CRITICAL SUCCESS FACTORS (CSFs) OF CONTRACTOR IN INDUSTRIALISED BUILDING SYSTEM (IBS) IMPLEMENTATION

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by

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CERTIFICATION OF APPROVAL

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Approved by,

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CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

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SHAHRUL FAZRY BIN ABDULLAH SANI

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ABSTRACT

Recently the Industrialised Building System (IBS) was promoted by government to improve and modernize construction practices and reduce national dependency on foreign labour. IBS has been identified as a potential method to improve overall construction performance in term of quality, cost effectiveness, safety and health, waste reduction and productivity. IBS Roadmap 2003-2010 was published and endorsed by the government in 2003 and the importance of IBS implementation is spelt out under Strategic Thrust 5 of Construction Industry Master Plan (CIMP 2006-2015). Even though the advantages of IBS are very conceivable, the idealism behind the industrialised construction is far from being practical and beneficial to the majority of contractors. This scenario leaves the contractors with noticeable difficulties in implementation while remain to be competitive and profitable. The limited take up is also associated with readiness issues and lack of previous experience in IBS. The construction project management currently practiced is not a new concept in Malaysia. Nowadays projects are far more complicated than ever before. They involve larger capital investment, embraces several disciplines, widely dispersed project participants, tighter schedules and stringent quality standards. Thus, this paper is identifying and ranking the Critical Success Factors (CSFs) for contractors in implementing IBS and also creating a project management guideline for contractor in order to implement IBS. This is done by relating the CSFs and the basic concept of construction project management. In general, the CSFs highlighted from both literatures and interview session from pilot survey are categorised as business strategies, finance, partnering and contract, enabling factors, roles and in-house manufacturing, lean and advanced planning, skills, process management and finally training and education. There are totals 18 CSFs was found under these 9 categories. Questionnaires were distributed in order to rank the CSFs based on experienced contractors choice. The CSFs derived from this paper will be used as Benchmarking criteria in a study between IBS and traditional contractors to capture best practices and improve contractor's general readiness.

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LIST OF ABBREVIATION

CSF	-	Critical Success Factor
IBS	-	Industrialised Building System
CIDB	-	Construction Industry Development Board
CREAM	-	Construction Research Institute of Malaysia
CIMP	-	Construction Industry Master Plan
GDP	-	Growth Domestic Product
IT	-	Information Technology
ICT	-	Information and Communication Technology
MMC	-	Modern Method of Construction
OSC	-	Off-site Construction
OSM	-	Off-site Manufacturing
OSP	-	Off-site Production
R&D	-	Research and Development
JIT	-	Just in Time

CHAPTER 1

INTRODUCTION

This report presents the details of Critical Success Factors (CSFs) for Industrialised Building System implementation in Malaysia.

1.1 Background of Study

The Malaysian construction industry and private sector play important roles in generating wealth and also improving the quality of Malaysians' life. The construction industry enables the growth of other industries through its role as a fundamental building block of the nation's socio-economic development. All the essential elements of healthy, functioning economy need to be built and maintained by construction industry. Construction industry contributes to the growth of other industries in its role as a large user of manufactured good, specialized tooling and heavy machinery as well as financial services.

Malaysia's housing policy is moving forward to meet the objective of ensuring access to adequate and decent shelter to all citizens, particularly the low-income group. The national housing policy will efficiently contribute to enhance the quality of life through the erection of decent human settlements. The quantitative and qualitative aspects of housing development are considered in order to implement this policy (Yahya, 1997). Moreover, Malaysia is progressively marching towards industrialization where the role of the building industry is greatly enhanced, with the idea of transforming the aspiration and needs of people into reality.

However, the overview of the Malaysian construction industry shows that while GDP grew at an average rate of 5.46% from 2000 to 2007, the construction industry stagnated, with average growth of 0.7% during the same period. Based on historical statistic, Malaysian construction industry has consistently been the smallest contributing sector to the economy, contributing 3% to the total GDP averagely (CIMP 2006-2015, 2006). This is because Malaysian construction industry is facing constant difficulties to improve its performance. Most of the construction workers usually are foreign workers. They are unskilled when they first arrived and this affects the quality and productivity of construction industry. Besides that, foreign workers are also usually associated with social and culture problems.

To cope with ascending demands of affordable housing, less time consuming, solving issue associated with labors and improving quality and productivity, Industrialized Building System (IBS) has been introduced by Minister of Housing and Local Government since 1964. In general, IBS method recently stormed into 21st century to improve construction performance.

1.2 Problem Statement

According to Construction Industry Development Board (CIDB) Malaysia, the construction industry provides job opportunities for 800,000 people which present 8% of total workspace. Out of these, 69% of registered workers as in June 2007 are foreign workers (Malaysian Construction Outlook 2008, 2008). The numbers of foreign workers keep increasing due to the shortage of local workforces. This is because the local workforces and new graduates are unwilling to work with the industry due to the 3-D syndrome; dirty, difficult and dangerous.

Conventional construction is the method commonly practiced in Malaysia where reinforced concrete frame and brick, beam, column, wall and roof are cast in-situ using timber framework while steel reinforcement fabricated off-site (Kamar *et al.*, 2009).

With the labour intensive and time consuming conventional method, the increase demands on housing, productivity, levels of quality are unable to be met. The excessive reliance on unskilled foreign labours method is sustainable and not in line with the future development in Malaysia.

Therefore, implementing IBS is one method of choice which guarantees better quality, productivity and safety. Government has also strongly supports the use of labour-reducing system in order to reduce dependency of foreign labours in the local construction industry. This dependency will increase the outflow of Ringgit to foreign economies apart from bring negative side impacts to the nation within social and cultural context.

In fact, in 2003, government had shown their effort by introducing IBS Roadmap 2003-2010 as a milestone for the implementation plan of IBS in Malaysia. The direction formulated is based on 5-M strategy; Manpower, Materials Components-Machine, Management-Processes-Methods, Monetary and Marketing (IBS Roadmap 2003-2010, 2003). To date, the adoption of IBS is still not as high as anticipated despite the well-documented benefits and the strong supports coming from the government. IBS Survey 2003 reported that only 15% of construction projects used IBS in 2006 (IBS Survey 2003, 2003). Besides that, IBS Mid-Term Review reported that less than 35% of total construction projects used at least one IBS product in the year of 2006 compared to forecasted IBS projects of 50% in 2006 and 70% in year 2008 as projected by IBS Roadmap (Hamid *et al.*, 2008).

Most of the contractors are not aware of this method of construction thus do not involve IBS system in their construction method. CIDB has been working a lot to give sufficient information in order to increase contractors' confidence to implement IBS in their projects. Shifting IBS seems to be an uphill task. The risk of cost factor is one of the problems which cause contractors prefer conventional building system than IBS. The financial risks could be whether the contractors have enough cash flow to enable them to progress with IBS work or financial failure of the owner or subcontractors (Hassim *et al.*, 2009). Perhaps the root cause of this problem is the fairly low labour cost in Malaysia. Contractors also thought that the need of more skilled worker is required to use IBS compared to conventional method. Those factors left the contractors with noticeable difficulties while remaining competitive and profitable.

From the above statements, it can be concluded that the contractors need a guideline to ease them implementing the IBS. So far, there are just a few discussion regarding key of success factor of contractors which transformed from traditional contractor to IBS are conducted. Some of the CSFs of IBS from literatures such as training and education, leadership and organization structure, information technology (IT) capability, cost management, supply chain and procurement and site management will be used as a benchmark of this research.

1.3 Objective

The objectives of this project are:

- To identify the Critical Success Factors (CSFs) for contractors to implement IBS as their method of construction.
- To rank the Critical Success Factors (CSFs) for contractors to implement IBS as their method of construction.
- To create project management guideline for contractor in order to implement IBS.

The result will be used as reference for policy makers and IBS promoters to path the way forward in establishing the new policies on IBS.

1.4 Scope of the Research

In IBS implementation, various parties; manufacturers, clients, designers and contractors; involve along the supply chain. However, in this paper the author only focus on contractor's perspective and aims to identify CSFs for contractor to embrace the IBS. The term contractor represents building contractor, IBS system integrator or installer as a matter of simplification. Contractors are given the questionnaire which covers all aspects regarding IBS implementation. The results are validated by some pilot interviews with Construction Research Institute of Malaysia (CREAM).

1.5 Procedure and Methodology

This paper is a part of Degree research. There are three different steps involved in this area of study which are planning, data collection and data analysis. These steps comprise of eleven continuous stages as shown below:

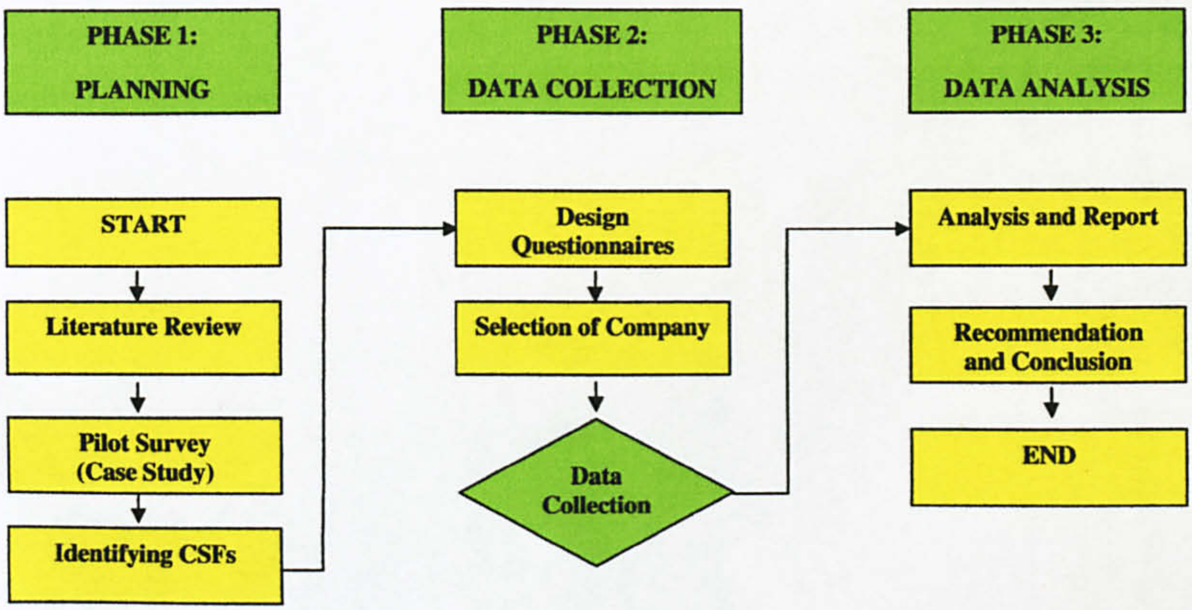


Figure 1.1: Work Methodology

The methodology is developed to gather the data required in order to achieve the outline objectives. The first step is to rationalise the issue for the purpose of setting up the topic study. Then the aims and objectives are established. This study employed several methods of data collection. They are compiling and analyzing all related literatures to investigate the current situation of Malaysian construction industry, Industrialized Building System (IBS) implementation status, programs on-going and done by government or other agencies and Critical Success Factors (CSFs) in IBS. For the knowledge acquisition phase, literatures related to the study are reviewed through journals, books, newspapers, conference papers and websites.

The research is then continued with the pilot survey whereby the author attended a workshop regarding IBS. The mentioned workshop is a sequence to the workshop entitled IBS: Implementation Strategy from R&D Perspective which was held on 29th July 2009. The results from the first workshop are discussed in details in the later workshop in order to identify the CSFs for IBS implementation for each trade. The outcomes of both workshops have been documented so that policy makers and IBS promoters could use them as guidance and reference to path the way in establishing new policies of IBS. The workshops' papers give strong addition support of evidence to the literature review for the next step which is identifying the CSFs. With that, the action moved on to designing questionnaire. In designing the questionnaire, a few matters had been considered based on previous researches done. The questionnaire which is prepared for this study is attached in **Appendix A**.

After that, companies which are going to involve in completing the questionnaire are selected randomly from IBS companies registered under CIDB Orange Book Program. The respondents are the Grade 7 contractors located in Klang's Valley. Three weeks after submission of the questionnaires to the selected contractors, they are collected back. The completed questionnaires are then compiled and analysed using Statical Package for Social Science (SPSS) for Windows version 16.0 and Microsoft Office Excel 2007.

CHAPTER 2

LITERATURE REVIEW

Numerous literatures have been gathered and reviewed in completing this research. The findings from the literatures are presented in this chapter. They are definition of IBS, types of IBS, benefits of IBS, construction project management, limitation of current project management practices, government policies in IBS, current situation of IBS, factors influencing implementation of IBS, definition of critical success factor (CSF) and also CSFs for IBS.

2.1 Definition of IBS

There are numerous definitions developed by previous researchers where they emphasized on the concept on pre-fabrication, off-site production, manufacturing and mass production of building components (Lessing *et al*, 2005; Thanoon *et al*, 2003;Warszawski, 1999). The terms and classifications are often misinterpreted as a system limited for construction building. IBS definitions have been classified into two categories which are IBS as a method, approach and process and IBS as a product, system and technology. The characteristics of IBS are industrialized production, transportation and assembly technique, on-site fabrication, mass production, structured planning and standardization and integration (Kamar *et al*, 2009).

Apart from that, there are also many different terms widely used to describe IBS such as pre-assembly, pre-fabrication, Modern Method of Construction (MMC), Off-site Construction (OSC), Off-site Manufacturing (OSM) and Off-site Production (OSP) (Kamar *et al*, 2009). In general, IBS is a construction process that utilizes techniques, products, components or building systems which involves pre-fabricated components and on-site installation (IBS Roadmap 2003-2010, 2003). This represents the pre-fabrication concept in Malaysia.

2.2 Type of IBS

Based on IBS Survey 2003, there are five types of IBS generally used worldwide. They are (IBS Survey 2003, 2003):

2.2.1 Type 1: Pre-cast Concrete Framing Panel and Box System

The most common types of IBS product are the pre-cast concrete element – pre-cast concrete columns, slabs, beams, walls, "3-D" components (e.g. balconies, staircases, lift chambers), lightweight pre-cast concrete, as well as permanent concrete formwork.

Figure 2.1: Pre-cast concrete framing panel and box (IBS Survey 2003, 2003)

2.2.2 Type 2: Steel Framework System

Steel framework system is considered as one of the "low-level" or the "least pre-fabricated" IBS as they generally involves site casting and subjects to structural quality control. The product offers high-quality finishes and fast construction with less site labours and materials requirement. The system includes tunnel forms, tilt-up systems, beams and column moulding forms and permanent steel formworks (metal deck).

