cost. This indicates that the integration can be an element in measuring the performance of the IBS project. Therefore, this study evaluates project success using measures such as time, cost, quality, and also includes integration as an additional element.

6.2.3 RO 3 – To Analyse The Relationship Between IPD Best Practices and The IBS Project Performance.

The third objective of this study is to analyse the relationship between Integrated Project Delivery (IPD) best practices and the Industrialised Building System (IBS)

project performance. Four hypotheses have been proposed to examine the relationship between those constructs.

6.2.3.1 H1: There is a significant positive relationship between people and IBS project performance.

The relationship between people and performances was empirically significant ($\beta = 0.342$, $t = 4.016$), supporting the H1. The significant statistical evidence supported the proposed relationship in this model regarding people and performances.

6.2.3.2 H2: There is a significant positive relationship between practice and IBS project performance.

The relationship between practice and performance was determined to offer statistically significant evidence ($\beta = 0.260$, $t = 2.416$) to substantiate H2. The study discovered that the relationship between practice and performance was strongly justified by empirical scientific evidence.

6.2.3.3 H3: There is a significant positive relationship between strategy and IBS project performance.

The strategy was found to be negatively associated with performance, as indicated by path coefficients ($\beta = -0.021$, $t = 0.223$). Thus, there was no significant relationship between strategy and performance.

6.2.3.4 H4: There is a significant positive relationship between technology and IBS performance.

The empirical findings validated the concept that technology has a significant influence on performance. First, technology was found to be positively associated with performance by path coefficients ($\beta = 0.288$, $t = 2.787$) result. Hence, technology and performance demonstrated a significant relationship, as found in the prior study.

6.2.4 RO 4 – To Develop An Integrated Project Delivery Best Practices (IPD-BP) Model for IBS Performance in Malaysia

The fourth objective is to develop an Integrated Project Delivery Best Practice (IPD-BP) Model for Industrialised Building System Performance in Malaysia. This study found that connectedness to IPD best practices and IBS project performance has a "symbiotic relationship". The model for this study was initially influenced by underpinned theories, with slight modifications from Leavitt, (1965) model and Figure 6.1 and Figure 6.2 illustrates the IPD-BP's Model for IBS Project Performance, which requires people, practice, and technology to enhance IBS project performance.

All three elements are essential for enhancing the IBS project's performance, resulting in significant improvements in time efficiency, cost control, quality, and seamless integration. The People element is pivotal in elevating IBS project performance. Without people in construction, the project can never be built. In an IPD environment, architects, engineers, owners, and other stakeholders collaborate effectively, leveraging their collective expertise and actively participating in every phase of the IBS project. This coordinated approach fosters innovation and drives results (Ghanbari et al., 2023). By employing various management tools, IPD integrates diverse forms of information, work processes, and activities within cohesive project boundaries (Whang et al., 2019).

Equally important, the Practice element is one of the key drivers of enhanced IBS project performance. The IPD model advocates for early planning and design, enabling teams to address potential challenges and optimise outcomes proactively (Ghanbari et al., 2023) that suits IBS management. Moreover, IPD procurement fosters an environment of collaboration among IBS project stakeholders, facilitating the seamless incorporation of manufacturers and suppliers into the decision-making process (Kahvandi et al., 2023; Wuni & Shen, 2020b). As highlighted by Capuyan and Jocson (2024), the collaborative nature of IPD substantially boosts supply chain effectiveness, ultimately leading to superior project results.

Lastly, the Technology element empowers both People and Practices to elevate IBS project performance. Research by Li et al. (2018), Nasrun et al. (2017), and Wuni & Shen (2020b) demonstrates that adopting Building Information Modelling (BIM) enhances design sharing, visualisation, robustness, flexibility, and system integration,

significantly increasing the likelihood of IBS project success. The integration of technology through Computer-Aided Design (CAD), Computer-Aided Manufacturing (CAM), and BIM revolutionises design, delivery, and project management, both on-site and off-site manufacturing for IBS projects. This technological convergence eliminates the cumbersome coordination phases traditionally required to transfer shop drawings to craftsmen, resulting in impressive time and effort savings (Ng & Hall, 2019). Therefore, by focusing on these three interconnected elements — People, Practice, and Technology — IBS stakeholders can unlock remarkable improvements in their IBS project performance and achieve exceptional results.

