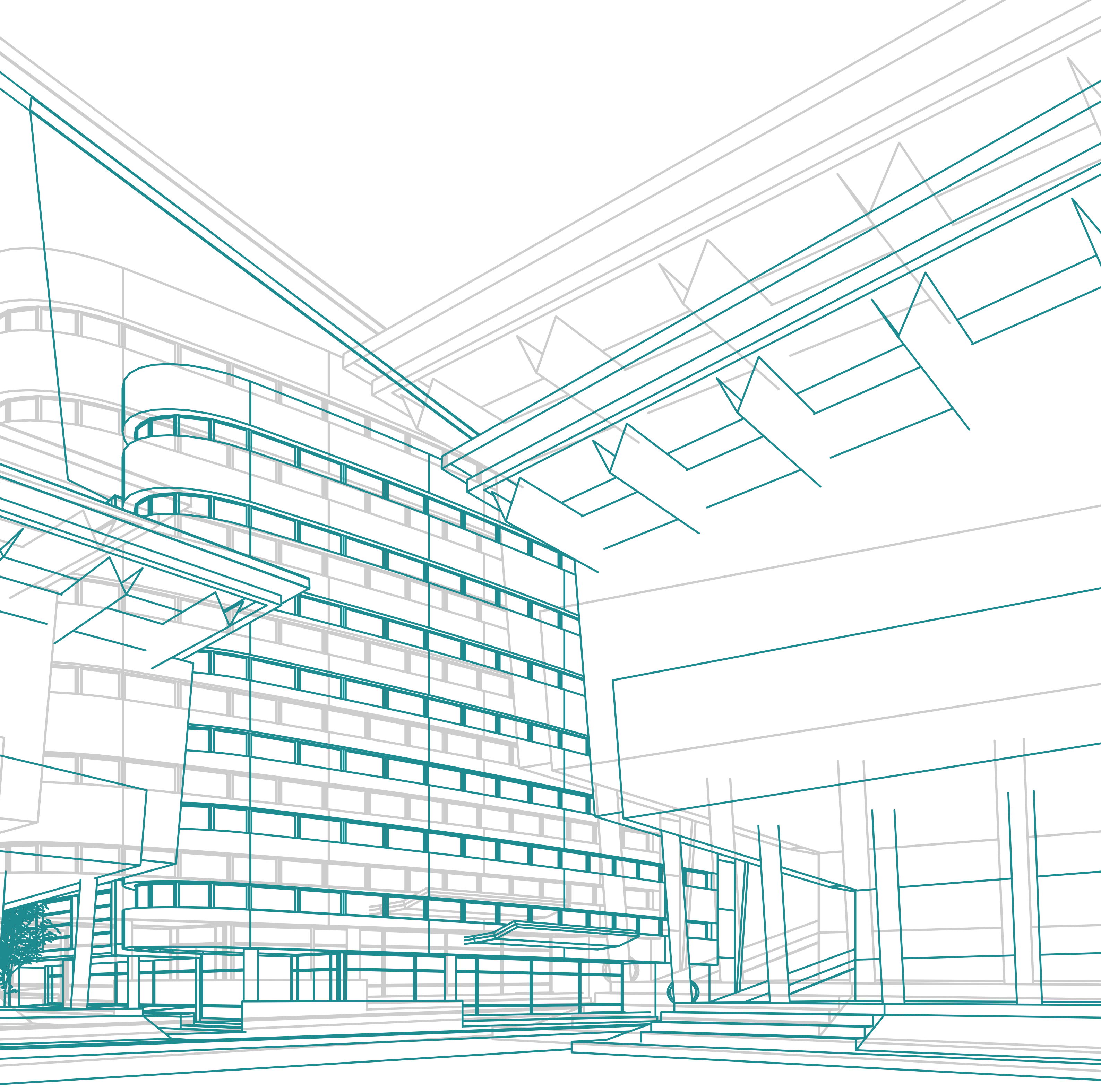
GUIDELINE
FOR SMALL AND MEDIUM ENTERPRISE DEVELOPERS AND CONTRACTORS

MIGRATION FROM CONVENTIONAL METHODS
TO IBS IN THE MALAYSIAN CONSTRUCTION INDUSTRY

CIDB Technical Publication No. : 211

CIDB MALAYSIA



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PREFACE

The introduction of Industrialised Building System (IBS) is one of the initiatives to resolve the issue of foreign workers, productivity, and quality of building. To realise the objective to increase the standard of Malaysian construction industry, government has initiates numerous programmes related to the implementation of IBS in the government and private projects. However, the take-up for IBS is still far from the expected number especially for private projects.

Thus, Construction Industry Development Board (CIDB) together with research arm, Construction Research Institute of Malaysia (CREAM) has prepared the guideline to assist the industry players to embark in IBS industry. The guideline covering the comparison between conventional and IBS construction, challenges on the transition, workflow of transition and smart approach to start up in IBS construction.

This guideline is resulted from the discussion and workshop with the developer and contractor related to this study. The guideline is hoped to benefit the parties who wished to embark in the IBS industry which will sustain the Malaysian construction industry in the future.

EXECUTIVE SUMMARY

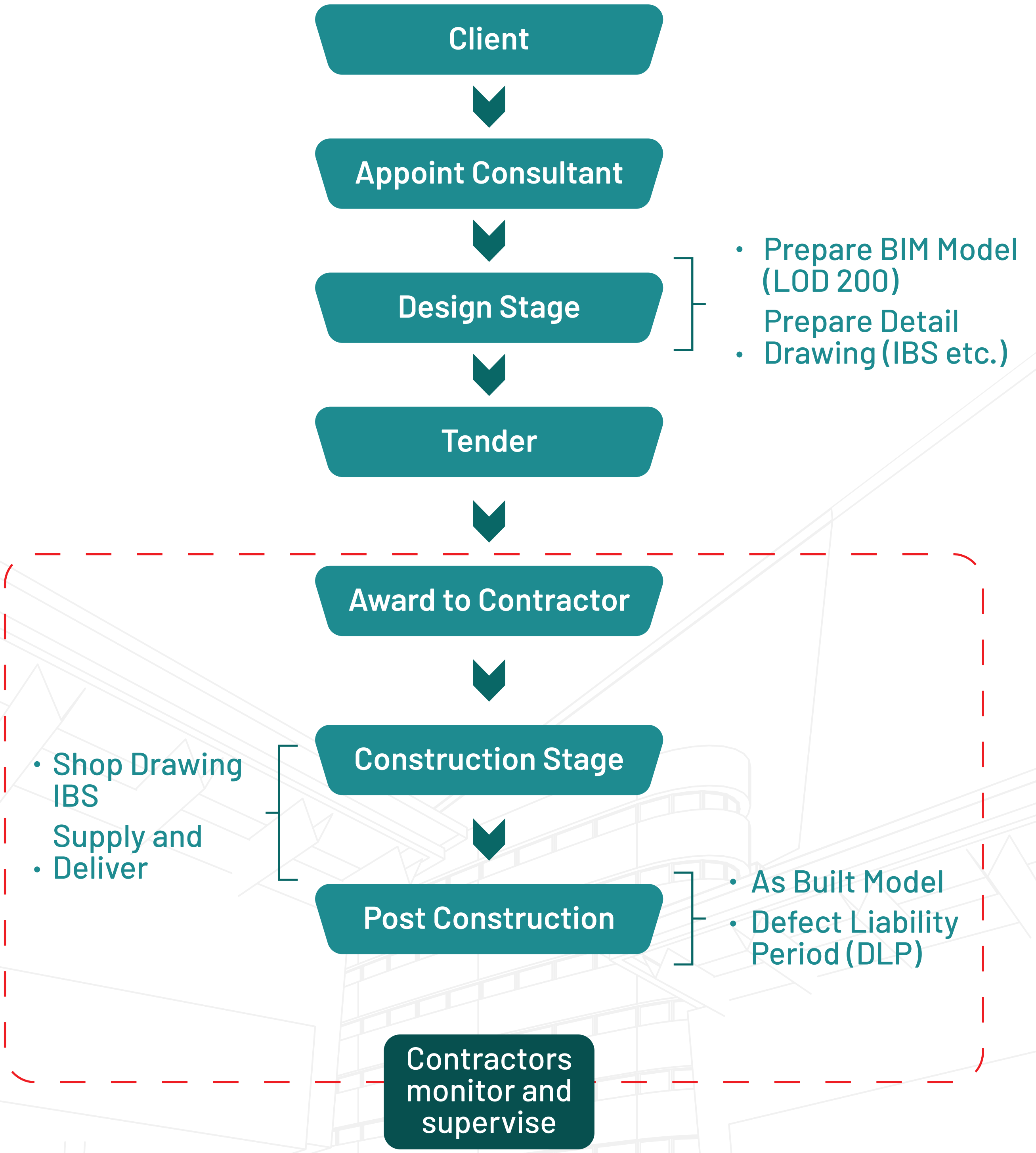
This guideline is framed based on the needs of the Malaysian construction industry to begin embarking in Industrialised Building System (IBS) industry. This guideline was developed by the Construction Research Institute of Malaysia (CREAM) with guidance from industry players and experts related to the IBS project implementation. A series of workshop, interview sessions and data collections were involved in this guideline's development.

The implementation of IBS project requires cooperation and coordination from many parties, especially the developers, contractors, consultants, architects, suppliers, and manufacturers. This guideline will describe the process of conducting IBS project from the start until the end of the project. This guideline also clarifies the roles and responsibilities of the parties involved in the project implementation.

This guideline hopes to benefit the related parties in IBS project implementation, including the developers, contractors, consultants, architects, suppliers, and manufacturers. The information in this guideline could assist those parties to start their business in the IBS industry, especially for SME contractors.

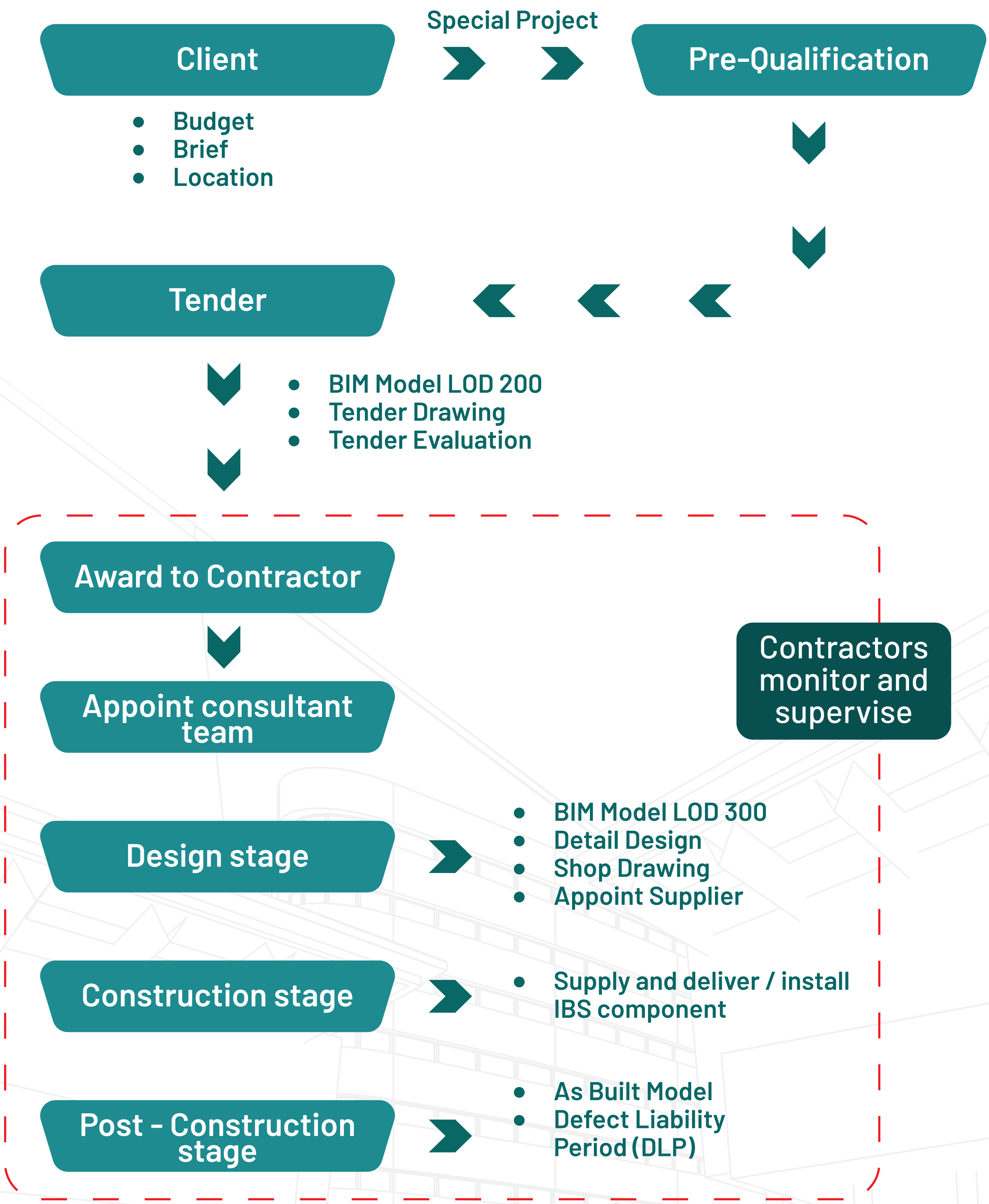
This guideline consists of four (4) sections, covering the overview of IBS construction, considerations before embarking in IBS business, guideline process to start up the IBS business by stages, and IBS business model. Section 1 introduces IBS industry and compares between conventional and IBS construction. Section 2 reviews the considerations before embarking the IBS business based on the challenges and the ways to resolve the issues related to IBS industry. Section 3 clarifies the process to begin an IBS business based on stages (planning, tender, design, construction, and post-construction stages). The last section briefs on the business model for developers and contractors.

CONVENTIONAL TENDER



Flow of Work of Conventional Tender for Contractors

DESIGN & BUILD TENDER



Flow of Work of Design & Build Tender for Contractors

IN-HOUSE CONSTRUCTION

(Developer + Contractor + Supplier)

Planning stage
- Set up plant (eg: machinery, mould)
- Skilled Worker

↓

Land Development

Subject to approval from Local Authority (LA)

↓

IBS Method
- IBS Drawing
- BIM modeler

↓

Submission to Local Authority

↓

Approval from Local Authority

↓

Construction Stage
- Supply and deliver / install IBS component

↓

Post - Construction Stage
- As Built Model
- Defect Liability Period (DLP)

Flow of Work of In-House Construction for Developers / Clients

Planning Stage

Land Development — Subject to approval from Local Authority (LA)

IBS Method — Comply 50 IBS Score as per Requiment

Appoint IBS Consultant

Submission to Local Authority (LA)

Approval from Local Authority (LA)

Tender

Award to Contractor

Construction Stage
- Shop drawing IBS
- Supply and deliver

Post Construction
- As Built Model
- Defect Liability Period (DLP)

Flow of Work for Developers without a Manufacturing Plant

EDITORIAL

This project was funded by the Construction Industry Development Board (CIDB) Malaysia and executed by the Construction Research Institute of Malaysia (CREAM). We would like to thank the following members for their contributions and support in completing ***"Guideline for Small and Medium Enterprise Developers and Contractors: Migration from Conventional Methods to IBS In the Malaysian Construction Industry".***

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LIST OF ABBREVIATION

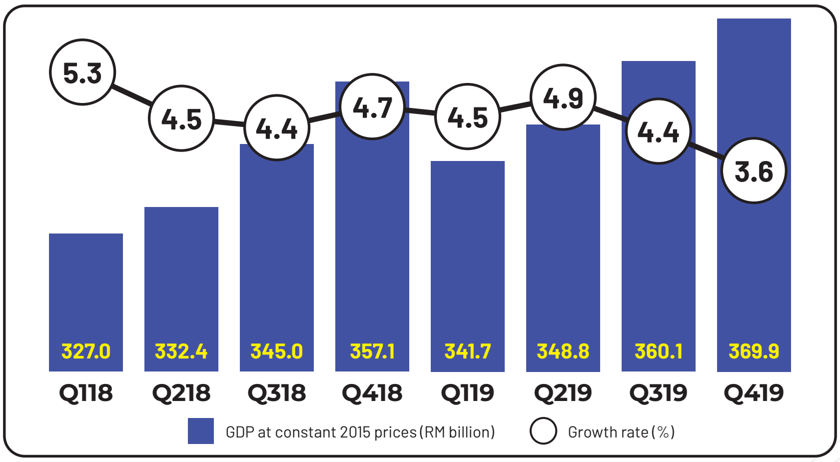
ABM	Akademi Binaan Malaysia
CCC	Certificate Completion and Compliance
CIDB	Construction Industry Development Board
CMGD	Certificate of Making Good Defects
CREAM	Construction Research Institute of Malaysia
D&B	Design & Build
DLP	Defect Liability Period
DOSM	Department of Statistics Malaysia
GDP	Gross Domestic Product
IBS	Industrialised Building System
IMPACT	IBS Manufacturer & Product Assessment & Certification
LA	Local Authority
LOD	Level of Development
MEP	Mechanical, Electrical, and Plumbing
RIBA	Royal Institute of British Architects
T&C	Testing and Commissioning
TVET	Technical and Vocational Education and Training
SME	Small and Medium Enterprise
QLASSIC	Quality Assessment System in Construction

SECTION 01

INTRODUCTION

1.1 Malaysian Construction Industry

The Malaysian economy grew 3.6% in the fourth quarter of 2019 as recorded by the Department of Statistics Malaysia (DOSM). The Gross Domestic Product (GDP) of Malaysia is contributed by services, manufacturing, construction, mining and quarrying, and agriculture sectors. On the production side, services and manufacturing sectors have continued as the main impetus to the economic growth. The recovery in the construction sector has also supported the growth. Figure 1.1 shows the growth rate of Malaysian GDP from Quarter 1 of 2018 until Quarter 4 of 2019.