Figure 2.2: Steel framework (IBS Survey 2003, 2003)

2.2.3 Type 3: Steel Framing System

This system is commonly used with the pre-cast concrete slabs, steels columns and beams. Steel framing system has always been the popular choice and is used extensively in the fast-track construction of skyscrapers. Recent development in this type of IBS includes the increased usage of light steel trusses consisting cost-effective profiled cold-formed channel sand steel portal frame system as alternative to the heavier traditional hot-rolled section.

Figure 2.3: Steel framing (IBS Survey 2003, 2003)

2.2.4 Type 4: Pre-Fabricated Timber Framing System

Among the products listed in this category are timber building frame and timber roof truss. While the latter is most popular, timber building frame system also has its own niche market: offering interesting designs from simple dwelling units to buildings require high aesthetical values such as chalets for resorts.

Figure 2.4: Pre-fabricated timber framing (IBS Survey 2003, 2003)

2.2.5 Type 5: Blockwork system

The construction method of using conventional bricks has been revolutionized by the development and usage of interlocking concrete masonry units (CMU) and lightweight concrete blocks. The tedious and time-consuming conventional bricks' laying tasks are greatly simplified by the usage of these effective solutions.

Figure 2.5: Blockwork (IBS Survey 2003, 2003)

2.3 Benefits of IBS

The quality and productivity, speed of construction and cost saving are the main emphases in the building construction industry in Malaysia. These are such of the benefits to IBS adopters. This is agreed by the research result done by researcher who compared between conventional system and IBS. For the speed of construction, it showed that the cycle time per house for conventional building system of 17 days found to be significantly different from IBS. The difference is four days or 76%. This will affect the productivity of the construction because the conventional system is 70% less productive than IBS for the completion of the structural element for one unit house (Kadir *et al.*, 2006).

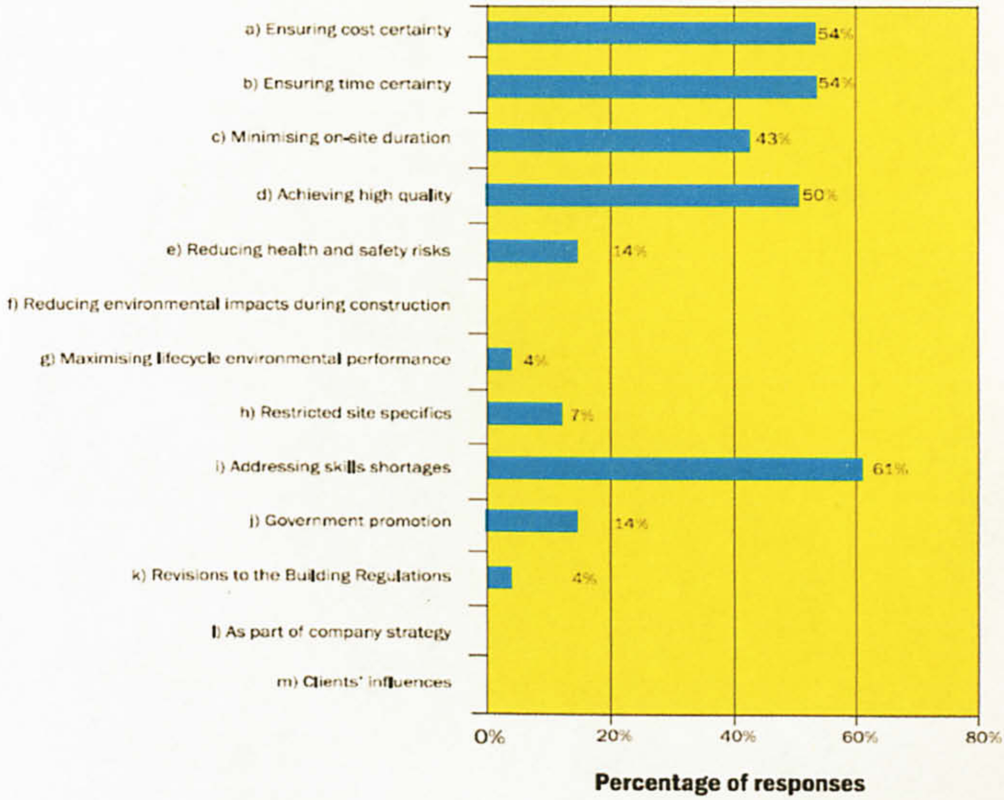
Reduction in manpower and material cost is very significant in IBS construction as the number of labours required in IBS is far lower than conventional method (Na, 2007 and Badir *et al.*, 2002). The work duration is shortened and process is simplified by reducing on-site activities and number of trades (Blismas & Wakefield, 2008; Blismas, 2007 and Mann, 2006). Other than that, IBS will solve issues regarding unskilled workers, dependency on manual foreign labours and also reducing risk related to occupational safety and health. In term of heavy equipment, IBS construction requires less usage of heavy equipment due to the fact that most type of IBS does not require usage of heavy equipment. The one and only type that uses heavy equipment is precast panel which will only be used during erection (Badir *et al*, 2002). The advantages of IBS or off-site when applied in the UK are presented in **Table 2.1** and **Table 2.2** (Pan *et al.*, 2005 and Goodier & Gibb, 2007). Both studies conducted by Buildoffsite UK emphasized that IBS implementation shortens construction time, improves construction quality and alleviates issue of skill shortage.

Table 2.1: Advantages of using IBS (Goodier & Gibb, 2007)

Advantages	Clients/designers		Contractors	
	% of respondents	% as 1st choice	% of respondents	% as 1st choice
Decreased construction time	87	38	92	69
Increased quality	79	28	77	15
More consistent product	77	18	54	0
Reduced snagging and defects	79	8	69	0
Increased value	51	5	23	0
Increased sustainability	49	3	31	0
Reduced initial cost	44	3	15	8
Reduced whole life cost	41	0	15	0
Increased flexibility	33	0	15	0
Greater customization options	33	3	0	0
Increased component life	28	0	15	0
Other	18	15	8	8

Note: 'Other' includes improved health and safety and reduced requirement for skilled labour.

Table 2.2: Advantages of using IBS (Pan *et al.*, 2005)



2.4 Construction Project Management

The construction project management is not a new concept. A strong understanding of project management in the construction industry and the wider built environment is the key to undertaking and delivering successful construction projects. The project development processes in **Figure 2.6** shows all stages in the project life cycle from inception until demolition.

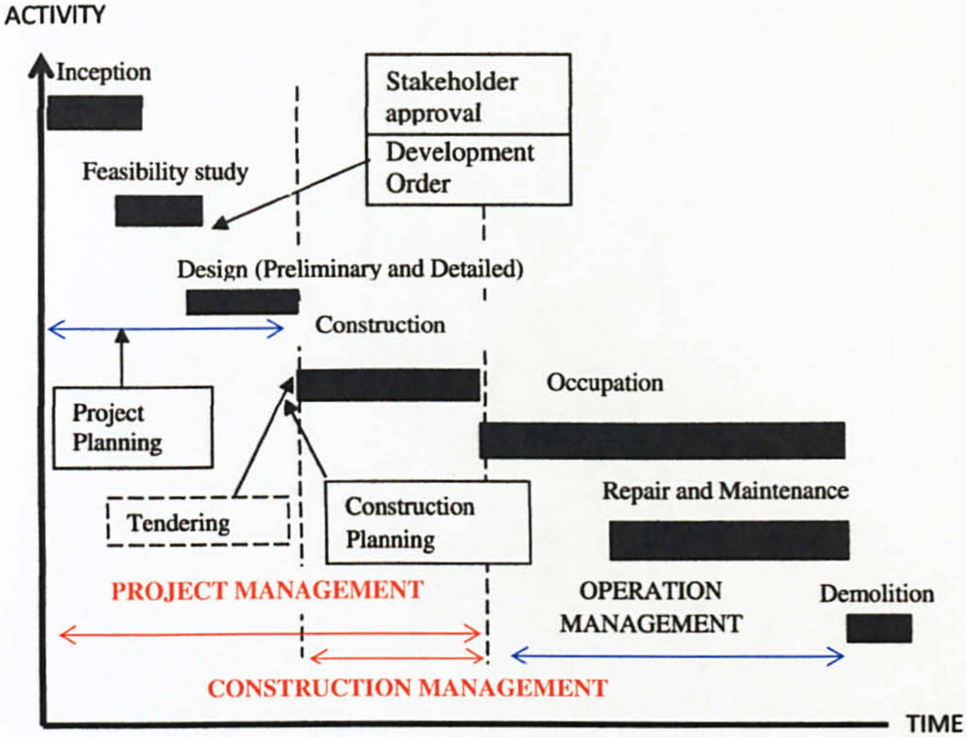


Figure 2.6: Stages in life cycle of building project (Nkado, 1991)

From the project life cycle, it can be concluded that construction project management mainly involves planning and design stage, construction management stage and handing over stage. Planning and design stage consist of project planning, design and construction planning. Pre-design stage planning is emphasized in project planning. The activities involved in project planning are inception, feasibilities studies, stakeholder approval and development order. As for the construction planning stage, it consists of design, tendering and construction. Post-design or pre-construction planning is emphasized in construction planning.

Historically, numerous projects have been undertaken successfully across generations. The overall planning and coordination of a project from inception to completion is vital. Efficient planning and coordination ensures client's satisfaction and that the project will be completed on time, within budget and of the desired quality. A good project management incorporates avoiding problems, tackling new ground, managing a group of people and trying to achieve very clear objectives quickly and efficiently.

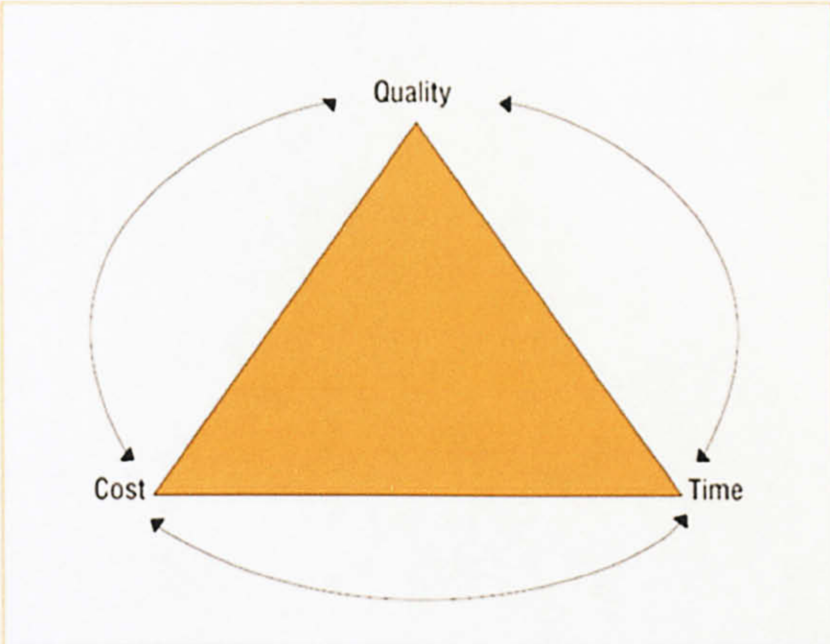


Figure 2.7: Construction management triangle

Figure 2.7 shows the principle of project management. The main objective for each construction project is to construct the building or facility in according to the design and specifications, with the most effective use of resources and control of risk, and to complete it (Luder, 1986; Raftery, 1999 and Nkado, 1991).

- Within the budget (allowable cost)
- On time
- To an acceptable and agreed standard of quality and workmanship

2.5 Limitations of the Current Project Management Practices

The current project management practices have many limitations in order to efficiently deal with construction demands. The limitations are as follows:

- Current project management practices are often isolated and concerned with handling problems related to individual stages of the projects.

- Conflict of information and information not received in time to the parties concerned resulted in reworking. The main cause is the lack of consistency in the information's flow between different parties is the main cause to this problem. For instance, architects and clients make amendments to designs rather frequently and they do not convey these amendments to the contractors and subcontractors in time for them to implement the works efficiently. Consequently, rework is needed. This causes a lot of strains on the client's budget. Rework in this sense predominates most of the construction sites.

- The current ordering, purchasing and invoicing practices have a lot of drawbacks such as delays in supplies being received, less collaboration with manufacturers and suppliers, and low integration of purchasing with accounts software. For instance, many delays are originated from implementation of current material procurement systems, which do not integrate well with project plans and schedules. The lack of a fully integrated procurement system inclines to affect stock control policies (e.g. carrying a high quantity of stock) of construction firms due to the inability to make precise predictions of resource requirements for the project. The roots to this are the poor communication and coordination among the supply chain partners and the overall lack of an integrated system to cater to this need.

- Usually, projects managed according to the experience of the project managers appointed. Each project manager, even within the same organisation, inclines to follow their own experience, which they gained over a long period of time. These practices cause large variations in management practices thus creating a significant impact on the capability of coordinating and controlling project information.

- Planning is a tedious process thus contributions from the entire project team are needed. It is also context dependent. If appropriate decision-making tools are incorporated into their structure, this process can be improved. Comprehensive systems have not yet been established this direction.

2.6 Government Policies

Since 1998, Construction Industry Development Board (CIDB), one of the government agencies has been actively promoting the use of IBS in the local construction industry as one new relevant technology. This is in line with the process of nurturing construction industry players towards global competitiveness. One of the actions taken by CIDB is organizing a lot of programs with numerous parties in order to educate the industry regarding the various benefits of IBS. Besides that, CIDB has deployed large funds for researchers, standards developments as well as various trainings and promotion programmes to develop innovative IBS application. The education given by CIDB is not only in the basics of conventional construction method, but also in the IBS site management and installation of IBS components.

CIDB plays important role in promoting IBS as an alternative to the conventional and labour intensive construction method has not made headway. Therefore, with the guidance from the IBS Steering Committee, CIDB redesigned its strategies and formulated IBS Roadmap 2003-2010 based on the 5-M strategy (Manpower, Materials Components-Machine, Management-Processes-Methods, Monetary and Marketing). It was endorsed by the Cabinet of Ministers to be the blueprint document for the industrialization of the Malaysian construction sector. IBS Roadmap targeted enforcement of IBS usage for government buildings projects in phases, which are from 30% in 2004 to 70% in 2008 (IBS Roadmap 2003-2010, 2003). Besides that, government tax reduction incentive for the Bumiputera components manufacturers was introduced since 2005.