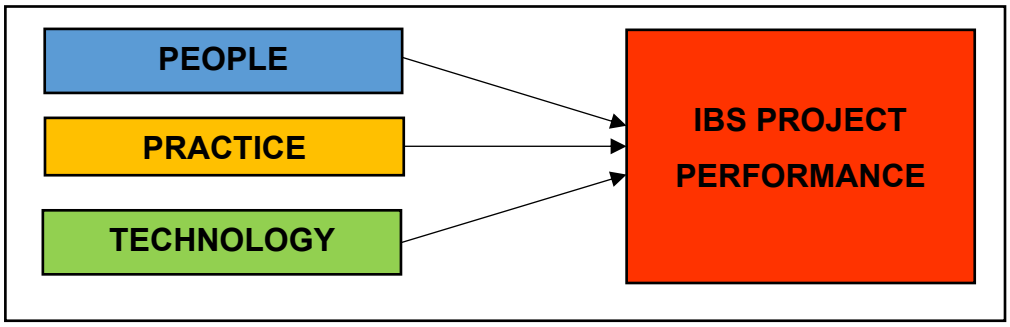


Figure 6.1 The IPD-BP's Model for IBS Performance

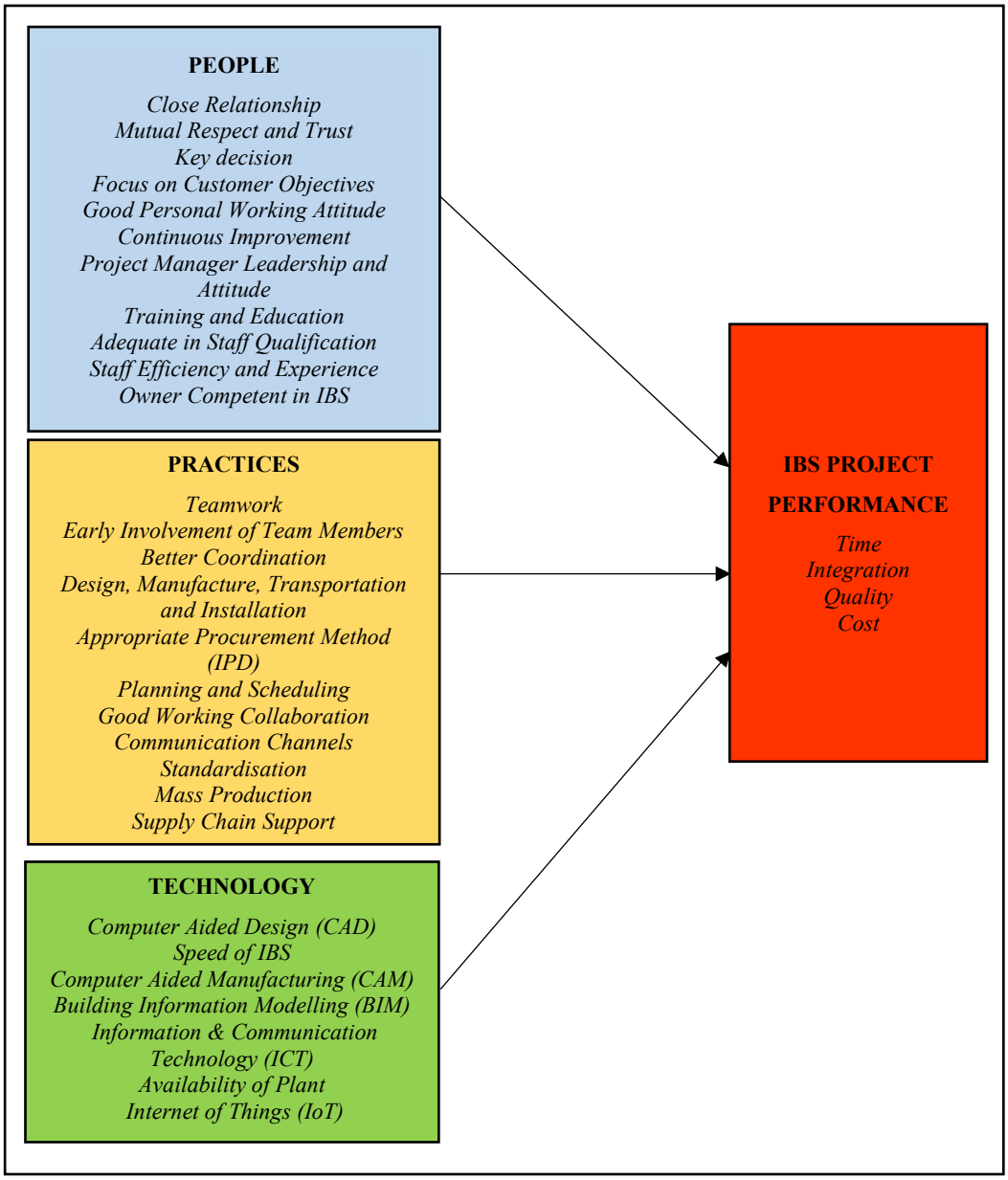


Figure 6.2 The IPD-BP's Model for IBS Performance (comprehensive)

6.3 Research Contributions

The findings of the current research highlighted several key inferences regarding the theoretical, methodological, and practical implications.

6.3.1 Research Contribution to Knowledge

In general, this research makes several significant knowledge contributions. It fills a gap in the literature by describing the influences of IPD best practices specifically on IBS. The study offers a better understanding of the concept of IPD in IBS, given the limited evidence available in this area. Given the extensive use of the IBS-precast concrete system, it has been argued that examining IPD best practices is essential to enhance the performance of IBS projects.

Second, this research is among the first to integrate two modified theories based on the Leavitt Diamond model and the Iron Triangle model into one research model. As mentioned, the study aims to examine the IPD best practices that influence the IBS project performance. A total of forty-one (41) IPD best practices within the four elements of the IBS project performance had been identified for this research. Following an analysis conducted with Smart PLS-SEM, the research confirms that the elements of people, practice, and technology comprising twenty-nine (29) IPD best practices influence IBS project performance. Only the element of strategy demonstrated an insignificant relationship with IBS project performance. The research has also explained how these IPD best practices influence the IBS project performance.