Source: Department of Statistics Malaysia (DOSM), 2019

Figure 1. 1 GDP of Malaysia

The construction sector recorded a share of 4.5% from the overall contribution with a value-added of RM 16.6 billion. CIDB has stated that there are four categories of construction projects: residential, non-residential, social amenities, and infrastructure. The details of construction product for each category are explained in Table 1.1.

Table 1. 1 Building Category and Construction Product

Category	Construction Product
Residential	• Quarters, terrace house, semi-detached house, bungalow, flat, condominium, apartment, townhouse, and dormitory. • Residential project which contains shop houses and shop office should be categorized as residential because the construction of shop houses and shop office is normally meant to complement the housing project.
Non-Residential	• Shop houses, shop office, business complex, exhibition centre, petrol station, storehouse, warehouse, factory and industrial plant, workshop, storage tank. • Hotel, rest house, chalet, motel, entertainment, and tourism centre.

Category	Construction Product
Non-Residential	• Office space, and government and statutory body office complex. • Livestock, fish and insect inspection centre; livestock treatment centre; slaughterhouse; livestock, fish, insect and crop farm; crop, fish, livestock and insect production centre; agriculture research centre and livestock research centre, clump. • Police station, army camp, prison building, civil defence centre and fire station, police marine camp, and navy camp. • Landscaping works.
Social Amenities	• Hospital, clinic, medical laboratory, and medical treatment centre. • Higher learning institution, school, education and training centre, and kindergarten. • Youth centre, welfare centre, rehabilitation centre, and protection centre • Public toilet, and solid and liquid disposal centre. • Mortuary, memorial centre, community centre, public hall, and multipurpose hall. • Public parking space. • Streetlight, religious house, small bridge, and pedestrian bridge. • Sports centre, leisure & recreation centre, club house, playground, and society office.
Infrastructure	• Reservoir, water pipeline, oil & gas pipeline, water tank, oil & gas tank, chemical tank, and water treatment plant. • Telephone cabling, electric cabling, hydroelectric power plant, communication, substation, and audio-visual station. • Airport, railway or train station, bus station, taxi station, harbour, jetty, road, highway, railway track, rail, traffic light, bridge and tunnel, and hangar. • Sewerage treatment plant and drainage system. • Flood mitigation work, slope protection work, fire prevention and disaster prevention work.

Source: CIDB Construction Quarterly Statistical Bulletin

1.2 Overview of IBS Construction

The Industrialised Building System (IBS) is defined as a construction technique which components are manufactured in a controlled environment on-site or off-site, transported, positioned and assembled into a structure with minimal additional site work (CIDB, 2003). Industrialised Building System (IBS) has been introduced in the Malaysian construction industry since 1964 with its first building being the 17-storey flats, alongside four blocks of four-storey flats as well as 40-storey lots of shops at Jalan Pekeliling, Kuala Lumpur.

Figure 1. 2 Pekeliling Flat

Since 2003, the Malaysian government, together with its agency, the CIDB, has aggressively urged the construction industry to use the IBS method of construction. Such lobbying is part of an integrated effort to further enhance the capacity, capability, efficiency, and competitiveness of the industry, and to reduce the industry's reliance on foreign workers. It is also an effort to promote a cleaner, safer, simpler, and more efficient method of construction.

In line with the objectives of the IBS Roadmap 2003-2010, the 2005 Budget has declared that all new government building projects are required to comprise of at least 50% IBS content. To attract private clients, the second announcement levied exemptions on housing projects with a minimum IBS Score of 50%. Since then, leveraged by the Construction Industry Master Plan 2006-2015 and the 9th Malaysia Plan 2006-2010, numerous activities have been spearheaded by the government.

Two of the major initiatives are the release of the Treasury Circular Letter No. 7, Year 2008 (Surat Pekeliling Perbendaharaan Bil. 7, Tahun 2008) and the announcement of the Action Plan for IBS Implementation in Government Projects (Pelan Tindakan Pelaksanaan IBS dalam Projek-Projek Kerajaan).

These initiatives have replaced the earlier instructions released by the Treasury on 6th July 2005 for the usage of 50% IBS content in all government projects. Released on 31st October 2008, the Treasury Circular Letter was issued to all Secretary Generals, Heads of Federal Department, State Secretaries, Heads of Federal Statutory Bodies, and all local authorities. The essence of the instruction is the usage of Open Building, Modular Coordination (MC) design and 70 IBS Score for all projects. Agencies are required to submit periodical reports of IBS project implementation to the Implementation Coordination Unit, which acts as the central monitoring agency.

Exemptions are offered for certain classes of projects and the IBS Centre functions as the main technical reference centre.

IBS was mentioned in the 2016 Budget and 11th Malaysia Plan, in which there was an allocation to promote IBS for the residential construction. It was revealed that there would be an IBS Promotion Fund of RM 500 million which would be provided by the SME banks. As mentioned by the Minister of Works, the usage of IBS was still low, far from expected.

At the moment, CIDB has categorised six (6) types of IBS system which are shown in Figure 1.3.

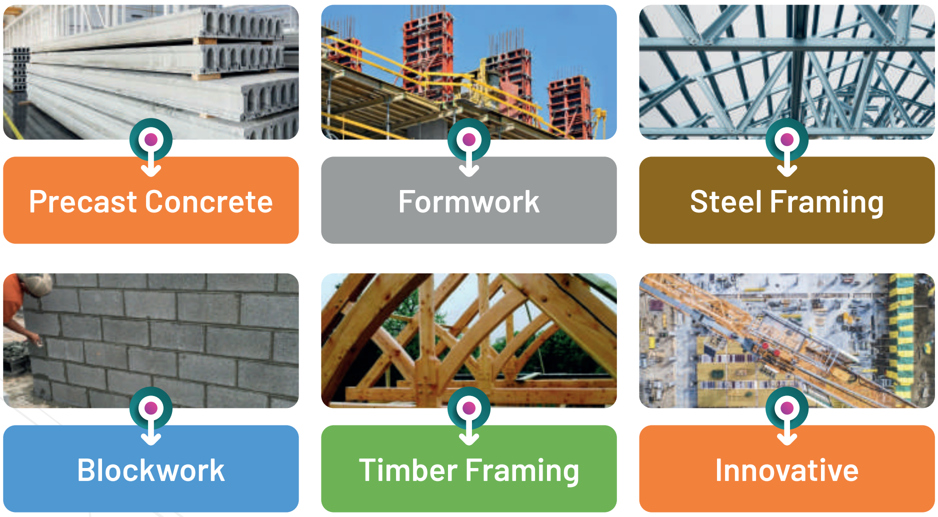


Figure 1. 3 Classification of IBS System

The total number of IBS contractors based on the CIDB classification is estimated around 13,371 as of April 2020. The details of the contractor based on classification is shown in Table 1.2.

Table 1. 2 Total Number of IBS Contractor Based on Classification

Classification	IBS System	Total
B01	Precast Concrete System	2,783
B02	Metal Framing System	9,457
B19	Reusable Formwork System	247
B22	Blockwork System	750
B23	Timber Framing System	134
TOTAL		13,371

Source: CIDB (2020)

1.3 Advantages of IBS

The advantages of IBS implementation have been widely known by the industry and recorded by previous researchers.

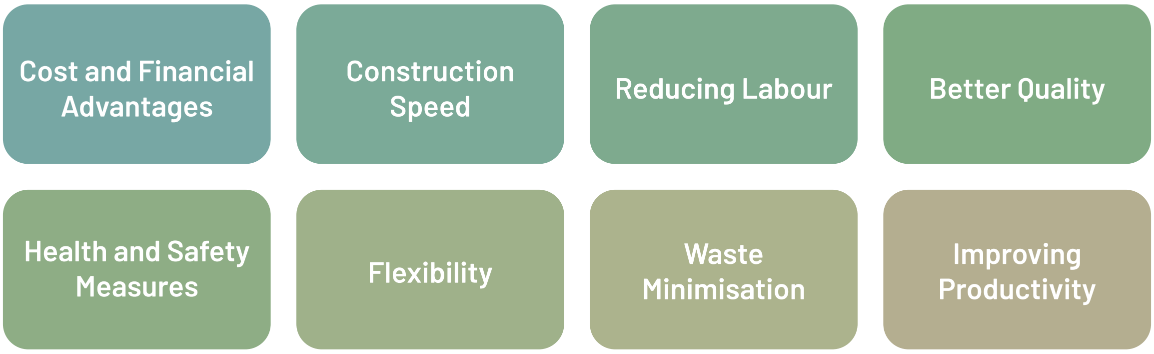


Figure 1. 4 Advantages of IBS

1.3.1 Cost and Financial Advantages

IBS in some ways could be a cheaper method of construction compared to the conventional method. The savings could emanate from a lower number of workers, better quality control and less material wastage. As mentioned by Kamar, Hamid, & Mustapha Alshawi (2009), IBS can be cheaper if one considers the whole life costing of the building. There are direct cost savings in materials and construction overheads while the indirect cost savings occur due to faster delivery of buildings (Trikha & Ali, 2004).

The construction of prefabricated elements in IBS results in a considerable reduction in the use of scaffolding, shuttering and other temporary supports compared to the traditional method of construction (Trikha & Ali, 2004). Blismas (2007) addressed that IBS significantly reduced the entire cost of construction, including lower site-related cost for constructors, and gave early income generation for clients. IBS also allows more efficient designs that reduce the need for high safety margins and specifications, and reduces labour and trade living expenses in remote areas.

Abedi, Mohamad, & Fathi (2011) stated that IBS would save on labour, cost and time; yield better quality and durability for building life; provide better safety and security system; and be more cost effective. This statement was supported by Kamar, Hamid, Zain, & Rahim (2008) whom stated that IBS was cheaper if the entire cycle cost of the building maintenance was considered.

1.3.2 Construction Speed

CIDB (2012) stated that the conventional method consisted of 5 activities: design, approval, site development and development, on-site construction, and site restoration. In the IBS methods, there are also five main activities. However, the on-site construction and site restoration can be reduced to a much shorter time because major components have been constructed and/or fabricated at the IBS plant. The direct and indirect benefits include faster installation and construction time, consequently saving in labour and overall costs as indicated in Figure 1.5.

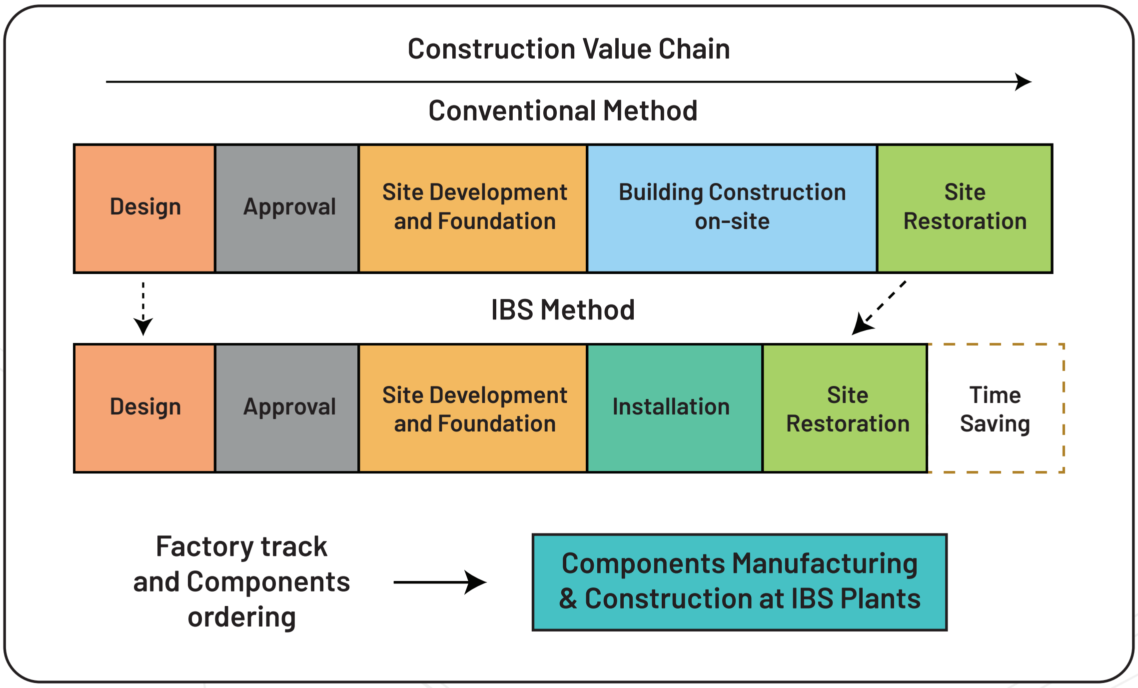


Figure 1. 5 Comparison between Conventional and IBS Method

1.3.3 Reducing Labour

One of the major objectives in using IBS is to reduce the dependency of foreign labour. The construction sector has recorded the second highest number of foreign workers among the three sectors, including manufacturing and agriculture. The number of foreign workers in construction is alarming because it has increased from year to year.

IBS offers significant savings in labour and material costs as the number of labour forces required in IBS is far lower than those required in traditional methods (Badir, Kadir, & Hashim, 2002). In many cases, the usage of IBS has proven to substantially reduce the amount of unskilled and skilled labour directly involved on site.

In Singapore, the use of fully prefabricated system provides labour saving of up to 46.5% as compared to the conventional method (Chung, 2006).

1.3.4 Better Quality

Zawawi (2009) has mentioned that IBS is a highly mechanised system that offers a lot of advantages to the construction process through high quality results. The production processes at the factory ensure higher quality of components produced at the site. Thanoon, Peng, Kadir, Jaafar, & Salit (2003) further affirmed that the careful selection of materials, advanced technology, and strict quality control and assurance ensured the quality of IBS components.