In the 2005 Budget, government had announced to raise about 30% to 50% of the construction of affordable houses using IBS. This percentage also included government's projects which is approximately 100,000 units of houses (Hamid *et al*, 2008).Apart from that, since 1st January 2007, the exemption of the construction levy (CIDB levy – 0.125% of total cost of the project according to Article 520) for contractors who use IBS in 50% of the building components has been commenced (Hamid *et al.*, 2008).

In addition to this action, the new circular of Surat Pekeliling Perbendaharaan Bil.7 Tahun 2008 dated October 2008 emphasized on the full implementation of IBS for government's projects. One of the pressing matters stated in the circular is that any government's projects that will be awarded should use not less than 70% of IBS components. Approximately 320 government's projects worth of RM 9.43 billion to be carried out using IBS were identified on February 2009 (Bernama, 2009).

The government policy goal which is to reduce the percentage of reliance on foreign labours to 15% on 2010 will be achieved by implementation of IBS. The government will establish a new policy to reduce 50% of current 320,000 foreign workers registered in the industry. This policy will be commenced 5 years from 2009. To cope with the loss, CIDB has taken action and allocated RM 100 million to train skilled workers among locals regarding IBS and other methods (Bernama, 2009).

2.7 Current Situation

In 2003, survey on IBS was conducted by CIDB in order to research and gain insight of current level of IBS in Malaysia. This study was undertaken to identify the extent of IBS usage, the advantages or weaknesses that affect the users of IBS, acceptance of local contractors to the available of IBS in market, support given by the clients, architects, engineers and government agencies to the contractors, action to be performed by the government in order to ensure higher and more effective usage of IBS as well as to identify the existing IBS manufacturers in the market.

From the survey, it is reported that 15% of the total construction projects used IBS in Malaysia in the year 2003. The percentage shows that IBS is becoming common in Malaysia and increasing each year. Companies with zero IBS-utilised projects are decreasing from year to year. Most of the respondents (54%) would like to use IBS in their next construction projects and majority (61%) prefers IBS to be made compulsory but to set certain percentage of usage. It can be concluded that the usage of IBS in Malaysia is getting more popular. About one third of the projects completed from 1998 to 2002 used IBS in one form or another (IBS Survey 2003, 2003).

Meanwhile, IBS survey 2005 which emphasized more on architects' and designers' perspectives on IBS stated that majority of architects claimed to have little and insufficient knowledge of IBS which contributes to the lower employment of IBS (IBS Survey 2005, 2005). To add more, IBS Mid Term Review 2007 estimated that only 10% of the completed projects used IBS for the year of 2006. In the same year, less than 35% of total construction projects used at least one IBS product. These percentages are relatively low compared to forecasted percentage for completed IBS project which are 50% in 2006 and 70% in year 2008 as projected by the IBS Roadmap (Hamid *et al*, 2008). The Construction Industry Master Plan 2006-2015 was published in December 2006 as the strategic move and future direction to transform Malaysian Construction Industry to be among the best in the world. The effort of IBS is highlighted under Strategic Thrust 5: Innovate through R&D to adopt a new construction method (CIMP 2006-2015, 2006).

2.8 Factor Influencing Implementation of IBS

In previous research done by Kamar *et al.* entitled Paper of Proceeding in Malaysian IBS International Exhibition at Kuala Lumpur, 21^{st} -24^{th} January 2009, Malaysia, he discovered that the factors influencing implementation of IBS in term of contractor's organization could be divided into five groups as below (Kamar *et al.*, 2009):

2.8.1 Nature of construction factor

The issues included in this factor are fragmented industry, issues on foreign labour, demand in housing as well as image and quality issue.

2.8.2 Barrier factor

Barrier factor involves issues of cost, poor knowledge, resistance from customers and professionals, building regulation, increase in risk, complex interfacing, market monopoly, IT integration, few code and standard, lack of integration design stage, manufacturing capability also legal and cultural issues.

2.8.3 Enabling factor

This factor includes the demand and market share, Research and Development (R&D), government promotion and incentives, political lever and standard plan, apprentice on-the job training program, testing and verification program and vendor developing program.

2.8.4 Pull factor

Pull factor is the factor that encourages the adoption of IBS. Pull factor includes quality improvement, reduce defect, reduce site duration, housekeeping improvement, waste reduction, saving in the use of manual labour, incentive from government and cost saving.

2.8.5 Push factor

On the other hand, there are also push factor that discourages IBS usage, namely: reduce in safety & health risk, addressing skills shortage, dealing with environment and sustainability issues, client influence and government policy.

2.9 Definition of Critical Success Factors (CSFs)

Critical Success Factors (CSFs) could be defined as the limited number of areas in which satisfactory results will ensure successful competitive performance for the individual, department or organization (Bullen & Rockhart, 1981). Hofer and Shendel (1978) defined the CSFs as variables which could significantly affect the overall competitive position of the various firms in an industry. Identification of the CSFs in a particular industry is a valuable practice for a number of reasons. First of all, it leads to a better understanding of the competitive environment, which in turn may assists in making decisions related to new product development and marketing activities (Auruskeviciene *et al.*, 2006). Second, the CSFs establish a range of limited areas of focus that companies could put their valuable resources on things which really make difference between success and failure (Bullen & Rockhart, 1981). Third, the study on CSFs evaluates a change for business start-up, planning of company's process and as effective implementation plan (Dickinson, 1984). Finally, the understanding and development of CSF enables a firm to make a successful entry into an industry, finds a different position among other firms and successfully combines creation of the perceived value and cost reduction (Ketelhohn, 1998). To date, there has been relatively little discussion or documentation on the CSFs of IBS in term of contractors who transformed from conventional to IBS.

2.10 Critical Success Factors (CSFs) of IBS

The discussions of the data captured through literature reviews and case studies are presented below. They grant general understanding on the factors which are critical for IBS implementation.

2.10.1 Early Decision to use IBS

It is imperative that an IBS project strategy needs to be established at the early stage of the project so that maximum benefits from IBS could be gained. Key decisions on strategy, application, design, logistic and detail unit should be developed as early as possible between all parties involved (Gibb, 1999 & Neala *et al.*, 1993).

Respondents agreed that IBS will be best implemented if consultants consider IBS element at the beginning of the design phase and contractors involve in the design stage rather than to produce alternative design. Meanwhile, some of the respondents said that it is more difficult to convert the conventional design to IBS. This is due to the fact that translating design conventional to IBS is not economical.

To ensure maximum benefits, IBS should be used as an integral part of the design from the earliest possible phase of the project rather than as an afterthought, or as a late solution to reduce construction time (Gibb, 1999 & Blismas *et al.*, 2006).

Some of the respondents stated that the designs and processes involved in transforming conventional to IBS are entirely different. If the contract is not tendered on

IBS from the beginning, more time will be consumed in order to get approval for the design from local authorities. However, other respondents said that Design and Build (D&B) projects which design on IBS from the beginning are easier and straight forward as there will be no late changing issue on the site later on.

2.10.2 Communication Channel and Information Flow

Effective communication is necessary if not critical with the increase of coordination involved in IBS project. The fundamental success of offsite project lies in good communication channel between all level of decision making and all project phases (BSRIA, 1998). Better communication effort is required during the early stage of the project whereby a thorough planning and design harmonisation are crucial (Blismas, 2007). To coordinate the process and deal with critical scheduling from the beginning until the project completion, effective communication channel across the supply chain needs to be developed (Pan *et al.*, 2008 & BSRIA, 1998). Clarity and simplicity are the key factors. Effective communication includes allocation of information regarding decisions, designs, transportation requirements and schedules (Haas & Fagerlund, 2002).

Above literatures are supported by respondents when they stated that decision-making process is vital in IBS and it needs to be coordinated by better communication and planning. They also mentioned that clarity and simplicity of communication could be translated into error-free construction. Problem at site could be solved by good communication and coordination with designer and manufacturer. One of the respondents stated that effective and clear communication is an essential part of the process to a predetermined discipline. This is to ensure all information reaches the affected part of the process in a timely and complete fashion, or there can be expensive waste resources.

Communication in this sense is not limited to verbal communication but also take account of information and documentation flows in the project (Blismas, 2007). Timely communication between the factory and project site is necessary during the construction phase. This is to ensure correct manufacturing provision and timely delivery of components to site (Malik, 2006). The respondents agreed with the above statements when they said that site people always need to keep in touch with factory to ensure correct time delivery components to site.

2.10.3 Early Assemble of Project Team

The IBS specialist should be involved during the design stage. By working with the designers, it can be ensured that the design has not reach the point where it restricts the benefits that can be brought by IBS (Pan *et al.*, 2008; Blismas, 2007; Sanderson, 2003 & Gibb, 2001). Due to the complexity process sequence and critical schedule, it is vital to identify and assemble project team from the start so that the whole sequence of construction process can be pre-planned (Goodier & Gibb, 2007). In addition, expert's advice on transformation and installation should also be sought as early as possible (Gibb, 1999).

The respondents could not agree more with the above statements when they stated that collaboration, contribution of expertise and sharing knowledge among the team at the beginning of the project speed up the knowledge transfer.

Compared to the conventional construction, one of the most significant drawbacks of using IBS technology is the inability to make amendment on-site. To solve this, the project team should cooperate with the owner in pre-project planning during the conceptual design phase to reduce the possibility of onsite changes (Lu & Liska, 2008). It is vital for contractors who use IBS to involve the project team in project decision-making process as early as possible to ensure their input on the issues of manufacturing capability, design harmonisation and constructability (Pan *et al.*, 2008).

It is beneficial to initiate design freeze into the programme. This will help to mitigate the impact of any late design changes, which may not be easy to incorporate when employing IBS solution (Buildoffsite, 2008).

From the survey, one of the respondents mentioned that inputs from mechanical and electrical, manufacturing and project team are vital at the beginning of the project. If there is no coordination at the early stage, building information will be scattered. Problem might arise at site and further will cost time and money. Respondents also agreed that inputs from the construction team, designer and manufacturer and even architect at early stage are critical to ensure smooth project flow and error-free manufacturing and construction.

2.10.4 Finance

Cost is one of the famous topics that until now has been discussed among contractor, supplier and even manufacturer before decided to implement IBS. Evidently, cost impact is the major barrier to IBS implementation (Goodier & Gibb, 2004; Venables *et al.*, 2004 & Pan *et al.*, 2007). It is obvious that IBS construction needs a good finance management to reduce cost redundancy.

In general, contractors are likely to maintain tight control over the budget and schedule to guarantee profit margin. Therefore, the use of IBS demands careful and detailed cost planning and management at all stages (Sanderson, 2003). This is done by embracing the approach of 'value for money' rather than 'lowest first cost focus' (Pan *et al.*, 2007). The contractors need a framework for comparing costing solution in more holistic manners (Blismas *et al.*, 2003). Pan *et al.* (2007) also draws attention to balance and clarify comparative costing framework for IBS project. Good cost comparison analysis tools are critical to support decision making in choosing IBS over the conventional method. Tool such as IMMPREST (Interactive Model for Measuring Preassembly and Standardisation Benefit in Construction) toolkit describes the details of risks and benefits measurements when using pre-fabrication (Blismas *et al.*, 2003). In the early appraisal and cost plan stage, it is important to establish a way of determining what prices for elements really are. Without well-established cost benchmark, it is difficult to be certain that suppliers' prices are realistic (Sanderson, 2003).

The respondent agreed that wise decision of investment is vital in the early stage. This is due to the fact that large amount of capital is needed in the early stage especially to set up the factory. However, the cost will be reduced once the project is completed provided proper cost control planning is implemented in all processes and stages. Better cost data lead the contractor in pursuit of systematic costing and estimating tools for tendering phase.

2.10.5 Top-down Corporate Vision

IBS is more of a process rather than just a collection of technology solution. A change from a traditional building process towards a manufacturing process is required by this approach. Definite target and strong aspiration from senior management are vital to convince the decision makers, customers, clients and own organisational to employ IBS (Kamar *et al.*, 2009). This is because this process is based on wanting rather than practicable (Hassim *et al.*, 2009).

These statements are further agreed by respondents when they mentioned that business is about profit and benefit. Their managements thought that IBS can give some advantage to them thus strong understanding and vision on IBS from the top decision-maker are vital. The same goes for projects involving government buildings. It is top management priority to use IBS since it is compulsory to achieve IBS Score 70 for government buildings as regulated.

Research by MTech consultant indicated that promoting the perspective of IBS technology to the boardroom appeared to create company success in IBS (Mann, 2006). According to our respondents, the idea to adopt IBS was first mooted by their Managing Director (MD). Then, this technology is preferred later on by professionals whom involved in decision-making and people form the top management as they are able to see the benefits of IBS in providing better quality of construction, solving labour shortage issue and increase speed of construction.

2.10.6 Identification of Market Sector and Technology

Contractors need to develop business process which is competitive in cost-sensitive environment in order to succeed in IBS. IBS companies have to find clear business needs in IBS (National Office Audit Report, 2005), strategize their business approaches and position themselves in the new playing field (Malik, 2006). The strategy should comprise effective combination of cost and production knowledge. The business decision-makers should first identify and evaluate the prospective benefits (BSRIA, 1998). Therefore, the consideration on types of the projects and technologies are critical in IBS.

The above statements show that selection of most beneficial projects and technologies are critical in IBS. One of the respondents stated that using appropriate technology at time is more beneficial rather than using too advanced technology which is costly in maintenance of machineries. With the budget given, they can successfully complete a project with high quality end product. Other respondents mentioned that their system needs to be flexible to accommodate different projects.

Identification of market sector especially in term of cost control is vital in IBS implementation. The adopters need to identify the cost driver in the project (Buildoffsite, 2008). IBS should invest significant resources into production facilities, product development and third party accreditation on product and system (Mann, 2006). One of the respondents stated that they had to discuss with top management whether to use the existing technology or to set up own factory. Business wise, they rather buy the components from existing manufacturers rather than make it themselves since it is more practical and cost effective.

Almost all of IBS adopters agreed that identifying market sector in order to use appropriate technology for IBS is important for in term of business viability. IBS requires heavy investment in terms of technologies and processes. So, the use of technology should be implemented in phases and based on adopter's maturity. The location of the project to existing manufacturing plan also affects the consideration on the use of IBS. Some respondents said that IBS adopters should select which project is suitable to use IBS. This is because setting up a factory or any venture on IBS needs volume. Location of the project affects the decision-making process to use IBS as transportation and logistics cost need to be considered.