Third, this research offers new insights into the innovative procurement aspect within IBS, particularly in IPD. Specifically, this research improves the existing literature by empirically identifying IPD best practices and linking them to project performance. These findings answer the open calls from prior researchers (e.g., Abd Hamid et al., 2011; Ahamad et al., 2024; Hu & Chong, 2020; Liyana et al., 2018; Nawi et al., 2014; Tajul Ariffin et al., 2019; Viana et al., 2020; Yin et al., 2025) to examine the potential role of IPD as an innovative procurement approach for the IBS industry in Malaysia. Concurrently, this enables the extension of the IPD concept beyond the traditional procurement method.

Fourth, this study contributes to the literature by adding an element to the model. This study distinguishes itself from other research that has explored how the element of integration in IBS project performance is affected by IPD best practices. This suggests that the integration can be an element in assessing the performance of the IBS project. As a result, the theory/model of the Iron Triangle used in this study was improved as a result of this research.

Finally, a key contribution of this study is enhancing the understanding of IPD in IBS, especially within developing countries like Malaysia. To our knowledge, although there are many studies on IPD, most focus on Western nations, leaving a gap in research concerning Malaysia. Conducting research tailored to the local context is crucial since findings from Western countries cannot be directly applied to Malaysia. As a developing country, Malaysia still lags behind more advanced nations in IBS and IPD development.

6.3.2 Research Contribution to Methodology

This study employed several distinct methodologies to achieve its research objectives. The study started with a preliminary survey when identifying the problem statement, which emerged from literature reviews. By conducting this initial study with various IBS industry stakeholders such as consultants, contractors, and manufacturers, the seriousness of the issue and the importance of the research to the industry were confirmed as genuine and valid.