The critical factors that should be closely monitored and controlled to ensure the quality of the product include temperature, mix design and stripping time (Abidin, 2007). IBS offers improvements in quality, productivity and efficiency from the use of factory-made products, consequently reducing the possibilities of poor workmanship and lack of quality control. The quality of final IBS products is normally far superior to that of conventional work as the former is produced under rigorously controlled conditions (Pan, Gibb, & Dainty, 2007; Trikha & Ali, 2004). IBS also provides high quality surfaces finishes in which the joints section is the only part to be grouted, eliminating the requirement for plastering (CIDB, 2010). IBS provides higher quality and better finishes because the production occurs under a sheltered environment in the factory. It also reduces the maintenance expenses because the prefabricated components require less repair and preventive maintenance. On the contrary, the traditional method produces low quality of building, yields poor finishes due to the workmanship, and requires higher maintenance expenses because of the low quality.

1.3.5 Health and Safety Measures

Trikha & Ali (2004) mentioned that the advantages of IBS could be observed through the indoor environment. Special features like the introduction of hollows in precast elements and use of insulating materials sandwiched within the wall panels can be achieved in the industrialised production of building elements, greatly enhancing the quality of the indoor environment. Industrialised construction is environmentally friendly as dust and suspended particles are absent on site. The noise pollution is greatly alleviated since the noise arising from the erection of the scaffoldings and formwork, and their later dismantling is almost eliminated.

1.3.6 Flexibility

Warszawski (1999) opined that in order to minimise uniformity of repetitive facades, IBS allowed flexibility in architectural design. Simultaneously, the flexibility of using different systems in IBS construction process produces a unique prefabrication method (Thanoon et al., 2003).

1.3.7 Waste Minimisation

Chung (2006) mentioned that IBS projects provided clean site conditions and reduced safety and health risks. IBS construction site has proven to be tidy and organised compared to the wet and dirty conventional method sites. Wastage of temporary work, such as timber formwork and props that are normal in conventional construction, is not on the site when the project applies IBS. Thus, the implementation of IBS project reduces the risk of health and safety by promoting safer working conditions.

1.3.8 Improving Productivity

The statistics recorded by the Malaysian Productivity Corporation (MPC) in 2017 showed that the construction labour productivity in Malaysia was about 2.2%. In 11th Malaysian Plan, the government has set the target to achieve at least 9.6% of the construction labour productivity in Malaysia. Overall, the Malaysian labour productivity is at 3.6%, which is about RM 81,039.00 while the target for 2020 is at 3.7%, which is about RM 92,399.00. Therefore, the construction industry is among the lowest compared to other industries. There are ten factors that affect the productivity of the construction industry as follows:

- Quality
- Number and balance of labour force
- Motivation of labour force
- Degree of mechanisation
- Continuity of work
- Complexity of work
- Quality requirement of finished work
- Method of construction
- Type of contract
- Quality and number of managers
- Weather

1.4 Comparison between Conventional and IBS Construction

The conventional building method is defined as the components of the building that are prefabricated on-site through the in-situ processes of timber or plywood formwork installation, steel reinforcement and cast. Conventional buildings are mostly built of reinforced concrete frames. The traditional construction method uses wooden formwork, which is costlier for constructions, including labour, raw material, transportation, and low speed of construction time.

The traditional or conventional procurement method has been a standard practice in the construction industry for 150 years, following the emergence of general contracting firms and independent client consultants. There are two main features of the traditional method:

i. The design process is separated from the construction (although JCT contracts provide the designs of specific parts of the works to be carried out by the contractors).

ii. Full documentation (i.e. drawings, work schedules, bills of quantities) must be supplied by the clients before the contractors can be invited to tender for carrying out the work.

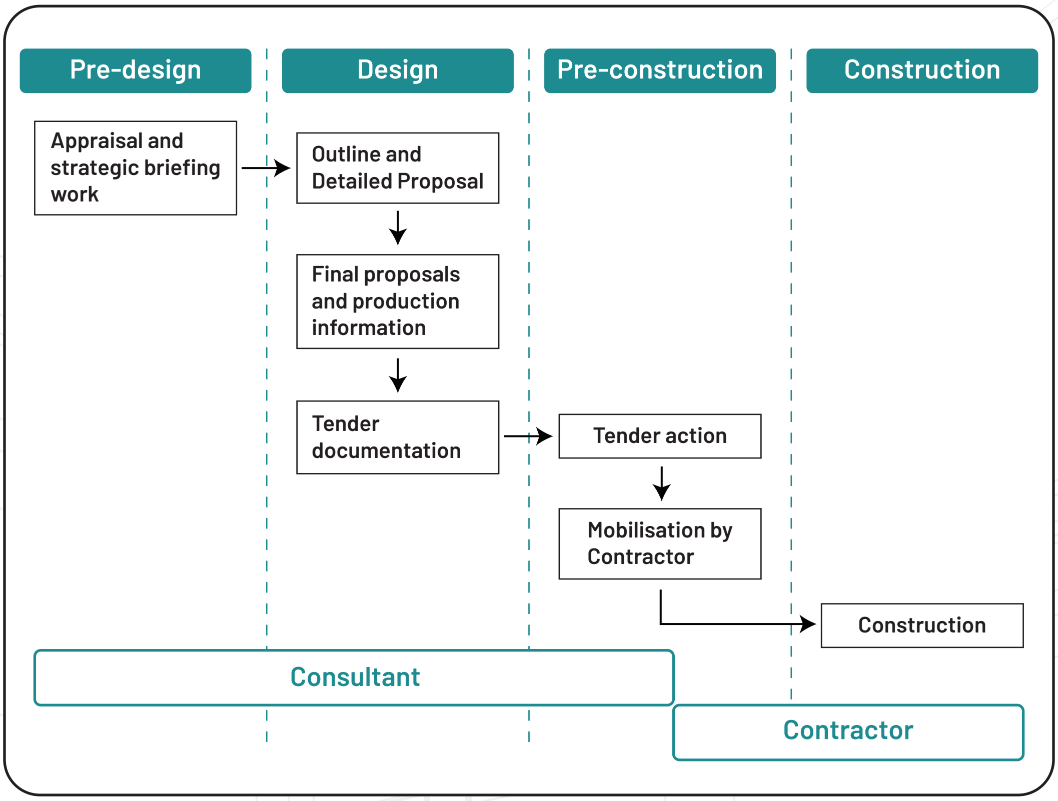


Figure 1. 6 Stages of IBS Construction

Hashemi et al. (2016) has mentioned the comparison between traditional and prefabrication process at the site works stage. Traditional construction requires separate stages for site works and construction while the prefabrication construction requires only one stage, combining the site work, fabrication and assembly. Thus, the prefabrication construction would save extra time compared to the conventional construction.

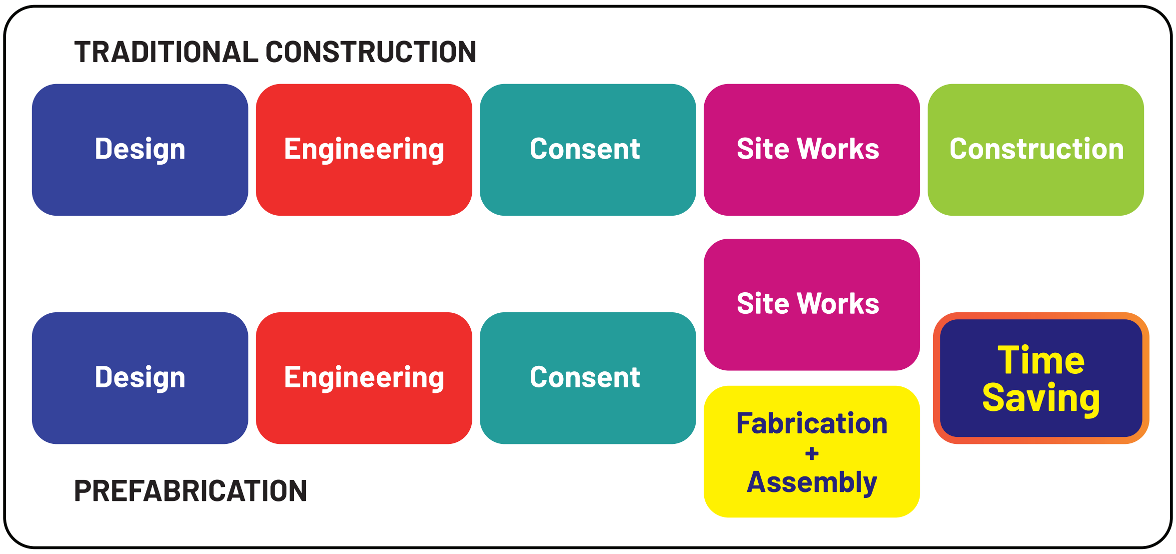


Figure 1. 7 Comparison Stages of IBS Construction

1.3 Operational Definition

1.5.1 Defect Liability Period (DLP)

Defect Liability Period (DLP) is the contractor's responsibility to maintain or repair defects or damage of a product after the construction is set out in the contract.

DLP activities begin from the date the CPC is issued until the deadline within the DLP period specified in the contract. The scope of clients and developers at the DLP level covers the process of monitoring defects list as identified in the disability list, and monitoring disability repair work (defects) after the CPC maintenance work (Planned Preventive Maintenance & Breakdown Maintenance) and customer management complaints.

After the DLP expires and all the conditions set out in the contract are met by the clients, the developers shall process the issuance of Certificate of Completion of Disability Repair (Certificate of Making Good Defects) (CMGD) and prepare the Final Certificate.

1.5.2 Land Development

Land development is defined as the process of acquiring land for residential housing construction, and of making, installing, or constructing non-residential housing improvements, including, without limitation, waterlines and water supply installations; sewer lines and sewage disposal and treatment installations; steam, gas and electric lines and installations; roads, streets, curbs, gutters, sidewalks, storm drainage facilities, other related pollution control facilities; and other installations or works, whether on or off the site.

1.5.3 Testing and Commissioning (T&C)

Testing is the process carried out to determine that the function of an installation, equipment or system operates according to the original design and the test results are recorded. This record is the datum (basic) information necessary to monitor the system capabilities throughout its life.

Accreditation is the process of running a system, and proving that the functional aspects and capabilities of a system are achieved according to the original design requirements. It includes a complete record of accreditation procedures and results.

Testing and commissioning (T&C) activities begin from the completion of physical work and involve all installation and equipment, mechanical, electrical, and civil engineering systems, such as sewage systems, resulting in the Test & Accreditation Record (T&C documents).

Contractors need to include the T&C schedule in the work program (CPM) for the whole project. Reasonable and practical period should be in provision for T&C purposes. The work to complete and carry out equipment or systems is done by the contractors.

The consultant or representative is mandatory to witness and record all data and procedures on the T&C form. The deputy consultant is necessary to obtain the PD approval first.

The T&C lies with the certified consultants and the declaration by the consultants is required to obtain the entire T&C conducted.

1.5.4 Plan of Work

According to RIBA, Plan of Work is a document that outlines all stages in the planning, designing and building process, from conception to completion on site. It is the most common document used in the UK to describe the stages in construction projects. The eight stages involved in the Plan of Work in the construction according to RIBA are initial consultation, site visit and further consultation, concept design, developed design, technical design, construction, handover and completion, and ongoing requirements.

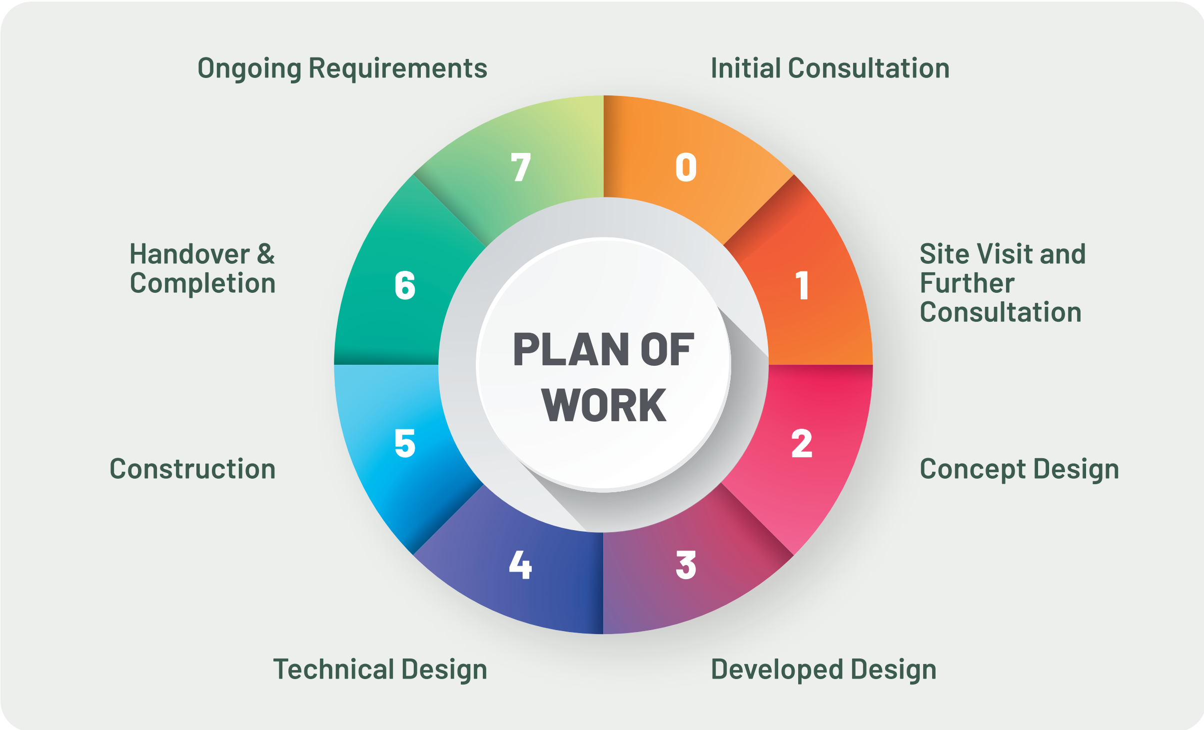
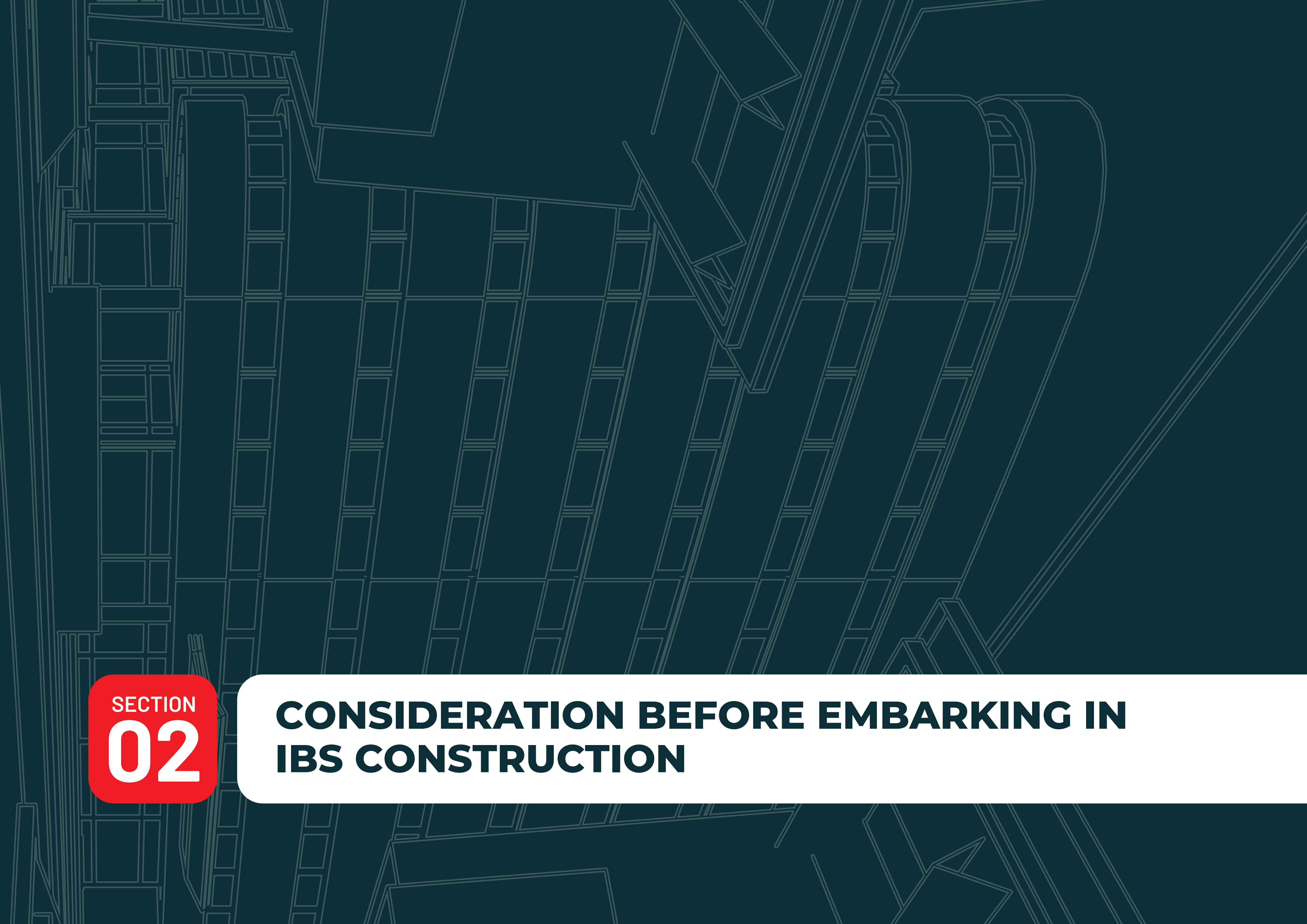


Figure 1. 8 RIBA Plan of Work

1.5.5 Supply and Deliver

Supply and deliver in this context mean that the material of IBS components is delivered to the construction site to begin the process of installing the components.