Some respondents said that currently, formwork is preferred by most of IBS practitioners due to its flexibility and low set-up cost compared to pre-cast system. A competitive pre-cast system is a system of doing casting work at site. By setting up plants at site, cost will be minimized.

2.10.7 Information & Communication Technology (ICT)

Construction industry faces great communication difficulties and therefore effective use of Information Communication Technology (ICT) which includes development, implementation, support and management of computer based information system is required. Eichart & Kazi (2007) and Herves & Ruiz (2007) stated that ICT is important and reliable support tool to improve offsite tendering, planning, monitoring, distribution, logistic and cost comparison process by establishing integration, accurate data and effective dealing with project documents.

ICT is also a reliable support tool in improving communication between project team and suppliers and as a medium for quality control of the whole IBS project outcomes (Oostra & Jonsson, 2007). One of the respondents agreed with the above statements when they mentioned that ICT is an important support tools to visualize drawing of IBS and very helpful in designing and identifying the work dimension.

Another respondent stated that ICT would be a useful tool to assist in IBS project in terms of communication and tracking of IBS components at factory and at site.

2.10.8 Demand and Volume (Economic Viability)

One of the main obstacles in IBS is inability to achieve volume and economic scale of production. It is important for adopters to plan for continuous demand which could be done by establishing long-term contract with the clients. This statement is agreed by the respondents. One of them said that volume is important for IBS to take off. Repetitive and continuous projects are needed for business to survive. Another respondent added by saying IBS will only be implemented if developers can fulfill certain volume of building. Otherwise, IBS need to be combined with conventional. Since volume is important, contractors must be creative and always try to negotiate with developers. Other respondent mentioned that sustainability in IBS business is vital. Long-term demand for IBS is important so that capacity could be build up and resources could be channeled.

The findings from the case study showed that successful IBS adopters are subsidiaries of well-established developers since they have sufficient and continuous demands. The alternative way to create sufficient demand of IBS is by setting up a joint venture company with the developers. This idea is supported by the respondents when one of them mentioned that their role as provider and developer at the same time ensure sustainable demand for IBS which is vital for business survival. Another respondent added that IBS requires continuous demand. As they are also a developer, they are therefore fortunate since they can ensure sufficient demand in certain period of time in order the factory to survive. The other respondent stated that a sustain demand of IBS is granted by their parent company, which is a developer. Guaranteed demand is critical to cover set-up cost for IBS factory.

2.10.9 Management of Supply Chain

A supply chain is a system of organizations, people, technologies, activities, information and resources involved in moving a product or service from supplier to customer. Supply chain activities transform natural resources, raw materials and components to a finished product which are delivered to end customer.

Supply chain characteristics consist of planning and management of all activities namely: procurement, conversion, logistic and coordination between contractor, suppliers, intermediaries and third party solution providers within and across the company structure (Faizul, 2006). IBS construction demonstrates the need to integrate the key business process from end user through original suppliers (Goodier & Gibb, 2004). The industry relationship between the main contractors with suppliers and subcontractors can be compared with master-servant relationship. Both have lack of togetherness and the information protectionism is widespread over the industry (Faizul, 2006). High demands on the management of supply chain and logistic activities will be raised in IBS (Lessing *et al.*, 2005).

From the respondents' point of view, arrangement with the manufacturer should be more than just purchase order. The manufacturer should give full commitment to provide continuous supplies to contractor. They also added that supplier with long-term relationship will give better quotation in pricing and guarantee of continuous supplies.

The current state of supply chain in the construction industry is fragmented and underpinned by poor communication, adversely relationship, lack of trust and commitment, (Hong-Minh *et al.*, 2001) and relationship between parties has been driven by cost agenda (Wood & Ellis, 2005). To harvest maximum benefits from IBS, contractors need effective management of supply chain. It needs to be constructed in a way the contractors could gain full control of the process with the intention to improve efficiencies and competitiveness (Faizul, 2006).

One of the respondents stated that they will not interfere with the supplier's creativity and aspiration in order to establish a good working calibration. But, they do advise them in terms of constructability and modularity.

2.10.10 Partnering and Strategic Alliance

The concept of partnering has been promoted for the purpose of addressing the fragmented supply chain in construction industry. The key to succeed in IBS implementation is partnering with suppliers and sub-contractors from the early stage of project sequences (Kamar *et al.,* 2009 and Pan *et al.,* 2008). Partnering with suppliers and manufactures from the early stages of project sequence is significant to ensure efficient and timely delivery of components at site (Sanderson, 2003). These statements are further agreed by respondents when they mentioned that collaboration and partnering ensure smooth supply chain and continuous business to IBS. Project's participants need to be engaged in long-term basis and work as a team with strategic partnering contract in order to gain utmost benefits of IBS (Oostra & Jonsson, 2007). Partnering contract is considered as an arrangement whereby contractor is engaged in a series of projects with the intention of lowering cost and improving efficiency or can be a short-term single project arrangement. With this approach, all the key suppliers and contractors are hired by clients or developers for a number of years, and for several projects (Gibb, 1999).

Based on the semi-structured interview conducted with Setia Putrajaya Sdn. Bhd. (a joint venture company between contractor and developer to undertake works at Putrajaya), they mentioned that, partnering is commenced through establishment of a new company with the project developer so that continuous demand is ensured. This is also to enhance organization capability to fulfill client's requirements.

Apart from that, partnering is also executed in form of joint venture arrangement with their more established oversea partner whom attained the technology and expertise in industrialised building. It is obvious that through partnering, knowledge and technologies on IBS will be transferred and shared. This is proven when one of the companies mentioned that they established a joint venture team with their partner, the Praton House from Germany. Due to limited knowledge in IBS, their partner supplies them technology and expertise through technology transfer activities between both companies.

2.10.11 Advanced Project Planning & Scheduling

Project planning is part of project management to deal with schedule of process. In construction, to comply with the project objective, appropriate balance between resources usage and project duration needs to be achieved. This could be realized by optimizing the project planning. Planning in IBS requires thorough arrangement of detail design, work delivery schedule, most financial effective method for installation and logistic (Pan *et al.*, 2008; Lessing, 2006; Oostra & Johnson, 2007 and Haas & Fangerlund, 2002).

Some of the respondents said that pre-planning is important in IBS operation in order to make sure the installation is coordinated and to minimize problem at site. Every detail on design and construction should be finalized so that people involved will have better idea in supervising during construction.

Attention needs to be paid in planning in order to realize the advantages of cheaper cost and shorter time (Neala *et al.,* 1993 and Whelan, 2008). During installation stage, the adopter has to determine the best path and time to the site, ground conditions and size of the site prior to installation works (Ahmad, 2005).

This statement is supported by the respondents when they mentioned that the use of machinery especially tower crane is critical to IBS panel installation. If the machinery fails to plan properly, the work will be delayed or even stopped thus affects the factory production. Proper study and planning are important to chart transportation route for transporting panels to the site to avoid any delays.

2.10.12 Process Flow Coordination and Control

IBS processes most of the time are complex. They require coherent structure and management of processes in order to attain the goals and deliver maximum value. Coordination is the process of making different people or process work together for a goal and effect. Coordination design, manufacture, transportation, tracking and installation process are the important factors which contribute to the success of IBS construction (Haas & Fangerlund, 2002; Li, 2006; Vrijhoef *et al.*, 2002 and Lessing, 2006). Recognition of main process and its time sequence is essential. Therefore, a thorough planning is required especially in the early stage of project (Lessing, 2006).

Most of the respondents agreed with the above statements as they highlighted that process flow coordination is the most critical factor in IBS. This could be seen through the process of erecting floor cycle system. The installation is based on sequences which are panel marking, erecting, concreting and mechanical & electrical. All processes need to be done in proper synchronization by initiating advance planning at the onset of the project. The respondents also stated that balance between factory and site is critical. Factory must be flexible to follow construction process flexibility and balance between this two is important to prevent double handling and problem with storage.

Coordination is also essential to handle interface between each elements and components of the building or between each organization involved in construction process (Gibb, 1999). IBS adopters have to realize the extensive coordination required before and during construction operation (Haas & Fagerlund, 2002). The respondents agreed with these statements when they stated that management of coordination is important. Proper planning and scheduling is needed to ensure tradesmen work in separate location without interfere with each other. This would create a good working condition where coordination between trades is practiced.

Further coordination may be required for materials management and supply chain scheduling in order to find correct matching of components with installation system in terms of performance, capacity and spatial arrangement (BSRIA, 1998). Standardisation of these processes could help to further reduce the overall cost and schedule (Haas & Fagerlund, 2002). One of the respondents stated that they use panel numbering method in installation. This is to ensure the installation is synchronized and coordinated carefully to prevent work redundancy.

2.10.13 Site, Logistic and machineries

Contradictory to the conventional method, the design, manufacture, assembly and other related processes in IBS project require more coherent structure of process planning and control at site, transportation and machineries so that defects and errors are reduced (Gibb, 2007; Warszawski, 1999). To reap utmost benefits from IBS, the team needs better schedule of components delivery at site (Pan *et al.*, 2008).

These literature findings were agreed by one of the respondents by mentioning that planning and monitoring on machinery is important. This statement is also supported by other respondents when they said that they put emphasis on planning and monitoring the safety of crane operation and also on loading and unloading of component at site. Lifting is a critical job in IBS and requires competent personal, close monitoring and planning.

The logistic aspect of IBS should be integrated with the construction process and high demand on will be raised on the management of logistic activities (Lessing *et al.*, 2005). The concept of Just in Time (JIT) principal is therefore recommended to be adopted in logistic management (BSRIA, 1998; Ogden, 2007; Lessing *et al.*, 2006). JIT concept is defined as a philosophy of manufacturing based on planned elimination of all waste and on continues improvement of productivity (Ahmad, 2005). Reduction of work in progress inventory, reduction of working capital, reduction of production cycle time, reduction of flow variations and contribution to continuous improvement are among the benefits of JIT (Ballard & Howell, 1997).

According to the respondents, JIT application would be the preferred way especially in big IBS projects and is practiced as much as possible. Therefore, site, machinery and logistic considerations are important.

2.10.14 Design Management and Integration

Change in design especially during the construction phase is often not recommended and favored in IBS. One most significant disadvantage of using IBS is the inability to make changes on-site which is contradictory to the conventional construction. It is advisable to provide information about site restrictions and integration with existing facilities into the specifications as early as possible (Buildoffsite, 2008).

Most of the respondents agreed with these statements. One of them said that everything must be decided earlier, not when panels have been fabricated. As such, all mechanical & electrical services need to be incorporated into pre-cast element in factory. Hacking of pre-cast element on site is costly and should be prevented. Another respondent added that confirmation at the early stage, design freeze is very important. Opening must be confirmed early before panel casting. For example, close attention should be put into sanitary and cold water services as well as lift service as problem can be incurred if opening is too narrow or big. The other respondents stated that any changes should not be made during construction. Input from M&E engineers and designers are vital to manufacturing team since all aspect of construction must be confirmed at the onset of the project. This is because cost of changes during construction is very high and will offset the benefit of implementing IBS.

Introducing *design freeze* into the program will help to alleviate the impacts of any late design changes, which is difficult to incorporate when using IBS (Buildoffsite, 2008). The respondents could not agree more with this concept when one of them mentioned that changing of mindset is needed for all project members. As they need to confirm anything early in design, they introduced the concept of design freeze to architect and clients. Another respondent added that it is very difficult to change design or requirement during construction phase. As such, the concept of design freeze is practiced while everything is decided and confirmed at the early stage of construction period. Meanwhile, the other respondent said that everything must be planned early in advance. Input from M&E services is important at the onset of the project. The concept of 'design freeze' is therefore essential in IBS.

Management of design is imperative to IBS implementation. It includes early consideration on manufacturing and constructability issue, incorporate M&E services into components, consider the loading distribution which optimising the use of pre-cast components and establish flexibility and ease of construction. This idea is supported by the respondents. One of them said that in IBS, forward thinking is vital. As early as design phase, they try to think and tackle leakage problem which could probably occur in the project. The other respondent mentioned that the benefit of IBS can only be materialized by proper design management. For example, IBS depends on vertical loading, thus any optimization and benefit depends on designing IBS to accommodate vertical loading. At the same time, one of the respondents also mentioned that knowledge and understanding on IBS are crucial for designer. IBS has some sort of thinking, considering constructability and vertical loading. As such, inputs from construction and manufacturing team are very critical at the design stage. The other respondents mentioned that, their system considers the application of pre-assembly during casting to reduce cost. However, it is important to coordinate between design and M&E in order to confirm the power point location before actual casting take place at the factory as it will reduce and eliminate hacking at site.

Design management establishes forward thinking in planning particularly in the issues of transportation and installation particularly on the issue of manufacturability and constructability. Therefore, cost would be reduced and maximum benefits for implementing IBS would be obtained. Most of the respondents supported this statement. One of them said that design management is vital. They think about transportation issues during the design phase to avoid problems and to make sure it is in good condition during transportation since the cost of repairing is high and will effect overall productivity of project and also time. Another respondent added that in IBS project, design planning is important. By having control of design, design which is feasible to IBS could be made thus maximum benefit of IBS implementation could be reaped. The other respondent said that design, manufacturing and construction are related process. The processes are controlled by controlling the design. The ability to produce and construct will be develop, once the design is mastered.

2.10.15 Competent and Experienced Workforce

IBS process demands new skills and knowledge namely: integration, planning, and monitoring and managing supply chain. There is a consensus of opinion that good site management, planning and control of overall process in project life cycle are the critical factors for IBS projects to succeed. Huge risk of uncoordinated error and tolerance during the construction tenure are the reason behind this opinion (Kamar *et al.*, 2009). During construction stage, components at site should be installed by expert, well-trained and fully competent personnel (Nawi *et al.*, 2006 & Badir *et al.*, 2002). Experienced and competent manpower coupled with quality training at all levels are vital to the success in IBS (Mole, 2001). Failure to have competent manpower will compromise the benefits of IBS and create further problem at site (BURA, 2005).

Most of the respondents prefer experienced and competent workers. Their workers are specialized in certain tasks and eventually become master of the trade. They are also provided with comprehensive method statement to familiarize them with the system. Another respondent also agreed that they cannot appoint the sub-contractor to do the job as how it would be in the conventional construction. Only trained and authorized competent person will be allowed to handle component installation and operate tower crane due to safety issue. The other respondent stated that experienced workforce will improve quality of workmanship. To improve the quality, IBS skill set which involve job training particularly on component installation and panel jointing system is provided to improve workers' skills.