The IPD best practices and IBS project performance are revealed because the first and second objectives were achieved through literature reviews and validated by the IBS expert panel before distributing the questionnaire to respondents. The third objective involves developing an IPD-BP Model by analysing the proposed relationships within it. This study employed a Structural Equation Model (SEM), utilising the Smart PLS-SEM tool, a powerful statistical analysis software well-suited for path modelling in this context. Although its application in this field is relatively new, the software is user-friendly. Nevertheless, careful adherence to specific guidelines is essential for effective use. Therefore, employing Smart PLS-SEM in this study is suitable for testing the hypothesised model and broadening the tool's applicability. An expert panel subsequently validated the final structural model of the research to confirm its accuracy. Therefore, employing the latest instrument (Smart PLS-SEM) in this research indirectly improves the methodology for studying IPD in IBS.

6.3.3 Research Contribution to Industry

The results of this study not only expanded the academic knowledge and methodology but also offer potential industry benefits. The Integrated Project Delivery Best Practices (IPD-BP) Model for IBS in Malaysia can also serve as an alternative to the conventional methods of managing IBS projects and aligns with the IBS agenda in the National Construction Policy 2030 in Thrust 6: strengthening good governance and adoption of best practices, which aims to enhance public procurement systems (4.6.1) and promote best practices in construction (4.6.4). Currently, inefficient management of construction projects has been associated with poor quality, delays, cost overruns, inefficiency, and significant environmental damage (Ministry of Works, 2022). This also includes several issues in public procurement. Thus, the innovative procurement models like IPD and IPD-BP's model can serve as practical solutions to enhance construction project management by adopting best practices that ensure the satisfaction of the public and stakeholders.

Furthermore, the IPD-BP's Model for IBS project performance aligns with the Construction 4.0 Strategic Plan (2021-2025), which identifies IBS as one of twelve technologies to be prioritised during the implementation of this plan. The IBS has been on the Malaysian government agenda since it was first introduced in 2003.

Ultimately, this IPD-BP model can facilitate the integration of diverse IBS people, technologies, and practices into a collaborative process. This approach aims to leverage the collective expertise and perspectives of all participants to improve project results, deliver greater value to the project owner, minimise inefficiencies, and enhance overall efficiency.

6.4 Research Limitation

Regarding the topic of research, the findings of the current study must be interpreted by taking some of the research limitations into consideration. However, the present study provides support for the hypothesised relationships between the variables. The research is limited to the major stakeholders in the IBS construction industry's perspectives. The sample for this research was derived from the IBS Orange Book 2023 and CIDB contractor directory, which includes IBS G7 precast contractors, IBS precast manufacturers and suppliers, IBS consultants, and IBS clients, and thus excluded

companies not listed in the directory. Therefore, generalisations from the findings of this research to all IBS stakeholders in Malaysia cannot be made.

6.5 Recommendations for Future Research

The limitations of the present study have generated numerous openings for future research to extend the current knowledge. Suggestions for future research pertinent to this topic are:

a) This study was only conducted on a precast concrete system. It is suggested that future studies focus on other types of IBS, such as steel structure framing systems, formwork systems and others.
b) This research found no significant relationship between strategy and IBS project performance. These results suggest that including a moderating element (external factors) identified by the expert panel during the structural model validation may influence the relationships between the constructs.
c) Further research on the implementation of IPD and IBS in other developing countries that have a higher degree of industrialisation, with similar practices and cultural backgrounds, could help validate the model.
d) As modular construction gains prominence, it is imperative to undertake further research on IPD contractual documents to more effectively accommodate the distinctive logistics, supply chain integration, and off-site manufacturing requirements.

6.6 Conclusion

This doctoral research presents a detailed investigation of Integrated Project Delivery (IPD) and Industrialised Building Systems in Malaysia. Although IBS has been widely researched, most previous research has focused on the focus on IBS area such as supply chain management contract in IBS, IBS business strategy, IBS project management, IBS maintenance, IBS formwork, IBS modular construction, IBS robotic & automation, communication in IBS, sustainable in IBS. There is a lack of studies on IPD in IBS procurement as most focus on IPD in IBS regarding readiness, literature review and design team communication(Nawi, 2012). Furthermore, only a few researchers had already focused on IBS procurement but not on IPD in IBS.