SECTION 02

CONSIDERATION BEFORE EMBARKING IN IBS CONSTRUCTION

2.1 Issues of IBS Construction

A new player who wishes to embark in the IBS is advised to ponder a few considerations. Jabar & Ismail (2018) has categorised the issues of IBS construction into three (3) phases: pre-construction phase, construction phase and post-construction phase.

Table 2. 1 Issues of IBS Construction by Stages

Pre-Construction	Construction	Post-Construction
This phase includes the initiating and planning phase. The planning phase comprises of defining the project scope, identifying resources, developing a project budget and schedule, and identifying risks.	This phase is known as the performing phase in which the project plan is executed, and work tasks are carried out to accomplish project deliveries and project objectives.	This phase also means as closing phase to the contractors. The contractors will conduct the project evaluations, identify and document lessons learned to help improve performance on the future projects.

2.2 Challenges to Embark in IBS Construction

2.2.1 Enormous Capital Cost

Figure 2. 1 Capital Cost of IBS Construction

Many researchers have mentioned embarking in IBS business involves a lot of initial investments, such as machinery, mould preparation, training the workers and others. The high initial cost has burdened the players of IBS project as they need to have high investments for IBS project. Before getting the first draw, the contractors will have spent a large amount of money. The contractors are required to provide capital not only on the construction itself, but also on other things such as the estimate, which is time consuming and expensive, and on setting up the job in the office and in the field, purchasing materials, renting equipment and hiring labour. Therefore, it is reasonable for the contractors to attempt to recapture this cash outlay as rapidly as possible. It is also reasonable to conclude that a contractor needs only a small profit margin on fixed and definite item costs, such as the subcontractor's bids and the purchase of materials, whereas a larger profit is required on risk items, such as labour performed by the contractor's forces due to the overrun cost (Wiley, 1984). The research conducted by Construction Research Institute Malaysia has shown that there were 44.2% respondents consisting of contractors and developers (total:350 persons) whom have agreed about the high cost to start an IBS business.

Additionally, the capital cost of traditional on-site construction is 10-20% lower than prefabrication (Mao et al., 2016). Despite increasing efficiency, the cost of prefabrication is also increased. The lower capital cost of traditional on-site construction has been favoured by the stakeholders. Hence, the capital cost becomes the most important factor for a client's consideration when they select the construction methods. About 85% of the clients refuse to choose prefabrication due to the high capital cost (Pan et al., 2007). Xue, Zhang, Su, & Wu (2018) classified capital cost into five (5) categories: design cost, production cost, precast component cost, transportation cost and on-site installation cost.

The findings by Ariffin et al. (2018) showed that the main challenges in IBS implementation were the high initial and set up costs. It was stated that IBS was an expensive construction method than the conventional method due to the excessive capital to pay the specialists or manufacturers in the beginning stage of construction. Furthermore, the IBS manufacturers have been revealed to obtain an advance payment of 10% of the total cost of IBS components from the main contractors to secure the financial aspect. Blismas (2007) mentioned that financial issues appeared to be important matters for the manufacturers. More than half of the respondents claimed that they were very keen on the capability and commitment of the contractors and the clients on the payment mechanism. The challenge for them was to ease their financing costs and cash flow because IBS was seen as incurring high initial and set-up costs. Many manufacturers also require some payments to be made once they have fabricated the components (Gibb & Isack, 2003).

Research done by Nawi, Lee, Kamar, & Hamid (2012) stated an enormous capital cost which included stepping up the plant, supplying machinery and moulds, and the expenditures involved in the transportation process (amounts to 3% to 5%) as part of their total cost for distances not exceeding 50km – 100km. According to CIDB (2018), the major issue in housing projects is still the upfront payment. The contractors have difficulties in the upfront payment as the amount tends to be too high. The main contractors must pay IBS manufacturers whom will then use the money to buy the required materials to fabricate the components. The materials purchased include cement, steel, sand and precast moulds. Besides that, other than contractors, the manufacturers also face cost of operations such as labour, machinery and crane operators.

In most cases, contractors have no financial source, meaning having to pay upfront using their own money. Underpayment issues in IBS exist when the orders are in large quantities. Depending on the shape and size of the components, the upfront amount normally ranges between 30% to 50% from the total cost. The main contractors who are not entitled to any financial help generally reduce the upfront payment to the IBS manufacturers as the amount between 30% to 50% is considered too high. Apart from the upfront payment for the IBS components, contractors also need to bear their own operational and construction costs such as preliminary works, machines and cranes, material suppliers and subcontractors. Without any financial help, most contractors have difficulties to pay the upfront cost.

As a consequence of the fragmentation of the construction industry, the designers, builders and developers remain generally as modest players with little resources to invest in equipment and plants necessary for automation in the manufacture of building elements, and mechanisation of assembly and erection processes. Funds are also required for the investment in training and imparting skills to efficiently utilise the building systems (Trikha & Ali, 2004).

The machinery cost also affects the mechanical cost since the large lifting weight of the on-site tower crane is usually acquired by the larger dimensions of precast component. Besides that, the specific construction technology has been added to the prefabrication process, such as steam curing and storage of precast components, which increase the production cost prefabrication (Xue, Zhang, Su, & Wu, 2017).

Based on the report by Jalil, Nuruddin, Jaafar, & Mydin (2015) and Blismas (2007), the IBS construction approach demands high initial investment capital for the fabrication processes, consequently leading to a highly tight cash flow and other problems. Due to this problem, the IBS construction approach is viewed as a threat to their business instead of potential opportunity. Shukor, Mohammad, Mahbub & Ismail (2011) agreed, stating that more than half of the IBS manufacturers were very concerned about payment issues, and worried about the commitment and capability of the contractors and clients based on the current payment mechanism.

The transportation used to carry IBS components need to be redesigned to be able to carry larger panels. Redesigned lorries must meet the suitability and at the same time, follow the road regulations. Currently, the transporters can carry limited weight, length and depth of IBS components stated in the road regulations; therefore, the optimum carrying capacity is not met (Chung, 2006). Ahmadian, Akbarnezhad, Rashidi & Waller (2016) concurred that the estimated transportation cost for prefabrication was accounted for about 10%-20% of the total project cost.

2.2.2 Human Barriers

One of the factors that hinder the implementation of IBS in the Malaysian construction industry is to change the mindset of the industry. During the early phase of IBS implementation in Malaysia, there are failures in the construction especially at the jointing parts. Studies have shown that 59% of respondents agree that there is lack of knowledge in the appropriate technique to be used in jointing the IBS components. However, the issue of jointing has been solved with the appropriate installation technique. From the users' perspective, IBS buildings are a fragile and impermanent structure.

Besides that, some of the construction players are reluctant to change to the new construction method as they must embrace the new ways of thinking and working, especially architects. The construction players also require the additional investments for human capital for training.

2.2.3 Insufficient Knowledge

Since IBS is a new construction method, the implementers should have knowledge especially the installation part. The barriers of IBS implementation are the lack of knowledge and exposure to IBS methodology which contributes to poor structural analysis and design, and leads to problems such as cracks, leakage, and other defects. Moreover, there were 63.5% of respondents whom agreed that the lack of IBS knowledge among contractors was one of the issues of using IBS method in construction.

2.2.4 Component Standardisation Issue

A successful IBS usage depends on the utilisation of standardisation of components. To date, the component standardisation is perceived to be low, preventing the same components to be used for other projects. The effects of low standardisation will increase the initial cost due to the design cost and moulding that cannot be used repeatedly for another project. There were 39.3% of respondents whom agreed that the lack of precise measurements due to the design problem of IBS components was one of the challenges of using IBS.

It is more suitable for repetitive designs, such as high-rise buildings, terrace houses, and others. Although it is not suitable for unique or custom designs, some IBS components may be adopted such as steel roof-trusses. For SME developers and contractors, house designs vary, consequently hindering the usage of standardised mouldings.

2.2.5 Availability of Cheap Foreign Labour

Since the low labour rates can be easily obtained, the contractors are hesitated to move into other construction method solutions which require higher capital cost and make IBS investment riskier. This situation is worsened by some irresponsible contractors who hire illegal foreign workers whom indeed can be acquired at a very low rate.

2.2.6 Transportation

Transportation issue is one of the main issues of IBS implementation. The IBS components comes in large and bulky sizes. Proper site logistic planning needs to be well established due to the size and weight limitations, route restrictions, permits and the availability of lifting equipment. Additional lift planning is required when the components reach the construction site. The complexity of lift normally increases with the increase in the level of IBS usage. Some SME developers are building small units of houses (less than 20 units) per project. Thus, the need for continuous usage of lifting machinery increases their cost drastically.

2.2.7 Coordination

Coordination of design, transportation, tracking, and installation is to ensure successful implementation. Apart from that, the work of breakdown structure, terminology, drawings, progress measurement, and scheduling for materials management and supply chain should also be taken into consideration. With the increase of coordination, effective communication becomes vital for the distribution of information regarding decisions, designs, transportation requirements and schedules.

Design changes can be caused by five (5) main reasons, which are from the perspective of contractors, clients, external, site and consultant-related causes.

Table 2. 2 Related Causes in Design Changes

Perspective	Related Causes
Contractor	• Rectify construction mistakes • Improve quality of works (defective) • Improve safety and health aspects (temporary structures, sequence of works) • Shop drawings coordination discrepancies • Skill shortage in certain trades (labour) • Request to use available materials • Alternative construction methods for schedule acceleration • To suit sub-contractors' design / requirements • Improving buildability (ease of construction) • Shortage of materials (resources not available)

Perspective	Related Causes
Client	• Change of requirements / specification • Desire to use new technology / materials • Value engineering (cost saving, alternative materials) • Change of financial status (funding of project) • Unclear client's brief • Slow decision making • Addition / omission of scopes • Change of use of building • Driven by market demand (sales) • Additional requirements (add-on features)
External	• Changes in government regulations, laws and policies • Problem with adjacent properties • Economic conditions (i.e. change in tax structure, interest rates, exchange rates) • Local authority planning permission requirements
Site	• Unforeseen ground conditions (geotechnical issues) • Site safety consideration (soil erosion, scaffolding, site access) • Clashes with adjacent structures • Undetected underground utilities
Consultant	• Lack of coordination among various professional disciplines or consultants • Poor understanding of client's needs • Insufficient soil investigation (SI) prior to design • Outdated design (new technology or construction method) • Modification to design (improvement) • Non-compliance to authority requirement • Erroneous or discrepancies in design documents • Design omission or incomplete drawings • Current design is too expensive • Constructability ignored in design process (difficult to build) Compliance to quality requirements (QLASSIC, CONQUAS etc.)

2.2.8 On-site Construction Process Issue

The IBS components, such as concrete panels are generally heavy and difficult to align, leading to the problem of improper assembly, leakage, and crack in the future. Site-specific constraints also cause problems to the IBS construction process since the IBS components require extra space for storage, and mobilisation and circulation of machineries and equipment. Busy cranage activity will also cause idling of IBS components.

2.2.9 Approval Procedure Issue

A thorough approval procedure has delayed the project implementation. The developers and contractors need to seek approval from CIDB, BOMBA, local authority and other related parties. The local authority's approval normally takes up to 3 months, which can delay the process of project completion. In addition to that, the delay in the planning approval, especially in Kebenaran Merancang (KM), Building Plan (BP) and Certificate Completion and Compliance (CCC) will increase the cost of construction. It is suggested to consider fast track approval for KM (Planning), KM (Building) and BP submission for projects with IBS score of 50 points and above.

Table 2. 3 Approval Procedure Issue with Related Parties

Party	Types of Approval	Remarks
Local Authority	Project and land approval (submit drawing, processing fee)	Processing fee
CIDB	Levy (based on project value)	Fee based on project value
Utilities (SYABAS)	To check the water pressure	-
BOMBA	Certificate Completion and Compliance (CCC) approval	-

2.2.10 Supply and Demand

IBS construction requires high technology of construction method. Therefore, the major challenge in IBS implementation is to prepare the demand for labour highly skilled in the IBS installation (Halim, Razak, & Hamid, 2017). The challenges also arise from the inconsistent demand of volume, especially in the private construction sector. About 37.3% of respondents agreed that there was uncertain supply and demand of IBS method from the end-users.

2.2.11 Market Readiness and Acceptance of House Purchasers

Developer's market are mass-consumers; therefore, the general perceptions are important factors to be considered before embarking into new systems of construction to avoid negative perception or lower confidence. Some of the house purchasers still have stigma on the new IBS materials, such as the dry wall system. A project is considered by potential buyers based on the location, price, design, amenities, access and others. Thus, the design must imply beauty, strong-built, sturdiness, durability and practicality for the Malaysian weather.

Currently, some IBS systems are perceived as lesser-strength or weather-unsuitable compared to the conventional construction materials. Besides that, house renovations are common; therefore, IBS systems must accommodate for an easy future renovation or extension. Generally, consumers, are willing to adapt to changes and migrate from the conventional to IBS construction if:

i. The cost variations or differences are wider. IBS is much cheaper, and the conventional materials are scarce and more expensive, such as clay bricks.
ii. The record of strength, sturdiness and beauty of IBS systems is proven (perception of high-quality).
iii. Options for conventional methods are less; for an example, government policy (eg, limitation on wood products usage).

2.3 SME for Construction Industry

The definition of small and medium enterprise (SME) varies between categories. The construction sector is included in the other sector categories. A small enterprise has sales turnover from RM300,000 to less than RM3 million or employees from 5 to less than 30. A medium enterprise has sales turnover from RM3 million to not exceeding RM20 million or employees from 30 to not exceeding 75. Table 2.4 shows the definition of small and medium enterprise based on the sector category.

Table 2. 4 Definition of SME

Category	Small Enterprise	Medium Enterprise
Manufacturing	Sales turnover from RM300,000 to less than RM15 mil OR Employees from 5 to less than 75	Sales turnover from RM15 mil to not exceeding RM50 mil OR Employees from 75 to not exceeding 200
Service and Other Sectors	Sales turnover from RM300,000 to less than RM 3 mil OR Employees from 5 to less than 30	Sales turnover from RM3 mil to not exceeding RM20 mil OR Employees from 30 to not exceeding 75

Source: SME Corp Malaysia (2020)

http://www.smecorp.gov.my/index.php/en/small-and-medium-sized-enterprises

The justifications by the CIDB for the SME in the construction sector to have a different definition from the services sector are as follows:

i. Contractors registered with CIDB are awarded grades of registration from G1 to G7. These grades reflect the tendering capacity of the construction companies to accept a range of construction projects of different values. They cannot accept contracts that exceed the value for which the companies are registered. The construction services include the infrastructure, residential and non-residential, and special trade services.

ii. A construction company is structured based on their grades of registration, which reflects their financial capabilities, tendering capacity and size of the company. When the company expands and increases their financial capabilities, a contractor can apply to upgrade to a higher registration grade and increase their tendering capacity. Table 2.5 shows the grades of registration of the contractors set by the CIDB.