2.10.16 Training & Education

The large proportion of construction industry workforces are general labours with narrow skills and limited trainings. Although IBS is used to attend to the skill shortage in construction industry, some evidences suggest that a skilled workforce in particular areas like integration, coordination and assembly becoming more important to IBS. This is due to the different undertaken roles and project methods. According to Mole (2001), the decrement of trade skills in IBS is offset by the need to establish new skill sets and competencies. A broader and comprehensive training program must be initiated to accommodate demand in these specialized skills (Goodier & Gibb, 2004). Respondents agreed that in-house training is essential in IBS organisation. The training is practiced for all sites and office staffs by attending courses to ensure better understanding on the system.

According to Goodier & Gibb (2007), training programs should concentrate on implementing the role as system integrator at site with a full amount of responsibility in coordination and integration activities. Contradictory to conventional method, Pan *et al.* (2008) and Goodier & Gibb (2007) claimed that IBS construction requires a high-level of technique and precision. One of the respondents said that their training program is conducted by attaching trained key workers or installers with the manufacturer to expedite learning curve.

2.10.17 Continuous Improvement and Learning

Continuous improvement is a management process whereby delivery processes are constantly assessed and improved for the purpose of efficiency, effectiveness and flexibility. IBS is not as easy as it appears to be. However, much of the expertise from the successful companies managed to overcome a serious problem in the learning curve of the implementation (Neale *et al.*, 1993). Therefore, successful IBS implementation depends on organisation ability to accelerate learning curve from one project to another

(Neale *et al.*, 1993). The above citations are supported by one of the respondents when they said that they have learnt from mistake whereby they had faced leakage problem on vertical and horizontal panels which are pre-fabricated at site. The problem is solved by casting in-situ for vertical element to avoid homogeneous issue between panels.

Compared to the conventional construction, the repetition process implemented in IBS allows continuous improvement and waste elimination in the technique and processes to achieve better performance (Treadaway, 2006; Sanderson, 2003 and Pasquire & Connolley, 2002). Continuous learning can improve the company's understanding on IBS processes and the principles behind it as knowledge will multiply as experience mount up (Treadaway, 2006). This justification is approved by one of the respondent when they said that at the beginning, they completed installation for one floor in 21 days. Later, they learned and improved to 14 days and finally they only need 10 days to complete one floor installation.

Pan *et al.* (2008) suggested IBS companies to stimulate innovation related to process improvement and continuously review latest offsite technique available in market. It is also vital to capture project experiences and be prepared to distribute this information in a structured manner as it allows improvement in process time cycle (Blismas, 2007). Benchmarking exercise has been suggested as a tool for continuous learning. This is done by encouraging learning from own projects and from the industry's best practices (Pan *et al.*, 2008 & Pan *et al.*, 2005). One of the examples given by respondents are they upgraded the technology to the third generation technology to improve their products and systems. Their statement showed that they agreed that they need to innovate and continue learning to be success in venturing IBS.

2.10.18 Development of Roles and Capability

Design, manufacturing and construction must not be separated as they are essential to IBS adopters. It is advisable for IBS adopters to set up their own fabricating yard and establish their capability in design. By doing so, they would have better control on coordinating IBS processes. Therefore, adopters could obtain maximum benefits through optimisation, quality, continuity and speed of construction. Apart from that, it is also recommended for IBS adopters to adopt role as a total solution provider to IBS.

These statements are seconded by the respondents when one of them said that factory which stands alone is not a good practice. IBS implementer must set their design team and own factory, so all the process can be fully integrated. Another respondent added that they design, produce and install IBS components. As they involve in the construction process, they can improve on quality by close monitoring every aspect in the process and necessary adjustment could be made. Meanwhile, the other respondent stated told that they design, produce, and construct. They aim to be a total solution provider for IBS. Having control in manufacturing and construction, we can ensure sustainable supply of components, quality, cost reduction and fast installation can be ensured.

CHAPTER 3

RESEARCH METHODOLOGY

The research methodology is essential in guiding the researcher to achieve the aims and objectives of the study. This chapter describes the methodology used in this study. First, related literatures are reviewed. Then, survey and interview are conducted. Subsequently, the survey's results are presented followed by discussions. The step is continued with recommendations for future study and eventually conclusion is drawn.

3.1 Research Methodology

The methodology consists of three steps. These steps are listed below in chronological order:

1) Literature review and case study;
2) Data collections; and
3) Analysis of data

3.2 Literature Review and Case Study

The purpose of the literature review is to help the author to get general overview of the study. The review is done through reading and searching of books, journals, international and local conferences papers, and magazines related to this study.

There are three important sections under the literature review. The first section explains about the Industrial Building System (IBS) construction. The second section describes the implementation of IBS in Malaysia while the last section describes the Critical Success Factors (CSFs) that influence the implementation of IBS in construction organization in Malaysia. The literature review hence, provides guidance to questionnaire preparation, which is discussed in the following section. Case study is done after that to get the validity of CSFs which taken from literature review. 5 of the company who were experienced and master in this industry are chosen and the interview session is done.

3.3 Data Collection

In this stage, data is collected through literature review. Questionnaire is designed based on the literatures and case study. Questionnaires are distributed to selected organizations. In selecting the potential candidates, there are a few specifications in which the organizations should have. The candidates are taken from IBS companies registered under CIDB Orange Book program. The chosen companies are the grade G7 contractors in which the organizations have no limit in tendering capacity. The respondents are also chosen from precast and steel framing contractors based on IBS specification. The area of distribution focused in Klang Valley area only. The questionnaire is designed in three sections. Section A, B and C are about the general information on the background of the respondent, the general perception on IBS construction and the opinion regarding factors that influence the success of IBS implementation in Malaysia respectively. **(Refer to Appendix A-Questionnaire Form)**

The distributed questionnaires are then collected and analysed using Likert Scaling method. Discussion is done based on the derived results, and related statistics and suggestions by the participants are also included. Out of the 100 significant organisations identified, a total of 36 responses are obtained. The number represents the percentage of 36% of total sampling, which is satisfactory in statistical point of view.

3.4 Questionnaire Design

The questions included in the questionnaire are in the forms of closed-ended and open-ended questions. The closed-ended questions are presented in the form of multiple-choice questions. Multiple-choice questions required the anticipation of the whole range of likely answers, which would be given, and formulating the options as such. The options available should be established had been on the desk research and preliminary casual interview with some industry players to test the validity of options.

Having considered the factors that influence the success factors of IBS implementation, rating scale approach is selected. The rating scale questions are based on Likert's scale of five ordinal measures of agreement towards each statement (from 1 to 5) as shown in the Figure 3.1. This technique is chosen because it is easy to construct, administer and score.

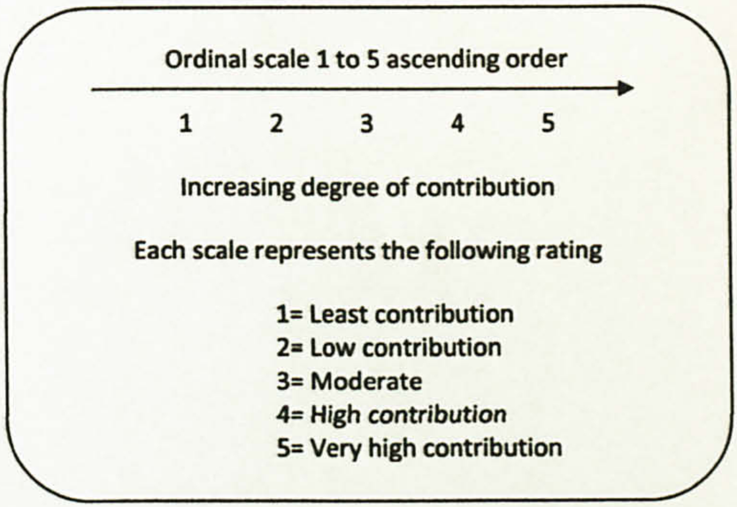


Figure 3.1: Five ordinal measures of contributing factors of Likert Scale

3.5 Questionnaire Development

This work applies a Likert scale type to the questionnaire design, running from 1 (Least contribution) to 5 (Very high contribution). To determine the questionnaire structure, second evaluation is conducted to ensure credibility and effectiveness. The original questionnaire includes 55 questions regarding IBS critical success factors (CSFs). In this work, validity is used to ensure accurate measurement of characteristics and factors. Generally, the correction of the measurement results and forecasting characteristics represent the degree of the validity. Interviews are conducted with an academic specialist and three industry specialists for validation.

3.5.1 Questionnaire Reliability

A pre-test was performed to ensure the questionnaire is phrased appropriately. It was done prior to distributing the questionnaire to the respondents. It is important to conduct pre-test before distributing the questionnaire to ensure the questionnaire is relevant to the topic studied. SPSS was used for this purpose. The Cronbach's α coefficient is used to determine the questionnaire's reliability. An α higher than 0.9 indicates high reliability while lower than 6.5 indicates low reliability. For the pre-test, Cronbach's α of 0.859 has been achieved and corrected scale contained 18 structural survey questions representing 18 CSFs.

Table 3.1: Reliability Statistics

Cronbach's Alpha	N of Items
.859	18

3.6 Analysis of Data

The next logical step after collecting the information is to analyse the information and available data. The factors that influence the success of IBS implementation for construction organisation in Malaysia were identified through numerous literature reviews. These factors are divided into ten main categories as listed in **Table 3.2.**

Table 3.2: Ten main categories of critical success factors of IBS implementation for construction organisation in Malaysia

No.	Categories
1	Business Strategies
2	Finance
3	Partnering and Contract
4	Enabling Factor
5	Roles and In-House Manufacturing
6	Lean and Advance Planning
7	Skills
8	Process Management
9	Training and Education

After identifying the main categories of the success factors, the sub-items for those categories are classified. These sub-items or sub-factors are classified based on the collected data from the related parties' experience and also through literature reviews. The complete statements of the success factors are recorded in **Table 3.2.**

Table 3.3: Success factors of IBS implementation for construction organisation in Malaysia

No	Success factors of IBS implementation for construction organisation in Malaysia
	Business Strategies
1	Top-down corporate vision
2	Early decision to use IBS
3	Market Sector and Technology
4	Demand and Volume
	Finance
5	Investment and Start-up Capital
	Partnering and Contract
6	Management of supply chain
7	Partnering in project
8	Early assemble of project team
	Enabling Factor
9	Information and communication technology (ICT)
	Roles and In-House Manufacturing
10	Development of Role
	Lean and Advance Planning
11	Advance project planning and scheduling
12	Site, logistic and machineries
	Skills
13	Competent and experienced workforce
	Process Management
14	Design Management and Integration
15	Effective Communication Channel
16	Process Flow Coordination and Control Process
	Training and Education
17	Training and education
18	Continues improvement and learning

The procedure used in analyzing the survey's result aims at establishing the relative importance for various factors that influence the success of IBS implementation construction and to determine the most common factors by ranking them according to the data given by the respondents. Besides that, the survey also aims to get the respondents' feedbacks regarding level of implementation of IBS in Malaysia and to find ways to improve the performance of construction organizations. It is intended that the results obtained would generate some proposals on how could the construction organization succeed in today's construction industry.

3.6.1 Questionnaire Measure

The sample of the questionnaire used in this study is attached in Appendix A. The questionnaire is based mainly on Likert's Scale of five ordinal measures from one (1) to five (5) according to the level of agreement.

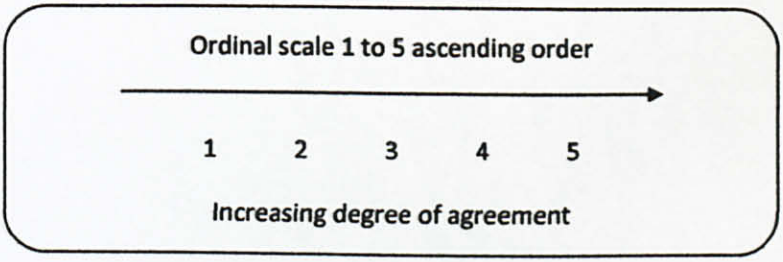


Figure 3.2: Five ordinal measures of agreement by Likert Scale

The raw data generated from the questionnaire are analysed by using software 'SPSS v16.0 for Windows'. The analysis is performed for the purpose of ranking the critical success factors (CSFs). The CSFs are ranked according to their means. If two or more CSFs happen to share the same mean values, the lowest standard deviation is assigned the highest importance ranking.

CHAPTER 4

RESULT AND DISCUSSION

This chapter presents the analysis, results and discussion of the research derived from the data gathered from the questionnaires.

4.1 Respondent Background

94.6 % of the questionnaires are distributed to Klang's Valley area while the rest to Johor Bharu. All of the respondents are the G7 contractors. 83.3 % of them involved in installing IBS, 54.1 % involved in designing IBS components and 24.3 % involved in manufacturing IBS components. Based on **Table 4.1** and **4.2**, the respondents involved have different level of experience and designation. The survey result shows that most of the respondents who answered the question are senior managers with the percentage of 51.4 %. Meanwhile, the percentage of respondents who have experience of more than 15 years in the industry is 64.9 %.