This doctoral research investigated the relationship between IPD best practices and IBS project performance in Malaysia. The findings confirmed IPD best practices had an impact on IBS performance. On the other hand, only one element (strategy) was found not to be significant to IBS performance. This has paved the way for an investigation of external factors as a moderating element that may influence the non-significant relationship between strategy and IBS performance. This research provides several important theoretical insights. It addresses a gap in the literature by examining how IPD best practices specifically impact IBS. Additionally, the study enhances understanding of the IPD concept within the context of IBS.

The findings also provide valuable insight to the IBS parties: the IPD-BP model facilitates the integration of diverse IBS people, technologies, and practices into a collaborative process. This approach aims to harness the collective expertise and perspectives of all participants to enhance project outcomes, deliver greater value to the project owner, minimise inefficiencies, and increase overall efficiency. Apart from that, these findings may also guide government bodies in adopting effective solutions to enhance IBS project performance by implementing IPD best practices, thereby ensuring public and stakeholder satisfaction. Finally, in addition to expanding existing knowledge, both the significant and non-significant findings in this study open up promising directions for future research.

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APPENDICES

APPENDIX 1

Questionnaire Survey

UNIVERSITI TEKNOLOGI MARA

Invitation Letter

To : Dato/Datin/Mr/Mrs
Subject : Invitation for research participation

I am conducting an academic research entitled: ***"Integrated Project Delivery Best Practices (IPD-BP) Model for Industrialised Building Systems (IBS) Performance in Malaysia"***. The purpose of my research is to identify best practices that influence the implementation of Integrated Project Delivery (IPD) in Industrialised Building Systems (IBS).
This questionnaire survey consists of four (4) sections (Sections A - D).

Section A:	General Information
Section B:	IPD Best practices influencing performance in IBS
B1:	Strategy
B2:	Technology
B3:	Practice
B4:	People
Section C:	Project performances in IBS adoption
Section D:	Closing

The survey will take only 10 minutes, therefore, I would appreciate it if you could take the time to complete it. Please read carefully all the instructions pertaining to every section and answer every question sincerely. "***There is no right or wrong answer***". All of the responses provided will be treated with strict confidentiality and will be used for this academic research only.
We would be grateful if you could complete the attached questionnaire and return it in the self-addressed envelope provided as soon as possible. Thank you very much for your kind cooperation.

Thank you

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Integrated Project Delivery Best Practices (IPD-BP) Model for Industrialised Building System Performance in Malaysia

Section A: General Information /

Please provide the following general information about your organisation. Please tick (/) all the boxes that apply.

1. *Where is the location of your organisation?*

☐ Selangor	☐ Kuala Lumpur	☐ Penang	☐ Johor
☐ *Perak*	☐ *Kedah*	☐ *Perlis*	☐ *Negeri Sembilan*
☐ *Melaka*	☐ *Pahang*	☐ *Kelantan*	☐ *Terengganu*
	☐ *Sarawak*	☐ *Sabah*	

2. What is the primary type of business of your organisation?

☐ Contractor	☐ Consultant
☐ Manufacturer	☐ Supplier
☐ Other (please specify) _____	

3. What is your job title in the company?

☐ Company Director	☐ Project Manager
☐ Project Manager	☐ Construction Manager
☐ Architect	☐ Quantity Surveyor
☐ Civil/ Structural Engineer	☐ Project Supervisor
☐ Other (please specify) _____	

4. How long have you been involved with IBS?
   - ☐ I am not
   - ☐ Less than 5 years
   - ☐ 6-10 years
   - ☐ 11-20 years
   - ☐ Above 20 years

5. Which stakeholder had been and/or being involved in your IBS project?
   - ☐ Government
   - ☐ Private
   - ☐ Both parties

6. What type of IBS project background had been and/or being involved with?
   - ☐ Residential project
   - ☐ Non-residential project
   - ☐ Both types of projects

7. Which area of your IBS project had been taken?
   - ☐ Urban
   - ☐ Sub-urban
   - ☐ Rural
   - ☐ All above

Section B: IPD best practices influencing the performance of Industrialised Building System

8. Please provide your view on a scale of 1 (Strongly Disagree) to 6 (Strongly Agree) by ticking the appropriate number in the scale provided at the top.