Table 2. 5 Grades of Registration of Contractors by the CIDB

Contractor Grades of Registration	Tendering Capacity	Paid-Up Capital	Size of Company
G7	No limit	RM 750,000 (USD 247,500)	Large construction company
G6	Not exceeding RM10 million (USD 3.3 million)	RM 500,000 (USD 165,000)	
G5	Not exceeding RM5 million (USD 1.65 million)	RM 250,000 (USD 82,500)	Medium size construction company
G4	Not exceeding RM3 million (USD 990,000)	RM 150,000 (USD 49,500)	
G3	Not exceeding RM1 million (USD 330,000)	RM 50,000 (USD 16,500)	Small size construction company
G2	Not exceeding RM500,000 (USD 165,000)	RM 25,000 (USD 8,250)	
G1	Not exceeding RM200,000 (USD 66,000)	RM 5,000 (USD 1,650)	

Based on the CIDB's definition of construction SMEs, G1 to G3 contractors fall under the small-size category; G4 and G5 contractors are categorised as medium-sized contractors; and G6 and G7 contractors are categorised as large.

However, these CIDB-recommended definitions remain at the proposal stage and they have not been endorsed by the National SME Development Council. For the purposes of this study, the selection and classification of SME contractors are based on their CIDB categorisation because all contractors in Malaysia must be registered. All contractors use the registration grades given by the CIDB to tender for projects. The CIDB also has a complete record of all contractors in every state in Malaysia according to their registration grade, which is accessible by researchers to perform data collection.

2.3.1 Economic Activities under Construction Sector

The economic activities under the construction sector are divided into three (3) main categories: construction of buildings, civil engineering, and specialised construction activities. The details of the specialisation for each category are described in Table 2.6.

Table 2. 6 Specialisation of Construction Sector

Construction Sector	Specialisation
Contractor	• Construction of buildings
Civil engineering	• Construction of roads and railways • Construction of utility projects • Construction of other civil engineering projects
Specialized construction activities	• Demolition and site preparation • Electrical, plumbing and other construction installation activities • Building completion and finishing • Other specialized construction activities

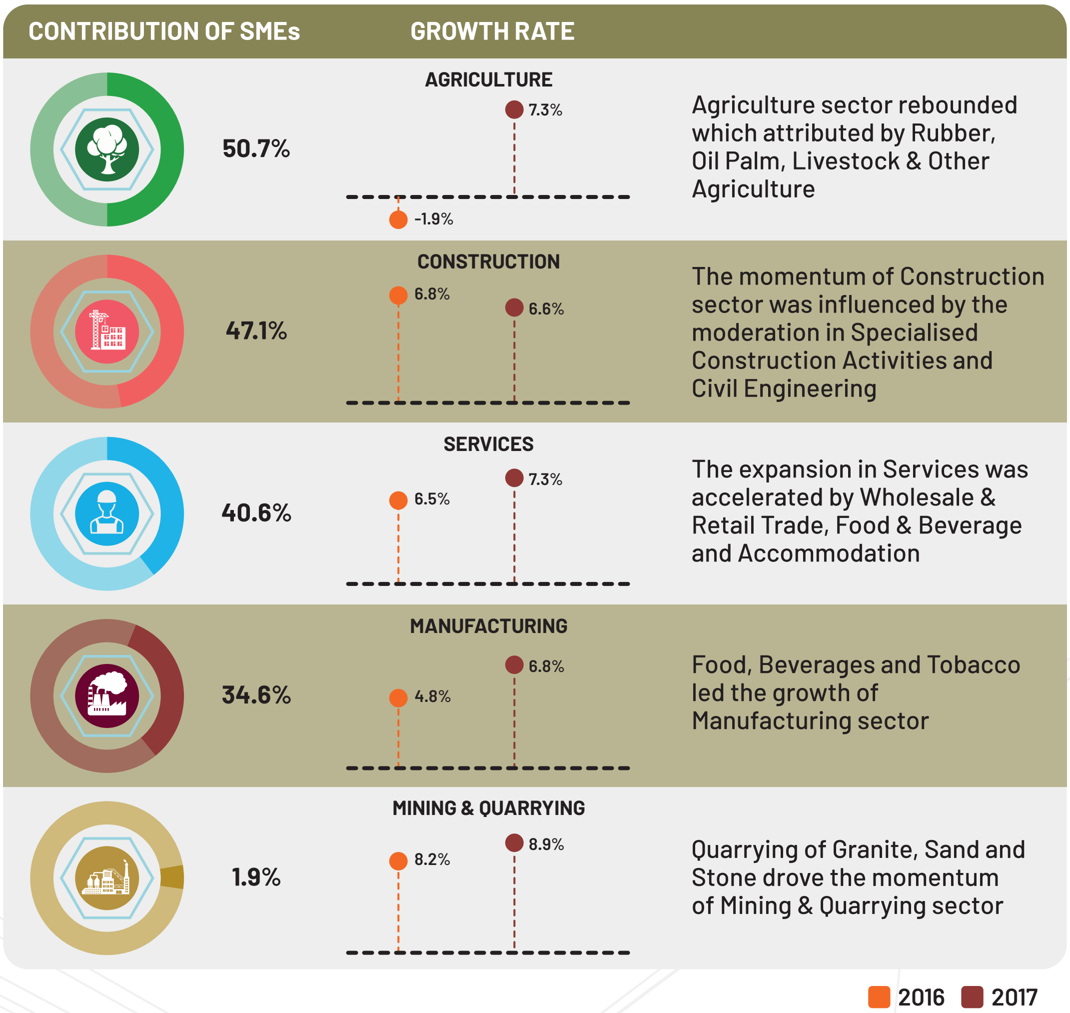
2.3.2 Key Characteristics of Construction SMEs

Based on the study by Kamal & Flanagan (2014), the construction SME are categorized into seven (7) key characteristics: (1) motivation for survival, (2) no policy for the implementation of new technology and training, (3) no preference on the type of construction work accepted (no specialisation), (4) dominated by a single owner, (5) small number of employees, (6) vulnerable to the political scenario and (7) different business approaches between Bumiputera and non-Bumiputera (Chinese) companies.

2.3.3 SME's Performance

The analysis done by the Department of Statistics Malaysia (DOSM) recorded that the SME in the construction sector contributed about 47.1% to the national GDP in 2017. Compared to 2016, the contribution in 2016 is about 6.8% and 6.6% in 2017.

The momentum of the construction sector is influenced by the moderation in Specialised Construction Activities and Civil Engineering. Figure 2.2 shows the comparison of SME's performance between sectors.



Source: Department of Statistics (DOSM), 2017

Figure 2. 2 SME's Performance in 2017

From the perspective of SMEs, the GDP contribution in all sectors recorded a high contribution in 2017, except for the construction sector. SMEs' GDP was led by the agricultural sector with a share of 50.7% in 2016 as portrayed in Figure 2.2. This contribution was influenced by the rubber, oil palm, livestock and other agriculture subsectors.

The contribution of SMEs GDP in the construction sector was 47.1% from the 47.2% in the preceding year. This was reflected by the lower contribution in the civil engineering activities. The SMEs GDP in the services sector expanded to 40.6% compared to 40.2% in 2016 and they were dominated by wholesale and retail trade, food and beverage, and accommodation subsector. Subsequently, finance, insurance, real estate and business services subsector have also supported the services sector.

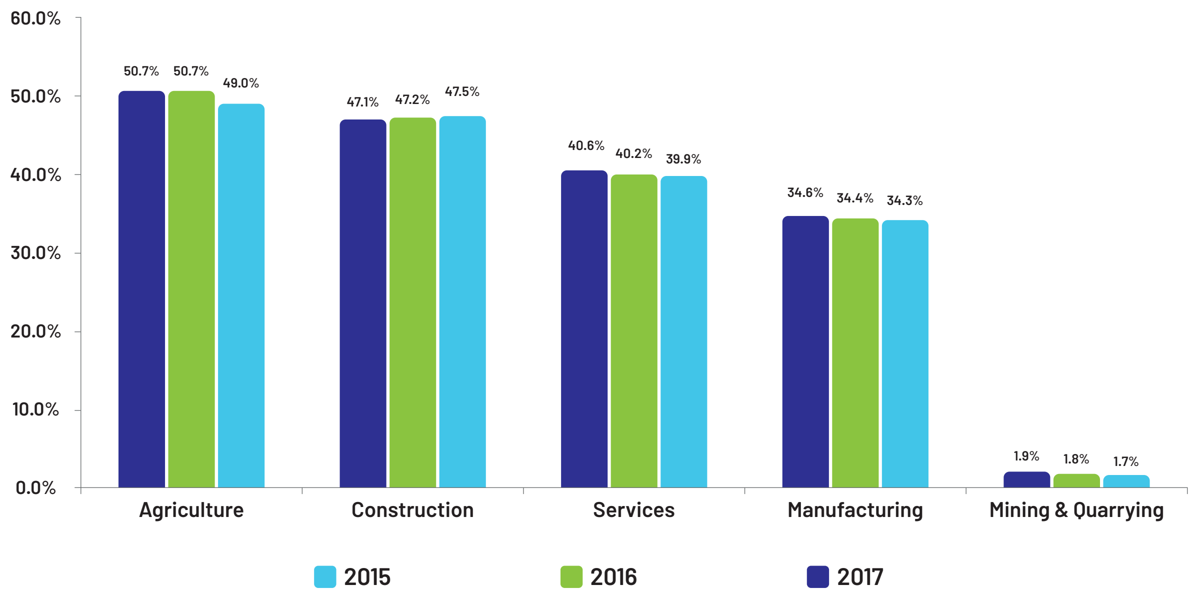
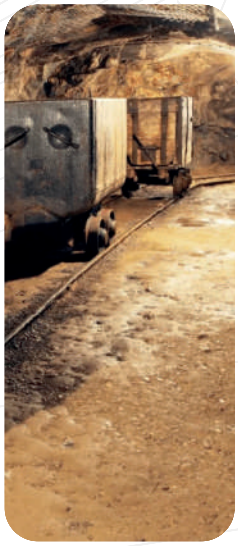


Figure 2. 3 Contribution of SMEs GDP for 2015-2017 at Constant 2010 Prices

Malaysian SMEs GDP recorded a strong growth at 6.2%, exceeding the Malaysian GDP which registered at 4.7% in 2018. The SMEs GDP contribution increased to 38.3% compared to 37.8% in 2017. The SMEs GDP of the construction sector showed the contribution of about 46.4%, which was the second highest compared to the agriculture sector (52.8%). Figure 2.3 shows the comparison of growth between the sectors.







SECTION 03

FROM CONVENTIONAL CONSTRUCTION TO IBS CONSTRUCTION

Changes from conventional to IBS method will influence the design, manufacture, and site work because of the increasing use of prefabricated structural elements and other innovative solutions. Therefore, changes in the overall process are necessary. There is a consensus that the IBS is best handled as a holistic process, requiring a total synchronisation of construction, manufacturing, and design. In this section, the steps involved in the IBS project implementation is divided into five stages: planning stage, tender stage (for contractor), design stage, construction stage and post construction stage.

3.1 Planning Stage

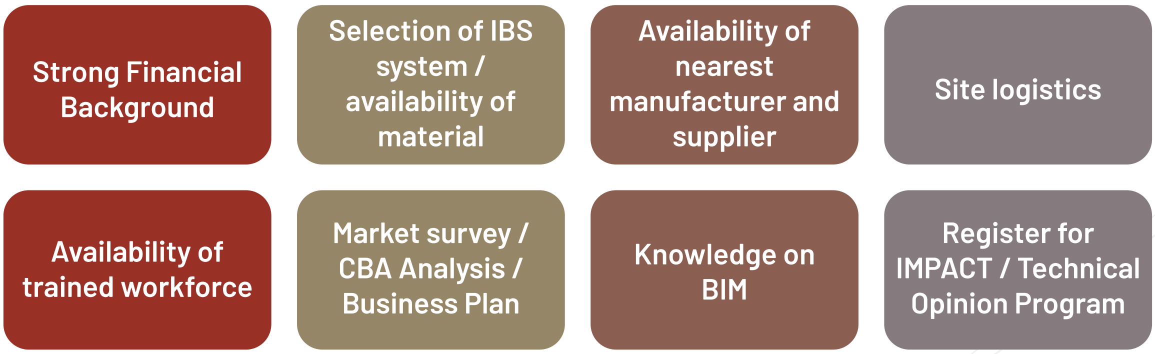


Figure 3. 1 Main Elements in Planning Stage

In this stage, the most important factor to start an IBS business is to have a strong financial background due to the high capital cost involved. The contractors should also know the best selection of IBS based on the availability of materials near the construction site or factory. The list of manufacturers and suppliers according to the IBS system and locations is shown in Table 3.1. Studies have proven that the level of importance for business strategy in the business entry for IBS industry included the selection of IBS system, availability of materials, site logistics, availability of trained workforce, availability of nearest manufacturers, registration with CIDB IBS for IMPACT certification, Technical Opinion (TO) Program or Engineering Inspection (EI), registration for Perakuan Pematuan Standard (PPS), and registration for Orange Book, all of which had the same ranking of 4 for the highest weightage from respondents with 69.2%, 71.5%, 55%, 59.8%, 41.6%, 41.6%, 46.2% and 42.7%, respectively. Only two items had ranking of 5 for the highest weightage, which were market survey, CBA Analysis or business plan, and knowledge on BIM with 37% and 37.9%, respectively.

As shown in Table 3.1, the majority of the manufacturers and suppliers are from Selangor, followed by Johor and Sabah. Precast Concrete System recorded the highest number of prefabricated components, followed by Innovative System and Metal Framing System. Examples of innovative system include the self-climbing formwork and modular unit that caters to fast construction time. The data on Precast Concrete System are divided into two categories: off-site precast (cast in factories) and on-site precast. Metal Framing System is grouped into two categories: steel structure and metal roof trusses.

Table 3. 1 Total Number of Manufacturers and Suppliers Based on IBS Classification and Location

No.	State / Location	Precast Concrete System	Reusable Formwork System	Metal Framing System	Timber Framing System	Blockwork System	Innovative System	Total
1	Johor	27	2	9	1	4	10	53
2	Kuala Lumpur	2	0	2	0	0	3	7
3	Kedah	4	2	3	0	1	2	12
4	Kelantan	1	0	3	0	1	2	7
5	Melaka	4	0	3	1	2	0	10
6	Negeri Sembilan	9	3	1	0	3	3	19
7	Pulau Pinang	2	1	3	0	1	0	7
8	Pahang	3	0	2	0	3	0	8
9	Perak	3	0	3	0	1	9	16
10	Perlis	2	0	0	0	0	0	2
11	Sabah	7	0	7	0	5	5	24
12	Sarawak	6	0	8	1	2	3	20
13	Selangor	29	29	18	0	13	35	124
14	Terengganu	3	0	2	2	1	0	8
TOTAL		102	37	64	5	37	72	317

Note: To discover the list of manufacturers and suppliers of IBS system in Malaysia, please contact IBS Centre, Construction Industry Development Board (CIDB) Malaysia.

Transportation cost is one of the main expenses during the early stage of IBS construction. It is estimated that about 10%-20% of the total project cost is for transportation cost. Therefore, it is essential for the contractors to take into consideration the distance between factory and construction site. The optimum distances should not exceed 50 km – 100 km.