Table 4.1: Respondent Designation

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Project Manager	6	16.2	16.2	16.2
	Project Engineer	2	5.4	5.4	21.6
	Senior Management	19	51.4	51.4	73.0
	Quantity Surveyor	6	16.2	16.2	89.2
	Other	4	10.8	10.8	100.0
	Total	37	100.0	100.0	

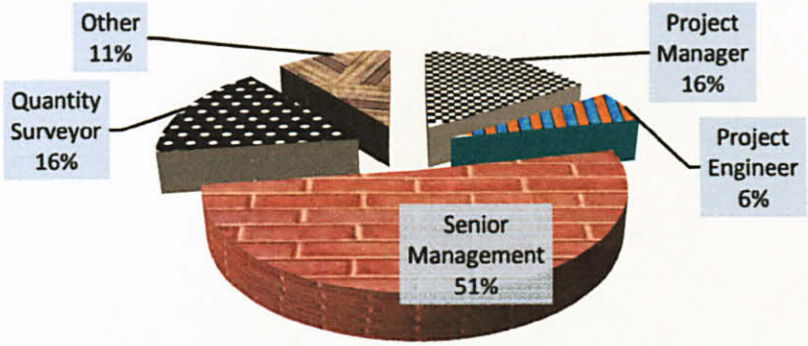


Figure 4.1: Respondent Designation

Table 4.2: Working Experience

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0-4 years	3	8.1	8.1	8.1
	5-10 years	7	18.9	18.9	27.0
	11-15 years	3	8.1	8.1	35.1
	More than 15 years	24	64.9	64.9	100.0
	Total	37	100.0	100.0	

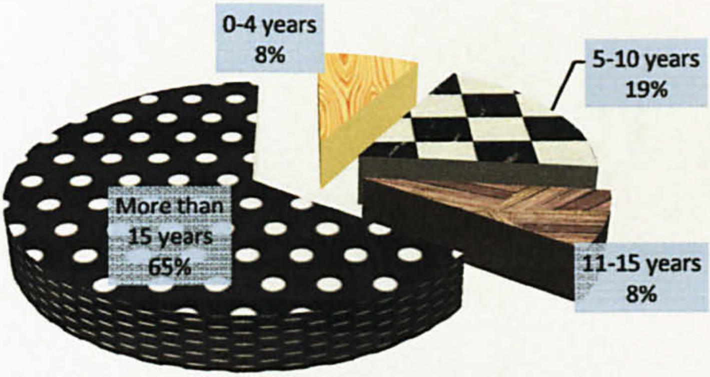


Figure 4.2: Working Experience

4.2 Respondent Perception of IBS

This section measures the current level of IBS implementation in Malaysia and general perception to IBS. **Figure 4.3** shows that most of the respondents which are 64.9 % prefer to use formwork systems while 54.1 % of them prefer precast concrete, framing, panel and box systems as type of IBS in the local industry.

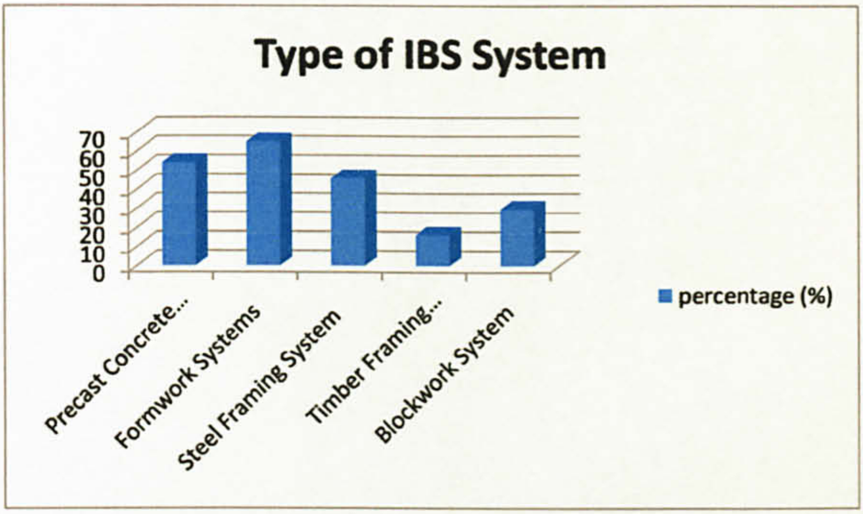


Figure 4.3: Type of IBS commonly use in IBS

Most of the respondents considered speed of construction and quality of IBS product as the drivers to the greater use of IBS construction Malaysia. The percentage is 80.6% as shown in **Figure 4.4**. From the survey, it is also found out that 67.6% of respondents choose cost while 59.5% of them choose capital investment as barrier to the greater use of IBS construction in Malaysia. Both of the percentages are represented in **Figure 4.5**.

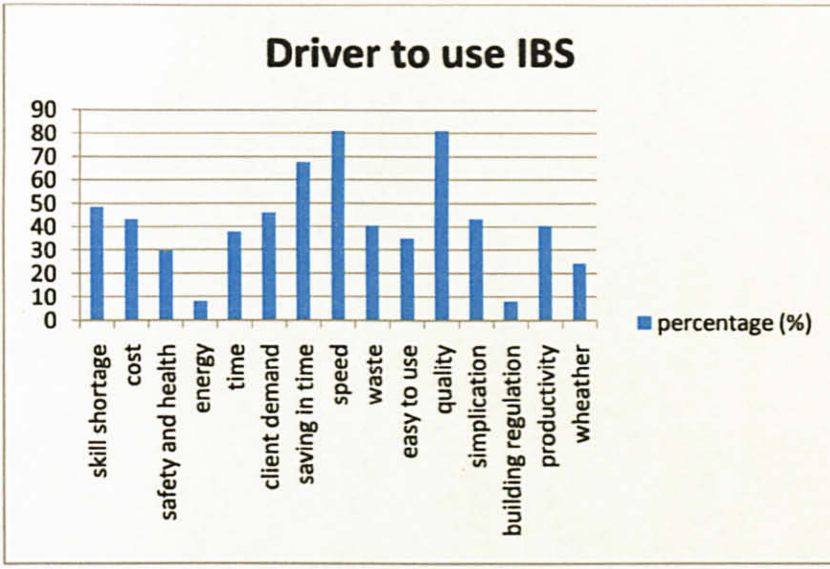


Figure 4.4: Driver to the greater use of IBS construction in Malaysia

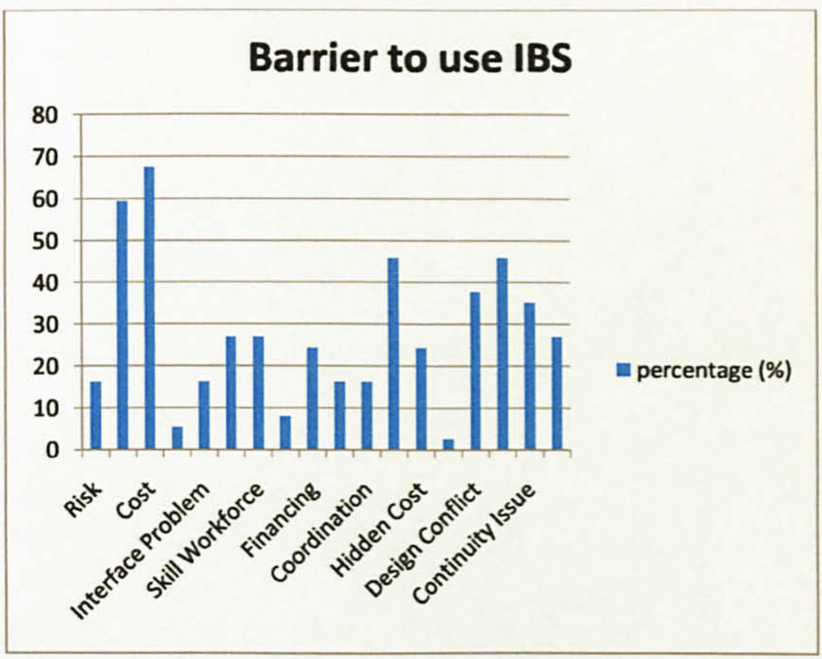


Figure 4.5: Barriers to the greater use of IBS construction in Malaysia

4.3 Ranking of Importance of CSFs for IBS

This part aims to investigate factors influence the success of construction organisations to implement IBS. The results are tabulated in **Table 4.3**.

Table 4.3: Ranking of importance

Descriptive Statistics			
	N	Mean	Std. Deviation
Top-down corporate vision	37	4.35	.676
Early decision to use IBS	37	4.30	.878
Early assemble of project team	37	4.24	.796
Effective communication	37	4.19	.569
Project management : Site, logistic and machineries	37	4.19	.660
Finance	37	4.19	.877
Coordination and control of processes	37	4.11	.614
Competent and experienced labour	37	4.03	.833
Planning and scheduling	37	4.00	.707
Design management and integration	37	3.95	.524
Management of supply chain	37	3.86	.751
Continues improvement and learning	37	3.78	.672
Partnering and strategic allience	37	3.78	.750
Demand and volume	37	3.76	.723
Market sector and technology	37	3.76	.683
ICT	37	3.70	.618
Training and education	37	3.68	.669
Development role	37	3.62	.924
Valid N (listwise)	37		

4.4 Discussion Based on Relation of CSFs of IBS Implementation with Construction Project Management Objective

The result is used as a guideline for the implementation of IBS. The author has compiled the result based on the fundamental of objective of construction project management and the rank of CSFs for IBS implementation. Every critical factor has clustered based on relation of objective theory of construction project management which is quality of the product, time saving and allowable cost within the budget. This study done through literatures review and case studies. As shown in **Figure 4.6**, the cluster is relating the quality with time, time with cost and also quality with cost.

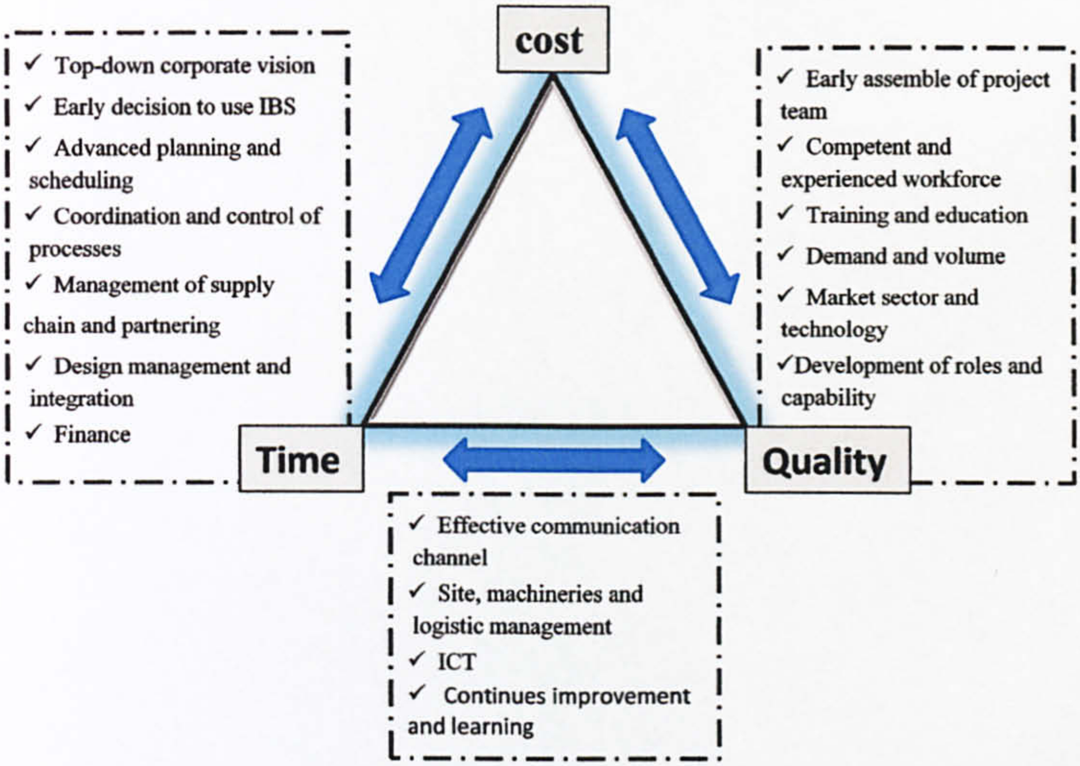


Figure 4.6: Relation of CSFs of IBS Implementation with Construction Project Management Objective

The discussions of all the critical points are based on the ranking presented above. The detailed results of each CSFs as attached in **APPENDIX B**. The final outputs of the project are as follows.

1. Definite target, strong aspiration, commitment, awareness, vision, knowledge and leadership from senior management is vital to convince the decision makers, customers, clients and own organization to employ IBS. Obtaining this top-down support could be the key to the successful IBS project.

2. IBS will be best implemented and can be only benefit if decision to consider IBS element especially in design stage as early as possible rather than during the project. Changing conventional design to IBS during after the tender has been rewarded is a bad practice. Cost can be reduced if the IBS element implemented in early stage. IBS also will be easier and straight forward if the contract is Design & Build (D&B) rather than conventional contract. This can saving more time.

3. Obtaining manufacturing input at an early stage of the project is essential to IBS design. It vital to identify and assemble project team as in project division making and design phase as early as possible to ensure their input on the issue of manufacturing, design harmonisation and constructability are captured before the design is confirmed and transfer to the manufacturing floor. This also will increase the quality of the product. It is beneficial to initiate design freeze into a programme to gather input from construction team, designer and manufacturer in order to mitigate the impacts of any late design change that might effecting the cost of the project.

4. IBS requires good communication channel and information flows between all level of decision making and all project phases. Effective communication channel across the supply chain need to be established in order to coordinate

processes and deal with critical scheduling in IBS from the beginning until the project completion. Clarity and simplicity of communication channel is the rule.

5. Advanced planning and coordination is requires thorough arrangement of detail design, work delivery schedule, most cost effective method for installation and logistic to realize the advantage of cheaper cost and shorter time. Tighter and longer period of planning are required to allow for design, logistic and installation planning, procurement and approval procedures. Proper planning on transportation route chart also essential in IBS.

6. Wise investment is vital in the early stage by proper planning. Attention need to be taken to balance and transparent comparative costing framework for IBS project. Even though the large capital is needed to start-up the project, but the cost will be much lesser comparing to conventional when the project is completed.

7. Coordination of design, manufacture, transportation, tracking and installation process are important in the integration of IBS components or modules into the building. This requires good planning and communication channel among the various parties and supply chain. Coordination is required before and during construction to handle interface between each elements and components of the building or between each organisation involved in construction process. It has been suggested that by implementing integrated approach in design and construction, fragmentation gap could minimised.

8. Due to a different undertaken roles and project methods of processes in overall project life cycle particularly in areas like integration, coordination and assembly, recommendation that experienced and well-trained workers are the critical for IBS contractors. A comprehensive training scheme will support this demand.

9. IBS project requires more coherent structure of planning and control in site, transportation and machineries in order to reduce defects and errors. Proper study, planning and monitoring on use of machinery especially tower crane are essential in IBS. Just In Time (JIT) principal –manufacturing based on planned elimination of all waste and on continues improvement of productivity- is recommended to be adopted in logistic management.

10. IBS can be best implemented if we have capability in design management and design integration, where aspects that can benefited the projects can be incorporated through design i.e. standardisation, pre-assembly, manufacturability and constructability.

11. Management of supply chain and partnering are critical factors to successful IBS implementation. It put emphasis advance planning, coordination and management between contractor, intermediaries and suppliers with the same shared vision. Partnering ensure the smooth process coordination from factory to installation with the intention of lowering costs and improving efficiencies. The relationship is based on strategic alliance with key suppliers. It is particularly important to engage with suppliers who know the products and the process exceptionally well, particularly on sub-contractors whom doing the work onsite.