No.	B1 The **strategies** to implement Integrated Project Delivery (IPD) in IBS projects, I believe that…/	Strongly Disagree					Strongly Agree
		1	2	3	4	5	6
1	…the **top-down commitment** was efficiently implemented.						
2	…the **risk assessment** was properly recognized.						
3	…the **government support** were fully applied. Example IBS levy exemption, IBS exhibition etc.						
4	…the **government policies** were properly recognized. Example IBS Score mandatory, tax incentives etc.						
5	…**business and financial** approach been applied.						
6	…**project trend & knowledge** were with the times.						
7	…the **quality management** were fully implemented during component manufacturing and installation stage.						
8	…the **adaptability** to IBS system were reached.						
9	…**share objective and goal** were achieved.						
10	…the **demand & supply** factor was appropriately identified.						
11	…**roles and responsibilities** each parties was appropriately identified.						
12	… **the shared risk and reward** are determined fairly.						

No.	B2 The **technologies** to implement Integrated Project Delivery (IPD) in IBS projects, I believe that…/	Strongly Disagree					Strongly Agree
		1	2	3	4	5	6
1	…**information and communication technology (ICT)** was extensively used.						
2	…**Building Information Modeling (BIM)** was successfully implemented.						
3	…the **internet of things (IoT)** was applied accordingly.						
4	…**robotic and automation** were appropriately introduced.						
5	…**speed of IBS construction** was acceptable.						
6	…**availability of plant** were sufficient.						
7	…**Computer Aided Design (CAD)** was extensively practiced.						
8	…**Computer Aided Manufacturing (CAM)** was effectively used.						
9	…**3D printing** were appropriately introduced.						
10	…**Virtual Reality (VR) and Augmented Reality (AR)** has been satisfactorily introduced.						

No	B3 The **practices** to implement Integrated Project Delivery (IPD) in IBS projects, I believe that…	Strongly Disagree					Strongly Agree
		1	2	3	4	5	6
1	…a **good working collaboration** was effectively achieved.						
2	…the **communication channels** were efficient / saluran komunikasi adalah cekap.						
3	…the **design, manufacture, transportation and installation** were extensively coordinated.						
4	…the **involvement during the design process** from all the team members was sufficiently achieved.						
5	…the **planning and scheduling** were extensively carried out.						
6	…**appropriate procurement method** were used such as integrated project delivery (IPD).						
7	…**compensation structure** was considered accordingly.						
8	…**standardisation** was effectivelyimplemented.						
9	…**teamwork** was strongly implemented.						
10	…**supply chain support** was sufficiently identified.						
11	...**better coordination** was effectively implemented.						
12	…**early involvement of team members** was fully supported.						
13	…**mass production** were fully achieved.						

No	B4 The **peoples** who implemented Integrated Project Delivery (IPD) in IBS projects, I believe that… /	Strongly Disagree					Strongly Agree
		1	2	3	4	5	6
1	…the owner were significantly **competent in IBS** knowledge.						
2	…the staff were highly **efficient and experience.**						
3	…showed quality **Project Manager leadership & attitude.**						
4	…the **staff qualification** were highly **adequate.**						
5	…**training & education** was adequately arranged.						
6	…have a good **personal working attitude**.						
7	…making **key decision** were professionally.						
8	…**continuous improvements** were continuously implemented.						
9	…**focusing on customer** need/objectives.						
10	…have high **mutual respect & trust.**						
11	…had **close relationship** with suppliers & sub-contractors.						

Section C: Project's performance in IBS adoption

9. Please provide your view on a scale of 1 (Strongly Disagree) to 6 (Strongly Agree) by ticking the appropriate number in the scale provided at the top.

No	Based on IPD best practice factors for IBS adoption in Section B, I believe that the project's performance was based on …	Strongly Disagree					Strongly Agree
		1	2	3	4	5	6
1	…the overall **COSTS** were substantially reduced.						
2	…construction **TIME** was significantly reduced.						
3	…the **QUALITY** of the product was successfully achieved.						
4	…effective **RELATIONSHIP** among project team members was significantly achieved.						