The implementation of IBS in the construction site requires the usage of trained or skilled workforce. Skilled workers are required and essential for implementing IBS construction projects to deliver and achieve projects within the specific time and estimated cost. Skilled workers in building and construction need to be trained in terms of knowledge of materials, methods, and tools involved in the construction or repair of houses, buildings and other structures, such as highways and roads. Many construction industries lack skilled and professional labours to handle the progress of construction projects effectively and successfully.

There are many Technical and Vocational Education and Training (TVET) institutions that offer related construction courses as listed in Table 3.2. One of them is Akademi Binaan Malaysia (ABM). ABM is a CIDB assessment and training centre, which caters to the need for developing skills and construction workers. ABM focuses on equipping building personnel with industry-standard competence. There are four centres in Peninsular Malaysia and two in Sabah and Sarawak.

Table 3. 2 List of Public Training Institutes in Malaysia

No.	Ministry	Public Training Institute	No. of Institute	Capacity
1.	Ministry of Human Resources	Industrial Training Institute	23	15,160
		Advanced Technology Training Centre	8	6,100
		Japan-Malaysia Training Institute	1	800
TOTAL			32	22,060
2.	Ministry of Education	Polytechnic	33	89,000
		Community College	91	32,470
		Vocational College	80	15,384
TOTAL			204	139,230
3.	Ministry of Women, Family and Community Development	Industrial Training and Rehabilitation Centre	1 (OKU)	300
TOTAL			1	300
4.	Ministry of Rural and Regional Development	MARA Training Institute	13	13,162
		MARA Higher Skill College (KKTM)	10	9,976
		GiatMARA	231	23,000
TOTAL			254	46,138
5.	Ministry of Youth and Sport	National Youth Higher Skills Institute (IKTBN)	1	600
		Vocational College	19	15,640
TOTAL			20	16,240
6.	Construction Industry Development Board (CIDB), Ministry of Public Works	Malaysian Construction Academy (ABM)	6	6,000
TOTAL			6	6,000

Source: Ministry of Human Resources

Table 3.3 shows the number of construction workers whom completed their training at ABM from 2012 until 2016. The trainee undergoes various types of training in building (bricklayer, concreter, plumber, bar bender, carpenter and painter), IBS, crane operation, plant operation, mechanical and electrical training. The numbers reflect the availability of skilled local construction workers to enter the industry for installing components.

Table 3. 3 Skilled Construction Workers from Malaysian Construction Academy (ABM, 2017)

ABM Campus	2012	2013	2014	2015	2016	TOTAL
Centre	2,224	3,411	4,229	4,347	5,154	19,365
Eastern	2,530	2,530	3,123	2,654	4,729	15,566
Northern	2,816	2,816	4,104	4,638	4,748	19,122
Southern	2,206	2,206	4,143	3,272	4,559	16,386
Sarawak	1,950	1,950	3,196	5,171	4,711	16,978
Sabah	3,489	3,489	5,530	6,076	5,436	24,020
TOTAL	15,215	16,402	24,325	26,158	29,337	111,437

Source: Construction Industry Development Board (CIDB)

Having an appropriate business plan is essential for any business. Business plan will help the company to make better decisions and avoid big mistakes in the future. Besides that, a proper business plan will set better objectives and benchmarks in the business. The most important thing in the business plan is to secure financing, whether or not to borrow from banks, venture new products and other related matters. Knowing the target market and market segmentation are also important in the business. Besides that, the company should be familiar with the profile of competitors to better plan the manufactured products. The studies have shown that the level of importance for the business strategy related to the target market in the IBS industry including the item of policies and regulation to implement IBS (from government or private sector) has the highest percentage with 61.8%, followed by volumetric construction and demand of the customer with specific layout with 57.8% and 57.5%, respectively.

CIDB encourages the usage of BIM in the IBS projects. The recommendation to make the usage of BIM compulsory in the IBS project is still in consideration. The success of IBS project is related to the usage of BIM since the early stage of construction. The BIM functions in the IBS projects involving the visualisation, shop drawings, scheduling and planning, construction sequencing, conflict and clash detection, facilities management, and coordination of work.

The IMPACT programme is based on the CIDB standard known as the Construction Industry Standard (CIS) 24:2018 IBS Manufacturer & Product Assessment & Certification. The IMPACT scheme is a comprehensive system that encompasses testing, inspection, and certification of IBS products based on requirements set by the CIDB. These requirements serve to raise awareness among industry players to ensure the quality of IBS products and components in a methodical manner. The system ensures high-quality and affordable products while maintaining a systematic, cost-efficient, and orderly construction site.

The production of IBS products and components is an important element in the IBS cycle. To ensure the quality of products and components produced for use in the Malaysian construction industry, CIDB has established a product evaluation mechanism that includes a complete process cycle, namely Verification, Validation, Testing and Certification found in CIS 24 (IBS Manufacturer & Product Assessment & Certification (IMPACT)).

The IMPACT program is a form of certification of production of IBS products in accordance to CIDB-related standards. This IMPACT process will involve document evaluation and product inspection to ensure the continuous quality of IBS products.

CIS 24 is a guide for stakeholders to monitor and evaluate the capabilities of manufacturers, and the quality of IBS products that have gone through the complete IMPACT process. In addition to that, the manufacturers must ensure that the basic materials used obtain the Standard Compliance Certificate (PPS) enshrined in the 4th Schedule of Act 520 (Amendment 2011).
The certification in the IMPACT process is divided into 4 categories as follows:

i. **Manufacturers**

Manufacturers are the party that manufacture IBS products or components. The scope of manufacturer evaluation is the production of quality IBS products based on set standards.

ii. **Installer Contractor and Manufacturer**

The manufacturers and contractors of the installer are the party that manufactures the products and carries out the installation work of IBS products on the construction site. The scope involves an evaluation of the production and installation of IBS products or components, and they must have an IBS installer certificate.

iii. **Designer and Manufacturer**

Designers and manufacturers are those who provide design drawings and produce IBS products according to the set standards.

iv. Designer, Manufacturer, and Installer Contractor

Designers, manufacturers, and installers are the parties who provide IBS design drawings, produce products and carry out component assembly work in accordance to the established standards and accreditation, and they must have an IBS installer certificate.

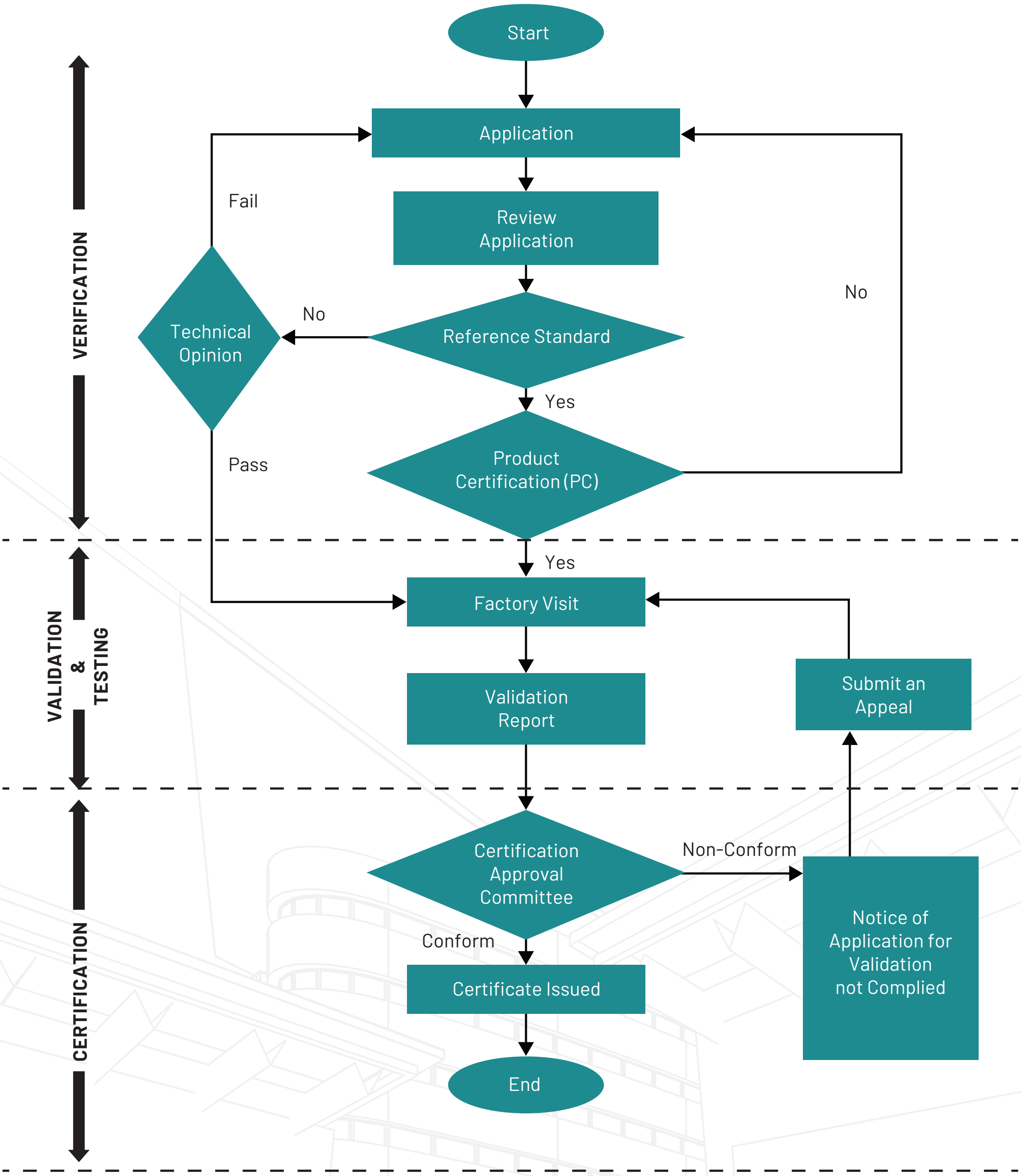


Figure 3. 2 IMPACT Flow Chart

**PC – Product Certification*

Note:

1. *With Product Certification (PC) - If the applicant has a valid PC and based on the registered product, the application will be forwarded to the factory visit.*
2. *Without PC - If the registered product does not have a reference standard, the applicant must go through the Technical Opinion process to complete the IMPACT application process.*
3. *For more information on IMPACT, please refer CIS 24: 2018 (IBS Manufacturer & Product Assessment & Certification (IMPACT) or contact CIDB MyIBS.*

The Technical Opinion process will be executed if the product does not have a reference standard.

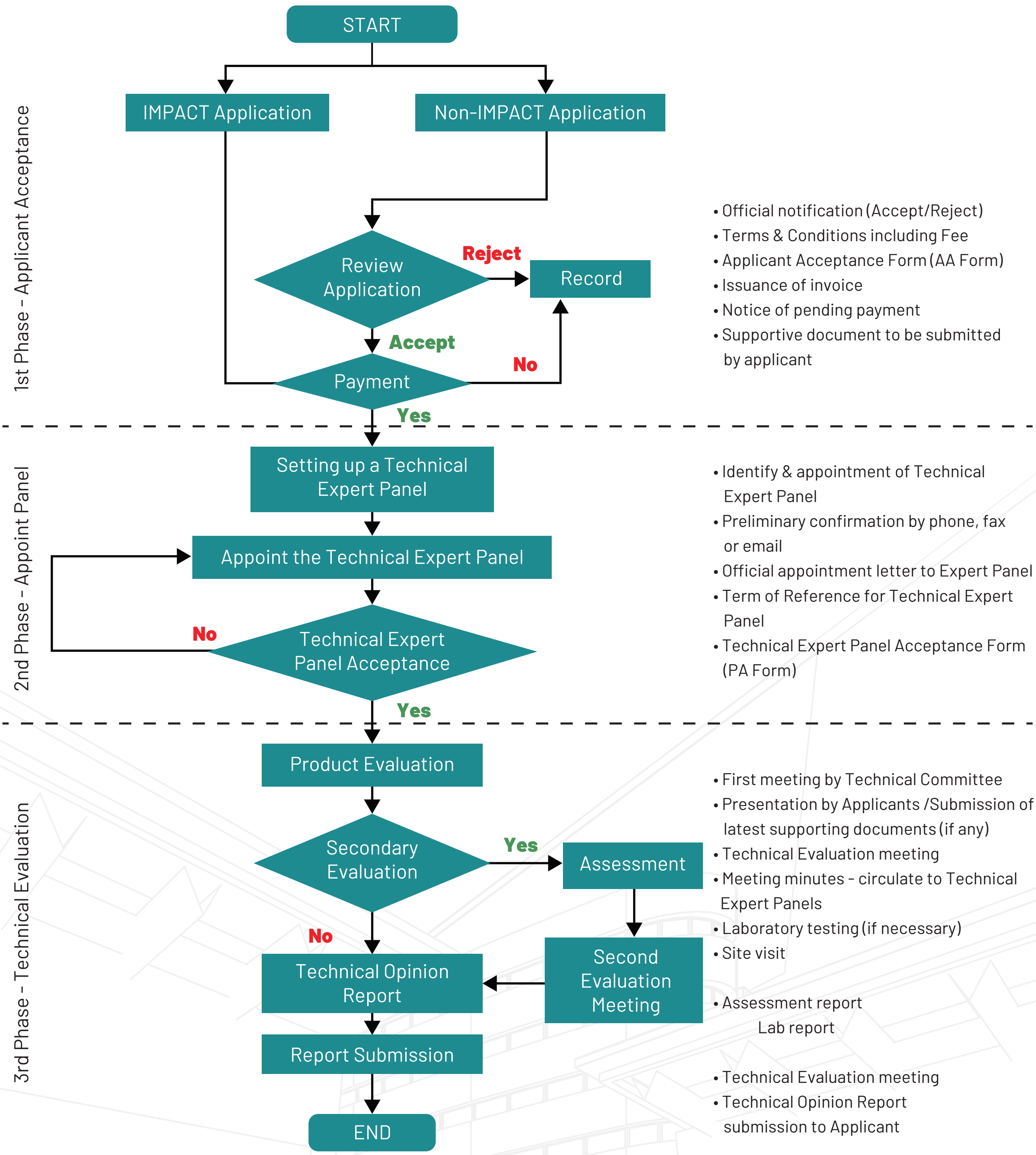


Figure 3. 3 Technical Opinion General Procedure

3.2 Tender Stage (contractor)

3.2.1 Conventional Tender

Implementation of conventional methods in which the project implementation responsibilities are shared by owners, designers and contractors requires effective coordination and communication.

3.2.2 Design & Build (D&B) Tender

System project delivery in which one entity, for example the contractors, is entirely responsible on designing, constructing, supervising, testing and commissioning, completing, and maintaining during the maintenance period as provided in the contract.

For the D&B method, the contractors need to appoint or have qualifications as a design consultant to manage and take on professional responsibilities in designing and supervising construction.

The D&B project implementation offers several advantages, including control over the implementation period, integration between designers and builders, relationship improvement, fast decision-making and having the incentives to control the overall costs by the related teams. The overall project implementation responsibilities are shouldered by the contractors. The contractors make guarantees to the Government that the design and work are completed and free from any inadequacies, failures and defects. Any costs or delays due to design imperfections will be borne by the contractors.

The roles and responsibilities of the clients in this project are as a developer and supervisor of the project while professional responsibility is fully under the contractors.

3.3 Design Stage

The design phase begins after the selection of the architects. Since the architects (usually a firm) may have limited capabilities for handling the broad range of building-design activities, several different, and more specialized consultants are usually required, depending on the size and scope of the project.

In most projects, the design team consists of the architects, landscape architects, civil and structural consultants, and mechanical, electrical and plumbing (MEP) consultants. In complex projects, the design team may also include an acoustical consultants, roofing and waterproofing consultants, cost consultants, building code consultants, signage consultants, interior designers, and others.

Some design firms have an entire design team (architects and specialized consultants) on staff, in which case, the owner will contract with a single firm. Generally, however, the design team is comprised of several different design firms. In such cases, the owner typically contracts the architect, who in turn contracts the remaining design team members (Figure 3.4).