12. Learning curve for continues improvement and waste elimination for the purpose of efficiency, effectiveness and flexibility in the IBS technique and processes can be expedited by repetition process each time project was implemented. Repetition can improve company understanding on IBS processes and the principle behind it. IBS can only benefit the adopters if the implementer can capture project experiences and be prepared to distribute the information in a structured manner. Benchmarking exercise has been suggested as a tool for continues learning.

13. IBS can only be implemented if we have demand and economy viable. It is suggested that, the adopter only chose selective projects that can benefits by the use of IBS. Large and repetitive contract is proffered. Some successful IBS adopters are a sub-division of developers which can ensure stability, continues resources and continues business. Only by having demand IBS can sustain

14. The adopters must have a clear business strategy, structured cost control instruments and initiate the use of appropriate technology at time. Based on industrialisation principal, innovation adoption is an evolution which depends on the maturity of organisation. There is no point on implementing the latest construction technology, without considering one capability and readiness to embrace in it.

15. ICT is the key enabler to IBS implementation and become a reliable support tool in improving communication between project team and suppliers, to visualize drawings in IBS and very helpful in designing and identifying the work dimension. The application of ICT tools needs to be utilised in a more widespread manner, in order for the IBS industry to improve efficiencies, planning, manage process and ensure reliability of components deliveries.

16. Capacity and capability in design, manufacturing and construction can not be separated. Adopters are suggested to close monitor and coordinate the processes. Whenever possible, adopters are encourage to develop own capacity in IBS design and set-up their own fabricated yard.

CHAPTER 5

CONCLUSSION AND RECOMMENDATION

This chapter concludes the study by listing down the results of the data analysis. Some recommentdations for the better performance of IBS transformation program based on CSFs were included.

5.1 Conclusion

This section presents the conclusions which are developed through the research's findings. Basically, all the objectives of this study have been successfully achieved. Overall, this study can be summarized as follow:

a. To identify the Critical Success Factors (CSFs) for contractors to implement IBS as their method of construction.

For the first objective, the findings from literatures and data collection from interview during pilot survey show that the critical factors in IBS implementation could be divided into 9 categories which are business strategies, finance, partnering and contract, enabling factors, roles and in-house manufacturing, lean and advanced planning, skills, process management and finally training and education. Under these 9 categories, there are 18 Critical Success Factors (CSFs) for contractors to implement IBS discovered.

b. To rank the Critical Success Factors (CSFs) for contractors to implement IBS as their method of construction.

As for the second objective, the analysis results indicate that top-down corporate vision is the most critical factor to bring the successful implementation of IBS. The other 17 CSFs are also ranked by using SPSS version 16.0.

c. To create project management guideline for contractors in order to implement IBS.

Lastly, the third objective of the study has also been achieved. The project management guideline is provided in the discussion by relating CSFs and fundamental theory of construction project management. The guideline is also developed based on the CSF ranked by respondents. It can be concluded that transformation of company from conventional system to IBS requires a tremendous focus on Critical Success Factors (CSFs) to achieve the transformation.

5.2 Recommendation

In this chapter, the author presented his recommendation on how to improve the research on implementation guideline manual of construction's organisation from the conventional system to IBS for future study. From the results obtained, a relation between Critical Success Factors (CSFs) and construction project management has been developed. There are many stages in construction project management. However, five stages have been chosen to relate to the ranked Critical Success Factors (CSFs). The five stages are Feasibility Study, Enabling Factor, Business Strategy, Design and Construction, Business Maintenance and Future Development. The relation developed between Critical Success Factors (CSFs) and these stages of construction project management is shown in **Figure 5.2**.

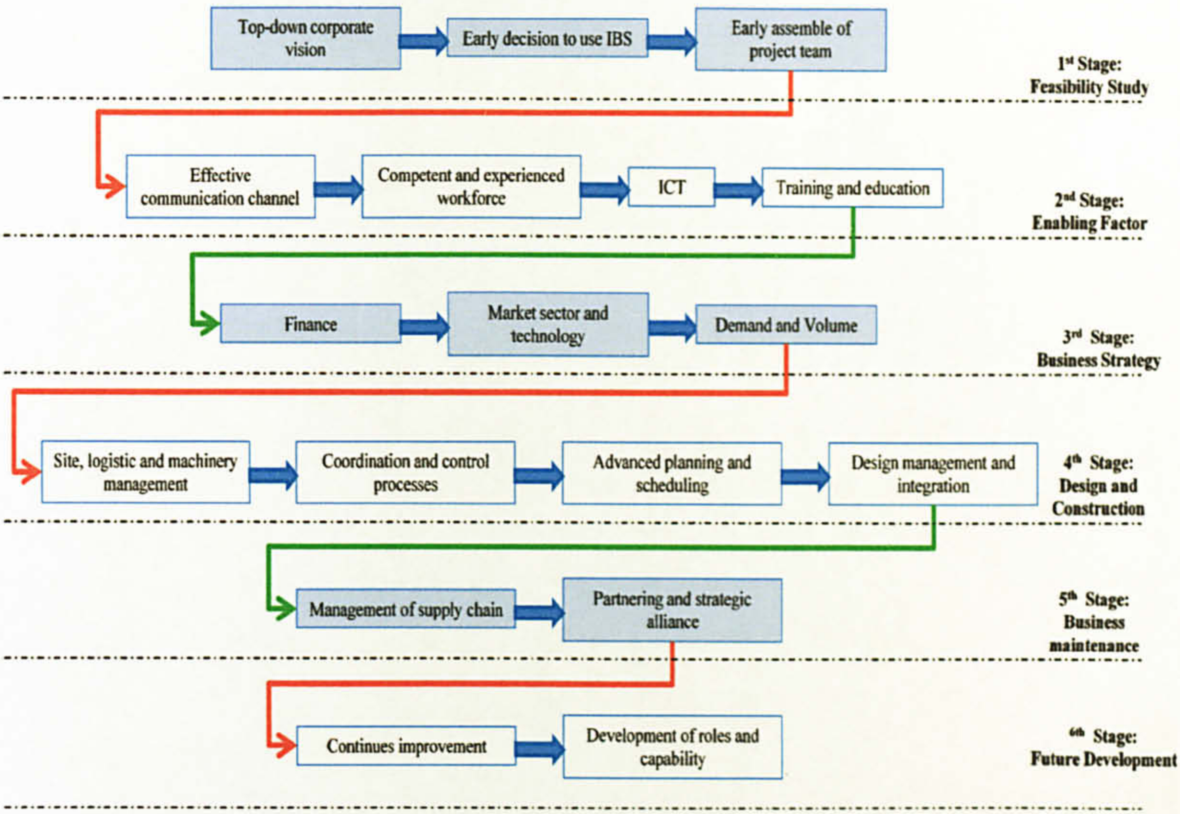


Figure 5.2: Implementation of IBS Manual Program Based on Critical Success Factors (CSFs) of IBS Implementation

The most important stage before construction starts is the Feasibility Study stage. When conducting Feasibility Study for IBS construction, the organization should have clear visions which are motivated by the top management. Also, the decision to use IBS need to be made as early as possible. To reap the maximum benefit of IBS, Design and Build (D&B) contract is recommended as the tendering contract. Besides that, early assemble of project team among designer, consultant and manufacturer is required to get input from manufacturing, and any issue regarding IBS construction.

For the next stage, it is important for the organisation to identify the Enabling Factors in IBS construction. To ensure smooth project flow, these factors need to be identified thus implemented from the beginning of the project until completion. Effective and clear communication channel among all parties is one of the factors which enable IBS implementation to be done in efficiently. Besides that, experienced and well-trained workers in each particular areas like integration, coordination and assembly is also a must. To support this demand, a comprehensive training scheme is required.

Up next is the Business Strategy which is the most critical stage in IBS construction. Without this strategy, the objective of construction management; meet the desired construction speed, save cost and meet desired quality of the construction; will not be achieved. The organisation needs to strategize the finance management as early as possible. An efficient finance management will ensure that the decision to use IBS benefits the company financially compared to conventional method. The use of appropriate technology at time according to the organization's capability and readiness to embrace it is also important. Wrong choice of technology cost the organization in terms of cost and time. The organization could also benefit from IBS if they have demand and volume viable. This is because it is inevitable that only by having demand IBS can sustain.

The following stage is the Design and Construction stage. During this stage, there are four elements which are important to the IBS implementation as shown in **Figure 5.2**. Coordination is necessary during construction to handle interface between each element and component of the building or between each organisation involved in construction process. Besides that, advanced planning is required to realize the advantage of cheaper cost and shorter time. The capability in design management and design integration is also important where aspects that would benefit the project can be incorporated through design. All of these are the success factors for the IBS implementation during construction stage. By putting emphasis on the mentioned factors, the construction flow at site will be smooth without any mistake from contractor, supplier and manufacturer.

Next is the Business Maintenance stage. There are two success factors grouped under this stage which are management of supply chain as well as partnering and strategic alliance. These two are vital for any organization which implements IBS to maintain in this industry. Therefore, it is advised to establish a strong relationship among contractor, supplier and manufacturer.

Last but not least is the Future Development stage. Other than maintaining the business, the development of should be taken into account. By having guideline for future development, quality could be improved. In addition, time and cost of construction could also be reduced. This way, the possibility of opting to use IBS as the method of construction for next project will increase.

CHAPTER 6

ECONOMIC BENEFITS

In this chapter, the author reviews the cost spent that contributed to the success of this research. The author spent mostly on the travel cost, which is from University Technology of PETRONAS (UTP) and author's hometown, Putrajaya to Construction Research Institute of Malaysia (CREAM) and Construction Industry Development Board (CIDB). CREAM and CIDB are where the resources and information are assembled and discussions and planning with research team of CREAM were held. The travel cost is defined by cost per one kilometer distance which is RM 0.20 per kilometer. The summary for the travel cost spent for this purpose is tabulated in **Table 6.1** below.

Table 6.1: Travel cost for meeting discussion with CREAM

No	Date	From	To	Reason	Distance (Km)	Toll (RM)
1	- 30th August 2009 - 27th September 2009 - 28th November 2009 - 19th March 2010	University Technology Petronas (UTP), Tronoh, Perak	CREAM, Makmal Kerja Raya, Jalan Chan Sow Lin, Cheras, Kuala Lumpur	Meeting discussion	220 (1 way)	23.50 (1 way)
2	- 7th, 11th, 23rd, 24th, 28th, 29th, 30th December 2009 - 4th January 2010	Precint 9, Putrajaya	CREAM, Makmal Kerja Raya, Jalan Chan Sow Lin, Cheras, Kuala Lumpur	Meeting discussion	33 (1 way)	1.30 (1 way)

Apart from the amount shown above, there are also travel cost for meetings and interviews with main player companies who are involved and experienced in IBS industry. The summary for this cost is as shown below (**Table 6.2**).

Table 6.2: Travel cost for meeting and interview with companies

No	Date	From	To	Reason	Distance (Km)	Toll (RM)
1	16th December 2009	Precint 9, Putrajaya	University Putra Malaysia (UPM), Serdang, Selangor	Visit to Housing Research Centre	32 (2 way)	-
2	2nd November 2009	University Technology Petronas (UTP), Tronoh, Perak	Legend Hotel, Kuala Lumpur	CIRAIC IBS Roundtable Workshop	432 (2 way)	47.00
3	22nd December 2009	Precint 9, Putrajaya	Global Globe Sdn Bhd, Taman Melawati, Selangor	Pilot Study regarding IBS	53 (1 way)	1.30
4	22nd December 2009	Global Globe Sdn Bhd, Taman Melawati, Selangor	Global Globe Manufacturing Plant, Cyberjaya	Site Visit to IBS manufacturing plant	45 (1 way)	1.30
5	6th January 2010	Precint 9, Putrajaya	University Technology Malaysia (UITM), Shah Alam, Selangor	Meeting discussion	80 (1 way)	7.60
6	7th January 2010	Precint 9, Putrajaya	Putrajaya Holdings Sdn Bhd, Putrajaya	Site Visit to IBS Project	-	-

Total traveled cost = (Total distance x RM 0.20) + Total Tol

= (2930 Km x RM 0.20) + RM 266

= RM 868

Other than travel cost, there is also cost for questionnaire preparation. As discussed and agreed by CREAM, cost for this part was financed by them. The list of questionnaire preparation cost is shown in **Table 6.3**.

Table 6.3: Inventory cost

No	Inventory	Unit	Cost per unit (RM)
1	A4 Paper	6	12.00
2	Printer (Cartridge)	4	100
	TOTAL		472

In conclusion, after summing up all the cost required in conducting this research, the final total cost is about RM 1324.

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APPENDIX A

Questionnaire Form

23rd December 2009

Dear Sir / Madam,

SURVEY ON INDUSTRIALISED BUILDING SYSTEMS (IBS) 2009/2010

Referring to the above matter, we are pleased to invite you to participate in Construction Research Institute of Malaysia (CREAM), Construction Industry Development Board (CIDB) Malaysia in collaboration with Universiti Teknologi PETRONAS (UTP), Malaysia research survey. The objective of this survey is to investigate the Critical Success Factors (CSFs) to Industrialised Building Systems (IBS) in Malaysia. This survey presents a unique opportunity for you to express your views on IBS.

2. The final outcome of this survey will be submitted to National IBS Secretariat, IBS Steering Committee, IBS Centre and IBS Technical Committee for the formulation of future IBS policies and action plans in 2011- 2015. Please do inform us, if you require a copy of the research output. It is our pleasure to share the research findings with our valued customers.

3. Please be assured that your responses will be held in strictest confidentiality. Under no circumstances will result specific to your company or yourself be made available to any individual or organisation. Your correspondent towards this survey is greatly appreciated. Any feedback or questions should be address to Mr. Kamarul Anuar Mohamad Kamar at 03- 9281 0800 ext 109 or at kamarul@cidb.gov.my

Respondents will be awarded with Certificate of Acknowledgement from CREAM. Please provide us with full details of your company in your respond letter.

Thank you for your participation and contribution.

Yours sincerely,

....