Section D: Closing

10. Do you wish to make any comments? If so, please give your comments below:

Thank you. You have reached the end of the survey.

APPENDIX 2

Expert Validation Form

UNIVERSITI TEKNOLOGI MARA

Invitation Letter

To : Dato/Datin/Mr/Mrs
Subject : Invitation for research participation

I am conducting academic research entitled: ***"Integrated Project Delivery Best Practices (IPD-BP) Model for Industrialised Building Systems (IBS) Performance in Malaysia"***.

The survey will take only 10 minutes; therefore, I would appreciate it if you could take the time to complete it. Please read carefully all the instructions for each section and answer every question sincerely. "***There is no right or wrong answer"***. All responses provided will be treated with strict confidentiality and used solely for this academic research.

We would be grateful if you could complete the attached questionnaire and return it in the self-addressed envelope provided as soon as possible. Thank you very much for your kind cooperation.

Thank you,

Researchers:

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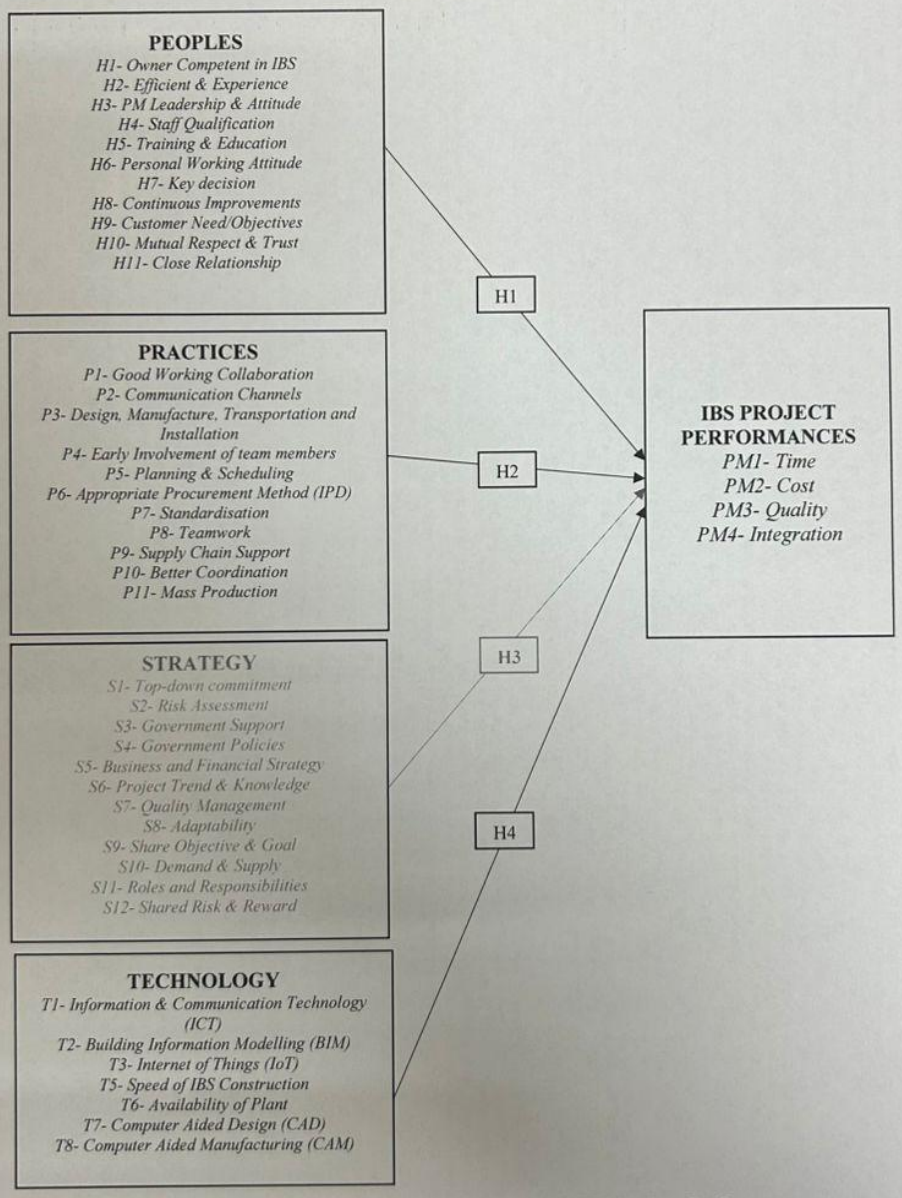
Expert Validation on
Integrated Project Delivery Best Practices (IPD-BP) Model for Industrialised Building System Performance in Malaysia

S0ection A: General Information

Please provide the following general information about your organisation. Please tick (/) all the boxes that apply.