Thus, the architect functions as the prime design professional, and to an extent, as the owner's representative. The architect is liable to the owner for his or her own work and that of the consultants. For that reason, most architects ensure that their consultants carry adequate liability insurance.

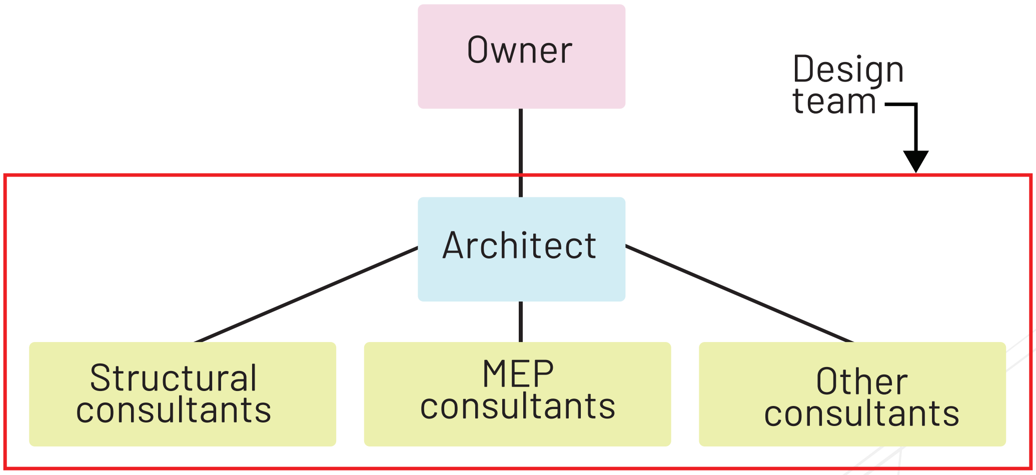


Figure 3. 4 Typical interrelationships in a traditional contractual set-up

In some projects, the owner may contract some consultants directly, particularly a civil consultant (for a survey of the site, site grading, slope stabilization, and the design of site drainage system), a geotechnical consultant (for investigation of the soil properties), and a landscape architect (for landscape and site design) (Figure 3.5). These consultants may be engaged before or at the same time as the architect.

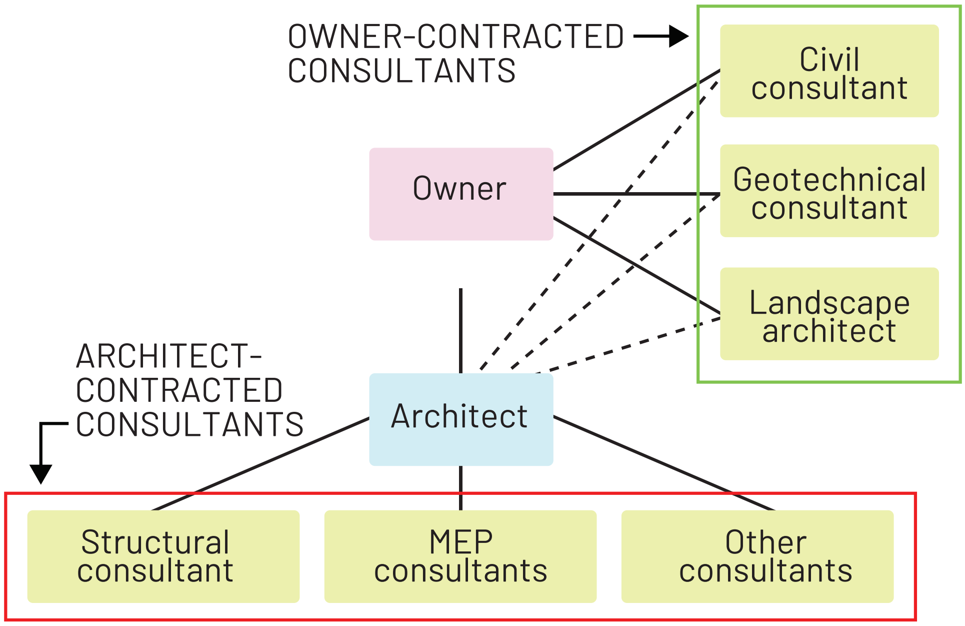


Figure 3. 5 Other typical interrelationship between owner and consultants

The owner's role in the design phase of the project may not appear as active as in the predesign phase, but it is important all the same. In fact, a conscientious owner will be fully involved throughout the entire project delivery process from the predesign phase until the project closeout phase.

3.4 Construction Stage

During this stage, the contractors are required to prepare a shop drawing for IBS. Manufacturer should supply and deliver IBS materials during this stage. The construction stage is known as the performing phase where the project plan is executed, and work tasks are carried out to accomplish project deliveries and project objectives.

Shop drawings are required for components and products that must typically be made off-site. The need for shop drawings for certain items arises because the construction drawings do not describe them to a level of detail that makes their fabrication possible.

3.5 Post-Construction Stage

In the post-construction stage, the items to be taken into consideration are regarding the defects in completed buildings, functional faults, and aesthetic faults. CIDB has introduced QLASSIC to ensure that the quality of workmanship meets the minimum standards.

The quality assessment, also known as Quality Assessment System in Construction (QLASSIC) is a system or method to ensure and evaluate the workmanship quality of a building construction work based on the Construction Industry Standard (CIS 7:2014). QLASSIC enables the quality of workmanship between construction projects to be objectively compared through a scoring system. Hence, this system assesses contractor workmanship and broader quality assurance for both contractors and overall construction projects.

Four principal components are assessed for building construction. The outline for each component is shown in Table 3.4. A QLASSIC assessment will normally be undertaken following the completion of building construction work or during the completion of the project.

Table 3. 4 Summary of building construction components assessed via QLASSIC

Component	Details
Structural works*	The structural integrity of the building is of great importance since the cost of any failure and repair is significant. The assessment of structural works comprises of: • Site inspection of reinforced concrete, structural steel, and prestressed concrete structures during construction. • Test results of the compressive strength of concrete and tensile strength of steel reinforcement. • Non-destructive testing of the uniformity and cover of hardened concrete.
Architectural works	Architectural works mainly deal with finishes. This is when the quality and standard of workmanship are most visible. Architectural works comprise of: • Floors • Internal walls • Ceilings • Doors • Windows • Fixtures • External walls • Aprons • Perimeter drains • Structure car parks • Car porches
Mechanical and Electrical (M&E) works	The quality of M&E works is most important given its increasingly high-cost proportion to the project and impact on the performance of a building. The assessment addresses: • Electrical works* • Air-conditioning and mechanical* ventilation works (ACMV)* • Fire protection works* • Sanitary and plumbing works* • Basic M&E fittings.

Component	Details
External works	External works address the general external work elements in building construction, such as: • Link-way/shelter • External Drain • Roadwork • Car park on the ground • Footpath • Turfing • Playground • Court • Gate • Fence • Swimming Pool • Electrical substation • Guardhouse • Bin centre.

Source: Construction Industry Standard (CIS7:2014)
**Components that are not covered in the current practice; the score will be pro-rated.*

Furthermore, in this stage, the Defect Liability Period (DLP) is identified. During the DLP, the contractors are responsible to maintain or repair defects or damages of the products after the construction is set in the contract.

The DLP activities begin from the date the CPC is issued until the deadline of the DLP period as specified in the contract. The scope of client or developer activities at the DLP level covers the process of monitoring work.

Defects List is as identified in the Disability List, and monitoring of disability repair work (defects) after the CPC, maintenance work (Planned Preventive Maintenance & Breakdown Maintenance) and customer management complaints. After a period, the DLP expires and all the conditions set out in the contract is met by the client; consequently, the Certificate of Making Good Defects (CMGD) is issued and the Final Certificate is prepared.

IBS BUSINESS MODEL

SECTION 04

4.1 Business Model for Developer

A good starting point for developers is identifying the segments of a portfolio where volume, repeatability, and retained ownership come into play. These can be designed as a "product core" that remains consistent across developments. These products may then need to be tailored for a modular approach (for instance, reducing the use of basements and bespoke ground floor designs, changing room widths to maximum road transport limits, or minimizing variability).

Using prefabrication and offering a degree of customizations, such as enabling customers to choose some interior finishes and altering the façade and layout, will be crucial to satisfy both customers and local authorities. Developers should look into understanding and optimizing the strategic trade-offs in the products they commission and develop between quality, cost savings, and time savings.

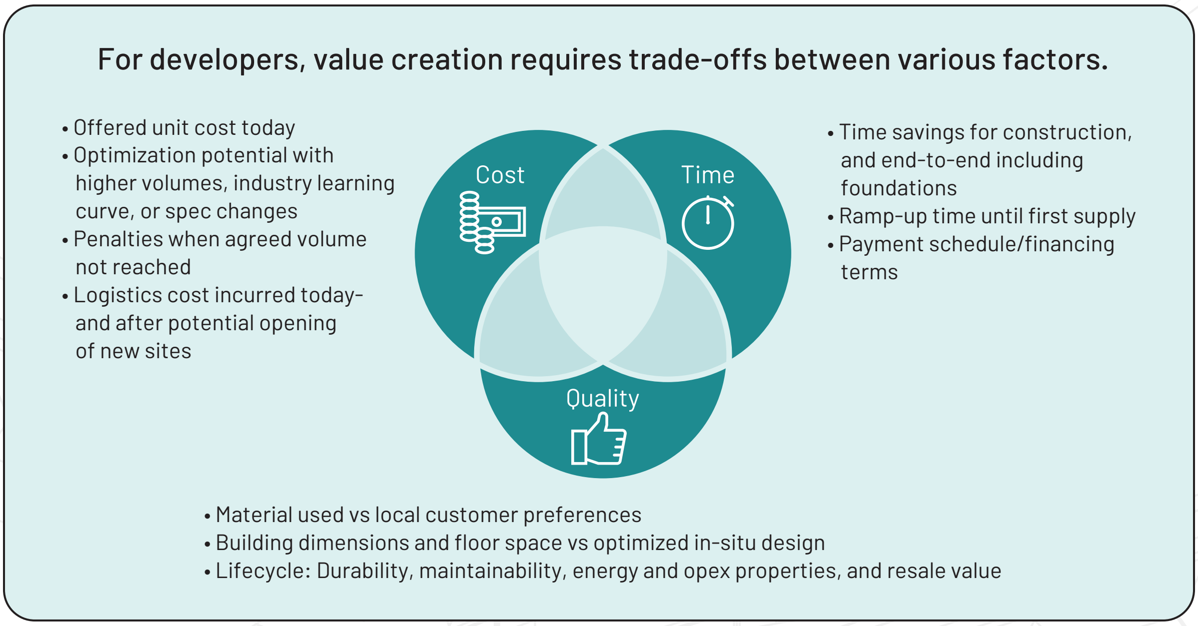


Figure 4. 1 Business Model for Developer

Kamar, Hamid & Dzulkalnine (2012) have determined the IBS strategy to begin a business in IBS industry. It will involve five (5) stages: Business Entry, Business Positioning, Market Target, Business Structure, and Business Operation.

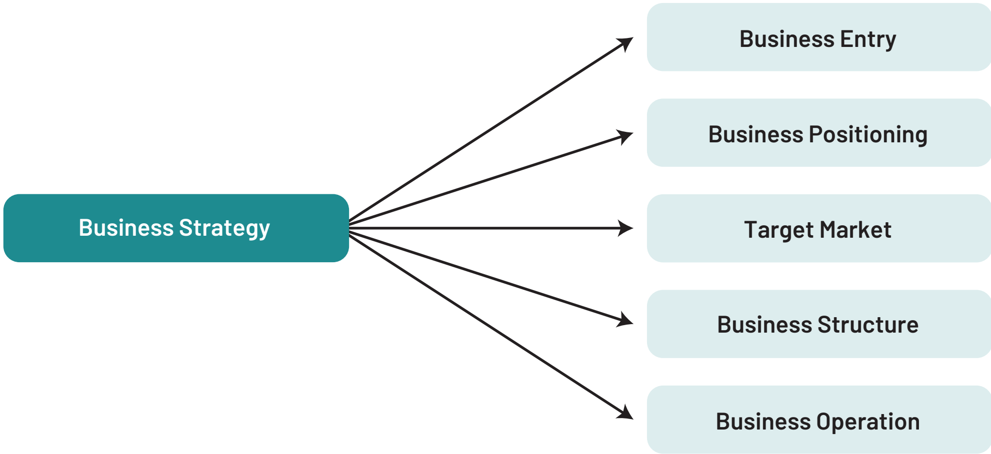
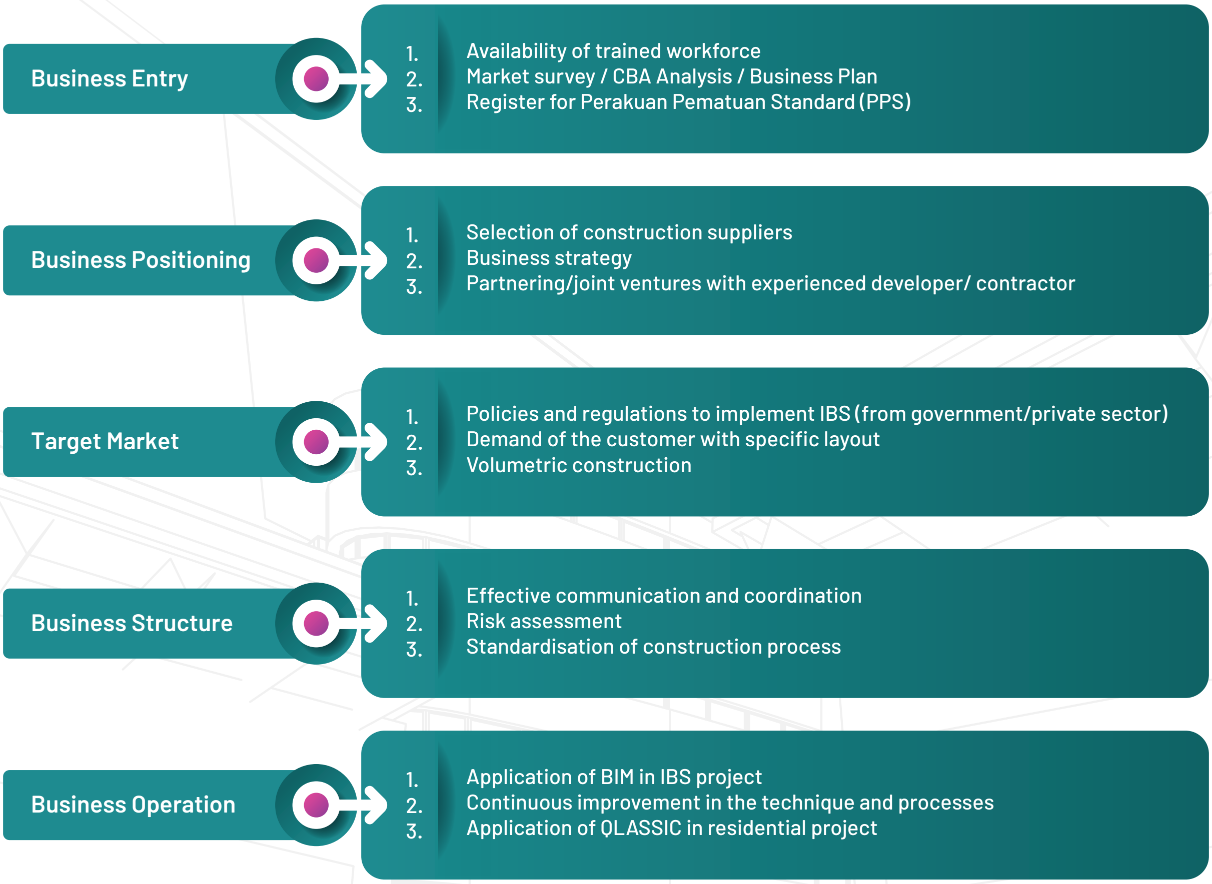


Figure 4. 2 Business Strategy

Based on the analysis of questionnaire, the main point of each business strategy level is ranked. The business model adapted from the business strategy is as follows:



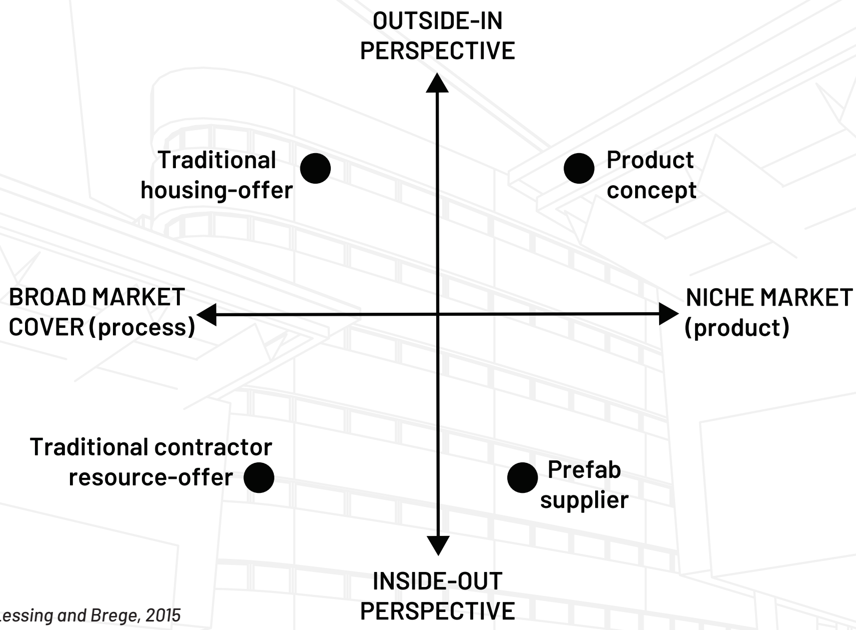
Whelan (2008) highlighted that the selection of material suppliers and specialist sub-contractors should not be made by lowest price alone. It may include the ability to add value to the project and contribute to the project team based on previous track records. Only specialist contractors with a successful track record in similar projects should be considered for appointment, and the specialist contractors should be involved in the projects as early as possible to realise the full potential of IBS.

Lessing & Brege (2015) brought further knowledge and understanding of business models in the context of industrialized building by introducing a framework centred around three cornerstones: operational platform, market position, and offering. This structure gathers the components required for describing a building company's business model, emphasizing the integration between the cornerstones and components.

The offering presents the value proposition of the company. The offering is a combination of physical products and services offered to the customers. **The market position** describes the company's role in the marketplace and supply chain, with close connections to strategic effectiveness (Are we doing the right things?). Market segmentation and marketing strategies for the segments based on the four Ps (product, price, place and promotion) are vital components for the market position. **The operational platform** consists of the company's resources and competence together with external resources from suppliers and partners; it has close linkages to the internal effectiveness (Are we doing things right?). A product platform and designated production system are important components to enable the company's product offer. A study has shown the level of importance for business strategy and positioning in the IBS industry. The item of selection of construction suppliers had the highest percentage with 57.3%, followed by partnering or joint ventures with experienced developers or contractors, and business strategy with 54.1% and 48.1%, respectively. About 60.4% respondents agreed that the application of QLASSIC in residential project was an important item for business strategy in IBS industry. However, the items of continuous improvement in the technique and processes, and application of BIM in IBS project are also important for business strategy in IBS industry, scoring 43.3% and 41.6%, respectively.

Figure 4. 3 Business Model Framework with Its Primary Domains

This work was continued by a study of product-oriented housebuilding companies as presented by Lessing & Brege (2015), whom developed a two-dimensional model for business model positioning. One dimension was broad market coverage versus a niche market focus. The other dimension was the strategic perspective, either outside-in or inside-out. Lessing & Brege (2015) found that product-oriented companies defined as companies with a high level of predefinition according to Hvam, Mortensen, & Riis (2008), were positioned within the niche markets with an outside-in perspective and with a specific market need as a starting point.



Source: Adapted from Lessing and Brege, 2015

Figure 4. 4 Strategic Perspectives and Market Cover for Building Companies

McKinsey (2014) has asserted that the seven factors determining the attractiveness of a modular market were regulation, access to material, quality perception, supply chain and logistics, local site constraints, labour dynamics, and consolidated and continuous demand volumes.

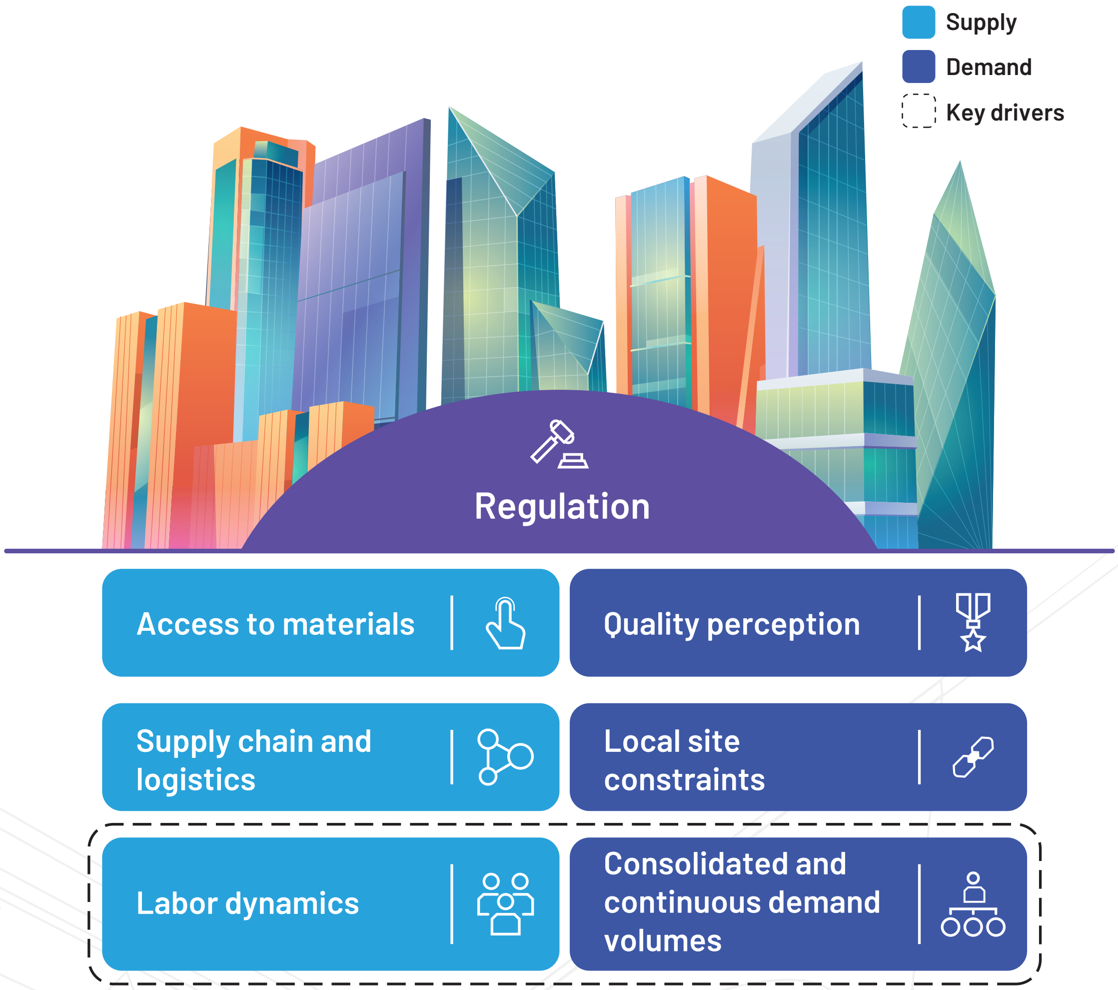


Figure 4. 5 Factors that Determine Attractiveness of Market

4.2 Business Model for Contractor

4.2.1 Partnering / Joint Venture

Analysis done by Adnan, Baharuddin, Hassan, Mahat, & Kaharuddin (2019) has shown that the joint venture acceptance among IBS contractors is to reduce the labour cost, share construction cost, and reduce capital cost. Besides that, the reason of a joint venture is for technology transfer and skilled workers, quality of material and speed of construction, and access to greater expertise. The factors to ensure a successful joint venture among IBS contractors are experienced workforce and technical capability, skilled labour for site installation, and good working collaboration.

Collaboration is a recursive process where two or more people or organizations work together to realize shared goals (Martinez-Moyano, 2006). The related personnel can be divided into the following parties by their functions: design, manufacturing, management, supervision, construction, inspection, and support.

At a construction site, there are personnel such as a project manager, a project engineer, site engineers, foreman, mobile crane operators, workers, and inspectors. Research conducted by Charnwasununth, Yabuki, & Tongthong (2009) demonstrated that the problems with team collaboration arose due to lack of information storing, sharing, and management among different types of personnel at the site, and other personnel at the main and branch offices. Good working collaborations between all parties in the initial works of IBS process are crucial to ensure a successful IBS project implementation (Baharuddin, Rahman, & Omar, 2006). This is more than just the intersection of common goals seen in cooperative ventures; it is a deep and collective determination to reach an identical objective. The collaborative approach between designers and manufacturers to make joint decision in the finalisation of IBS design is significant. Good working collaborations according to Kamar et al.(2009) will solve the problems related to complex interface between systems, and ensure efficient process sequence in manufacturing plant and on site.

A joint venture is a contractual business undertaken between two (2) or more parties involved in one project. A joint venture normally involves at least two companies to achieve the same goal when these companies may have differences. These companies generally have the tendency to expand their business and to compete in the global economy where investment is important. Good collaboration and commitment will help the joint venture firms to perform better in accessing new markets, knowledge, capabilities, and other resources.

Joint ventures are commonly used to:

- Enable smaller companies to deliver large projects by combining their expertise and resources.
- Enable a larger company to acquire new resources or expertise from a smaller company.
- Enable a smaller company to benefit from the credibility and financial stability of a larger company.
- Gain local knowledge in overseas markets.
- Share risks and costs.

4.2.2 One-stop Shop

Strategy Type 1: 'Low Risk Taking – Low Opportunity Seeking' Precast Manufacturing Business.

Main Target Market: Self-Generated/Created – create own demand [Assured Market].

Organizational Structure within IBS Value Chain: Developer + Designer + Contractor + Manufacturer + Installer.

Manufacturing Plant location: Regional.

4.2.3 Product or Component Type Specialist Manufacturer Based on Volume

Strategy Type 2: 'Medium Risk Taking – Medium Opportunity' Seeking Precast Manufacturing Business.

Main Target Market: Major Construction Client – as a preferred precast component supplier, a business is able to secure repeat orders with high volume.

Organizational Structure within IBS Value Chain: Designer + Manufacturer + Installer (or preferred installer).

Manufacturing Plant location: Strategic (targeting location according to main client building development plans).

4.2.4 Independent Temporary Set-ups with High Outsource or Joint-Venture

Strategy Type 3: 'High Risk Taking – High Opportunity' Seeking Precast Manufacturing Business that is contractor-led without the existing manufacturing capability.

Main Target Market: Random.

Organizational Structure Within IBS Value Chain: Contractor-based (handling both conventional and IBS projects) operating mobile plant or joint-venture with established precast manufacturer.

Manufacturing Plant Location: Based on existing manufacturing plant to minimize transaction costs otherwise set up own precast yard.

4.2.5 Readiness Model for IBS Contractor

Figure 4. 6 Readiness Model for IBS Contractor

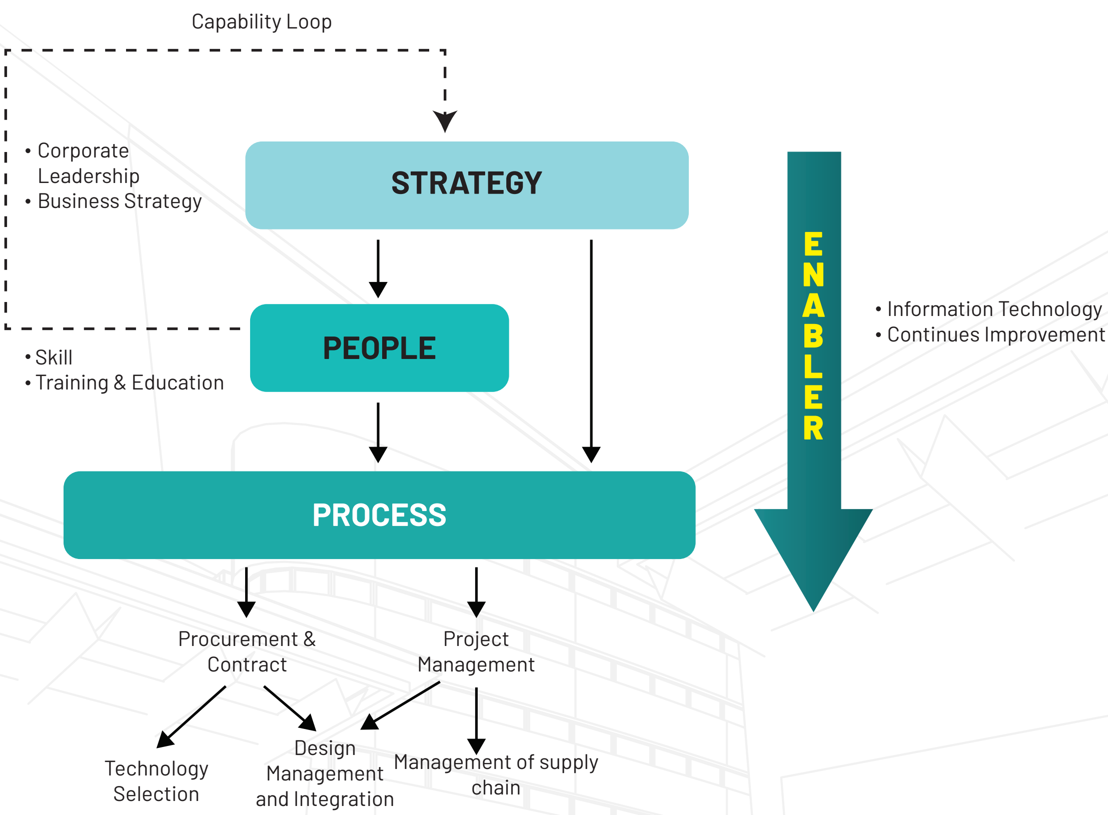


Figure 4. 7 Flow of Readiness Model for IBS Contractor

The respondents from survey gave opinions to improve the usage of IBS in the construction industry. The suggestion is as shown in Figure 4.8.

Procurement and Procedures	Need to make adjustment with existing procurement method because the current is not suitable with the IBS procedure. Also need to enforce rules to use IBS for certain construction such as cost to drive IBS and establish IBS form of contract. Lenient rules and regulation to encourage contractors using IBS method.
IBS material	The respondents also suggest to set the affordable and reasonable price of IBS material and labour so that all the developers and contractors can use IBS method in construction project.
Promotion and marketing	The respondents also suggested that the promotion and marketing part for IBS is important to support all parties using IBS. The promotion such as events, seminars and conferences can spread the information about IBS for contractors and developers.
Enhance training skill	Enhance training skill and development for higher education institutions. This method can help improve the knowledge about IBS. Insufficient evidence using IBS and lack of scientific information concerning IBS. Set up profession for IBS industry from vocational collage.
Skilled workers in the industry	Need to increase availability of skilled workers in the industry. Lack of technical expertise is also the problem of using IBS in construction industry.
Work Progress	Need to highlight the initial stage of prefabrication and manufacturing process payment within the work progress.
Lack of Incentive	Lack of awareness and incentive for developers and contractors.
R&D Programme	Importance of R&D programme to improve and enhance the quality and workability of IBS system. Need more market analysis for IBS system. Venture of new types of material that can be used to produce IBS at lower cost.

Figure 4. 8 Suggestions for IBS usage Improvement

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