1. What is the primary type of business of your organisation?
   - ☐ Contractor
   - ☐ Consultant
   - ☐ Manufacturer/Supplier
   - ☐ Client
   - ☐ Researcher
   - ☐ Local Authorities
2. What is your job title in the company?
   - ☐ Director
   - ☐ Project Manager
   - ☐ Construction Manager
   - ☐ Quantity Surveyor
   - ☐ Engineer
   - ☐ Other (please specify) _____
3. How long have you been involved with IBS?
   - ☐ I am not
   - ☐ Less than 5 years
   - ☐ 6-10 years
   - ☐ 11-20 year
   - ☐ Above 20 years

Section B: The Relationship between IPD Best Practices and IBS Project Performances



Proposed Relationship Model of IPD Best Practices and IBS Project Performances

Question 1

H1: There is a **significant positive relationship** between people and IBS project performance.

Do you

☐ Agree

☐ Disagree

Your comment and view.

Question 2

H2: There is a **significant positive relationship** between practice and IBS project performance.

Do you

☐ Agree

☐ Disagree

Your comment and view.

Question 3

H3: There is an **insignificant relationship** between strategy and IBS project performance.

Do you

☐ Agree

☐ Disagree

If you disagree with the statement above, do you believe that other factors may influence the negligible relationship between strategy and IBS project performance? Please tick (/) all applicable boxes. You may select more than one.

Your comment and view.

Question 4

H4: There is a **significant positive relationship** between technology and IBS project performance.

Do you

☐ Agree

☐ Disagree

Your comment and view.

Thank you. You have reached the end of the survey.

AUTHOR'S PROFILE



Ts. Sr Mohd Reeza Yusof, PQS, possesses a Diploma in Quantity Surveying, a Bachelor of Quantity Surveying (Honours), and a Master of Science in Integrated Construction Project Management from Universiti Teknologi MARA, Malaysia. Presently, he serves as a Senior Lecturer at the Faculty of Built Environment, Universiti Teknologi MARA. He is recognised as a Professional Quantity Surveyor by the Board of Quantity Surveyors Malaysia (BQSM) and the Royal Institution of Surveyors Malaysia (RISM). Additionally, he holds a Professional status in Building and Construction Technologies with the Malaysia Board of Technology (MBOT). With fifteen years of professional experience in public universities and the construction industry. He actively engages in research activities and supervises undergraduate students. His scholarly contributions include publications in several journals indexed by Scopus and ERA, as well as book chapters and conference papers.

LIST OF PUBLICATION:

Yusof, M. R., Jabar, I. L., Nawawi, A. H., & Nawi, M. N. M. (2025). An Integrated Project Delivery (IPD) Best Practices Approach for Industrialised Building System (IBS). Malaysian Construction Research Journal, 47(3), 1–21. https://www.cream.my/prod/mcrj-volume-47-no-3-2025

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Yusof, M. R., Nawi, M. N. M., & Jabar, I. L. (2023). The Absence of Smart Technology as One of The Key Factors of Transportation in Modular Construction: A Case Study in Malaysia. *Journal of Advanced Research in Applied Sciences and Engineering Technology*, *30*(1), 264–274. https://doi.org/10.37934/araset.30.1.264274

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Farhan Nur Ariff Rosman, M., Laili Jabar, I., & Reeza Yusuf, M. (2023). Improving Hazard Identification, Risk Assessment and Risk Control (HIRARC) Implementation in Industrialized Building System (IBS) Construction Projects. *Research in Management of Technology and Business*, *4*(1), 1174–1184. http://publisher.uthm.edu.my/periodicals/index.php/rmtb