Ir. Dr Zuhairi Abd. Hamid
Executive Director
Construction Research Institute of Malaysia (CREAM)

23rd December 2009

Dear Respondent,

SURVEY ON INDUSTRIALISED BUILDING SYSTEM (IBS) CONSTRUCTION

Referring to the above matter, I would like to invite you to participate in a degree dissertation research conducted by Civil Engineering Department, University Technology of PETRONAS and in collaboration with Construction Research Institute of Malaysia (CREAM). The objective of this survey is to investigate the success factor for IBS implementation construction organisation. Attached herewith is the questionnaire which is prepared to identify what you, as an IBS construction organisation in Malaysia, consider to be:

- The main barriers and drivers for the use of IBS technologies
- The Critical Success Factors (CSFs) for IBS construction organisation

This questionnaire is designed for construction management personnel who have experience in IBS construction. This survey presents a unique opportunity for you to express your views on what the other parties in the development process can do to help support and raise your performance and enhance the value of your products and services. Your responses are much appreciated as they contribute to the success of the research. Please do inform us, if you require a copy of the research output. It is our pleasure to share the research finding.

Please be assured that your responses will be held in strictest confidence. Under no circumstances will result specific to your company or yourself be made available to any individual or organization. If you wish to comment on any questions or qualify your answers, please feel free to use the space in the margins provided. Your contribution towards this study is greatly appreciated.

Thank you for your participation and contribution.

Yours sincerely,

Shahrul Fazry Abdullah Sani
University Technology of PETRONAS

Ir Dr Zuhairi Abd Hamid
Executive Director
Construction Research Institute of Malaysia

CIDB
MALAYSIA

CREAM
Construction Research
Institute of Malaysia

SURVEY ON INDUSTRIALISED BUILDING SYSTEM (IBS) 2009/2010

Kindly Post OR Fax completed survey to:

POSTAL ADDRESS

CONSTRUCTION RESEARCH INSTITUTE OF MALAYSIA (CREAM)
IBS Centre,
1st Block E, Lot 8, Jalan Chan Sow Lin
55200, Kuala Lumpur

FAX: 03-9282 4800

Please submit this questionnaire before 7th January 2010

SECTION A: RESPONDENT INFORMATION

Q1. Name of Organisation : ______________________________

Q2. Tel./E-mail : ______________________________

Q3. Location of Organisation:

- [ ] Klang's Valley
- [ ] Other (Specify):______________

Q4. Type of business:

- [ ] Building Contractor
- [ ] IBS Manufacturer
- [ ] General Contractor: Civil
- [ ] Specialist

Q5. Contractor Registration Grade under Construction Industry Development Board (CIDB):

- [ ] G1
- [ ] G2
- [ ] G3
- [ ] G4
- [ ] G5
- [ ] G6
- [ ] G7

Q6. IBS Contractor Registration Grade under Construction Industry Development Board (CIDB):

- [ ] B1
- [ ] B2
- [ ] B13
- [ ] B15
- [ ] B19

Q7. Respondent Designation:

- [ ] Project Manager
- [ ] Project Engineer
- [ ] Consulting Engineer
- [ ] Senior Management
- [ ] Quantity Surveyor
- [ ] Other (Specify): ______________

Q8. Working Experience:

- [ ] 0-4 years
- [ ] 5-10 years
- [ ] 11-15 years
- [ ] More than 15 years

Q9. Does your company involve in design of IBS construction components?

- [ ] Yes
- [ ] No
- [ ] Not Sure

Q10. Does your company involve in the installation of IBS components?

- [ ] Yes
- [ ] No
- [ ] Not Sure

Q11. Does your company involve in the manufacturing of IBS components?

- [ ] Yes
- [ ] No
- [ ] Not Sure

SECTION B: GENERAL PERCEPTION ON IBS CONSTRUCTION

This section is to obtain general perception on IBS construction

Q12. Type of IBS system most commonly used in your IBS construction projects?
(You may tick (√) more than one box)

- [ ] Precast Concrete Framing, Panel and Box Systems
- [ ] Formwork Systems
- [ ] Steel Framing Systems
- [ ] Timber framing Systems
- [ ] Blockwork Systems

Q13. Which of the following are considered as drivers to the greater use of IBS construction in Malaysia?
(You may tick (√) more than one box)

☐ Skills shortage	☐ Client Demand	☐ Quality
☐ Cost	☐ Saving in Time	☐ Simplification
☐ Safety & Health	☐ Speed	☐ Building Regulation
☐ Energy	☐ Waste	☐ Productivity
☐ Time	☐ Easy To Use	☐ Weather

Q14. Which of the following are considered as barriers to the greater use of IBS construction in Malaysia? *(You may tick (√) more than one box)*

☐ Risk	☐ Skill Workforce	☐ Hidden Cost
☐ Capital investment	☐ Code & Standard	☐ Building Regulation
☐ Cost	☐ Financing	☐ Design Conflict
☐ Level of IT	☐ Lead-in Time	☐ Economic Scale
☐ Interface Problem	☐ Coordination	☐ Continuity Issue
☐ Manufacturing Capacity	☐ Lack of Knowledge	☐ Lack of Collaboration

SECTION C: CRITICAL SUCCESS FACTORS (CSFs) FOR IBS CONSTRUCTION COMPANIES

Please tick (√) the box that indicates your level of agreement for each statement ONCE for each item.

Terms and Definition

1: Extremely Not Agreed	-	if the factor is extremely not contributing to CSFs of IBS implementation
2: Not Agreed	-	if the factor is not contributing to CSFs of IBS implementation
3: Slightly Agreed	-	if the factor is slightly contributing to CSFs of IBS implementation
4: Agreed	-	if the factor is contributing to CSFs of IBS implementation
5: Extremely Agreed	-	if the factor is extremely contributing to CSFs of IBS implementation

Q15. Classification 1: Business Strategy

	1	2	3	4	5
1. Corporate vision and strong motivation from senior management are important to IBS company.	☐	☐	☐	☐	☐
2. Contractor need to convince clients to use IBS.	☐	☐	☐	☐	☐
3. Early decision to use IBS by the client can maximize overall benefits and profits.	☐	☐	☐	☐	☐
4. Early decision to use IBS by the client may avoid duplication of roles and inability to make change on-site.	☐	☐	☐	☐	☐
5. Business strategy is important in IBS adoption in giving direction to company.	☐	☐	☐	☐	☐
6. It is essential for contractor to analyse potential benefits of IBS before embark in any project	☐	☐	☐	☐	☐
7. Risk management strategy will help the IBS contractor to avoid project delay.	☐	☐	☐	☐	☐
8. Identification of market sector is essential to IBS.	☐	☐	☐	☐	☐

Statement	1	2	3	4	5
9. Good market research is important in identifying strong target market and secure repetitive client.	☐	☐	☐	☐	☐
10. Identification of target market is vital since not all projects are suitable for IBS.	☐	☐	☐	☐	☐

Q16. Classification 2: Finance

Statement	1	2	3	4	5
11. A wise investment in start-up capital will encourage overall cost control during IBS project construction.	☐	☐	☐	☐	☐
12. A large amount of capital is needed in early stages of IBS construction to set up factory.	☐	☐	☐	☐	☐
13. As IBS business entity, support from parent company is vital in financial aspect.	☐	☐	☐	☐	☐
14. Support from parent company is needed for long-term sustainable in business.	☐	☐	☐	☐	☐
15. Repetition in the IBS project will ensure sustainability and continuity in business.	☐	☐	☐	☐	☐

Q17. Classification 3: Marketing

Statement	1	2	3	4	5
16. Excellent marketing and branding strategy is important to IBS.	☐	☐	☐	☐	☐
17. Accreditation on product and process will increase client's confidence level on work quality.	☐	☐	☐	☐	☐

Q18. Classification 4: Partnering & Contract

Statement	1	2	3	4	5
18. Good communication and trust in relationship between main contractor and supplier/sub-contractor is important in management of supply chain.	☐	☐	☐	☐	☐
19. Management in supply chain will maximize benefits from IBS especially in term of cost.	☐	☐	☐	☐	☐

	1	2	3	4	5
20. Long-term partnering contract in project will ensure efficient and timely delivery of component at site.	☐	☐	☐	☐	☐
21. IBS contractor shall focus their effort on the task of component procurement and management rather than task related to actual work.	☐	☐	☐	☐	☐
22. Procurement and contract should allow the contractor and manufacturer to contribute their knowledge at early stage of the project	☐	☐	☐	☐	☐
23. IBS requires procurement strategy that clearly identifies supplier, manufacturer and sub-contractor not only with low cost but with high capability, competence and capacity.	☐	☐	☐	☐	☐
24. Early collaboration between team project and the owner in pre-project planning during conceptual design can minimize the possibility of late on-site change.	☐	☐	☐	☐	☐
25. Early assemble of project team allows sharing of knowledge and information in term of manufacturability and constructability.	☐	☐	☐	☐	☐

Q19. Classification 5: Enabling Factor

	1	2	3	4	5
26. ICT is a reliable support tool to all levels of management and operation by establishing integration, accurate data and effective dealing with project documents.	☐	☐	☐	☐	☐
27. Change management is important to deal with change from conventional to IBS.	☐	☐	☐	☐	☐
28. Benchmarking is a support tool for IBS firm to expedite learning curve.	☐	☐	☐	☐	☐

Q20. Classification 6: Roles & In-House Manufacturing

	1	2	3	4	5
29. Each party should understand their own role so that work could be conducted smoothly, improvement could be done and problem could be solved.	☐	☐	☐	☐	☐

	1	2	3	4	5
30. IBS firm should concentrate only on project management and contract to transfer risk to manufacture and designer.	☐	☐	☐	☐	☐
31. IBS firm should establish their own casting yard to control the manufacturing activities.	☐	☐	☐	☐	☐
32. Coordination in designing, manufacturing and construction is critical to IBS implementation.	☐	☐	☐	☐	☐
33. Quality control is important in IBS construction.	☐	☐	☐	☐	☐

Q21. Classification 7: Lean & Advanced Planning

	1	2	3	4	5
34. Application of lean construction concept is important in designing IBS production system to minimize waste.	☐	☐	☐	☐	☐
35. Application of lean construction concept is important to achieve zero inventories.	☐	☐	☐	☐	☐
36. Just-in-time construction concept is applied whenever possible in IBS.	☐	☐	☐	☐	☐
37. Advanced project planning and scheduling can maximize the efficiency of the operation and reduce overall cost.	☐	☐	☐	☐	☐
38. Good site planning and logistic will reduce the work-in-progress inventory, working capital, production-in-cycle time, flow variation and contribute to continuous improvement.	☐	☐	☐	☐	☐
39. Site planning and logistic is usefull to achieve appropriate balance between resources usage and project duration to comply with project objective.	☐	☐	☐	☐	☐

Q22. Classification 8: Skills

	1	2	3	4	5
40. In deep knowledge and skill in designing are important to ensure what is designed in-house is the same as the real situation on-site.	☐	☐	☐	☐	☐
41. Competent and experienced workforce is critical for new IBS adopters.	☐	☐	☐	☐	☐

	1	2	3	4	5
42. Job repetition will ensure the development of low skill worker.	☐	☐	☐	☐	☐
43. IBS firm needs to employ project manager who is able to deal with multi-organization of IBS.	☐	☐	☐	☐	☐
44. Profound understanding in building regulation will ensure compliances and avoid any mistake in any critical process of design and concept.	☐	☐	☐	☐	☐

Q23. Classification 9: Process Management

	1	2	3	4	5
45. The emphasis of standardization and concept of repetition help to simplify process management and further reduce overall cost and time.	☐	☐	☐	☐	☐
46. Effective communication during early phase of project in all level of decision-making processes will help project planning and design harmonization.	☐	☐	☐	☐	☐
47. Effective coordination management of construction process will ensure critical issues are viewed from overall perspective.	☐	☐	☐	☐	☐
48. Coordination on interface between element, system and organisations are critical in IBS process flow.	☐	☐	☐	☐	☐

Q24. Classification 10: Training & Education

	1	2	3	4	5
49. IBS requires high-level techniques and precision compared to conventional method.	☐	☐	☐	☐	☐
50. Skilled labour supported with quality internal and external training is essential to the success of IBS implementation.	☐	☐	☐	☐	☐
51. IBS requires tremendous education and training effort especially people involved in those handling, positioning and erecting the finished product.	☐	☐	☐	☐	☐
52. The success of IBS implementation depends on organization's ability to expedite a learning curve from one project to another.	☐	☐	☐	☐	☐

Q25. Please state your other comment or suggestion regarding to the critical success factors (CSFs) for IBS implementation in Malaysia

____
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Kindly Post OR Fax completed survey to:

POSTAL ADDRESS

CONSTRUCTION RESEARCH INSTITUTE OF MALAYSIA (CREAM)
IBS Centre,
1st Block E, Lot 8, Jalan Chan Sow Lin
55200, Kuala Lumpur

APPENDIX B

SPSS Analysis

Market sector and technology

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not Agreed	1	2.7	2.7	2.7
	Slightly Agreed	11	29.7	29.7	32.4
	Agreed	21	56.8	56.8	89.2
	Extremely Agreed	4	10.8	10.8	100.0
	Total	37	100.0	100.0	

Top-down corporate vision

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Slightly Agreed	4	10.8	10.8	10.8
	Agreed	16	43.2	43.2	54.1
	Extremely Agreed	17	45.9	45.9	100.0
	Total	37	100.0	100.0	

Demand and volume

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not Agreed	2	5.4	5.4	5.4
	Slightly Agreed	9	24.3	24.3	29.7
	Agreed	22	59.5	59.5	89.2
	Extremely Agreed	4	10.8	10.8	100.0
	Total	37	100.0	100.0	

Finance

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not Agreed	1	2.7	2.7	2.7
	Slightly Agreed	8	21.6	21.6	24.3
	Agreed	11	29.7	29.7	54.1
	Extremely Agreed	17	45.9	45.9	100.0
	Total	37	100.0	100.0	

Management of supply chain

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not Agreed	2	5.4	5.4	5.4
	Slightly Agreed	7	18.9	18.9	24.3
	Agreed	22	59.5	59.5	83.8
	Extremely Agreed	6	16.2	16.2	100.0
	Total	37	100.0	100.0	

Partnering and strategic allience

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not Agreed	2	5.4	5.4	5.4
	Slightly Agreed	9	24.3	24.3	29.7
	Agreed	21	56.8	56.8	86.5
	Extremely Agreed	5	13.5	13.5	100.0
	Total	37	100.0	100.0	

Early assemble of project team

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not Agreed	1	2.7	2.7	2.7
	Slightly Agreed	5	13.5	13.5	16.2
	Agreed	15	40.5	40.5	56.8
	Extremely Agreed	16	43.2	43.2	100.0
	Total	37	100.0	100.0	

ICT

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not Agreed	1	2.7	2.7	2.7
	Slightly Agreed	11	29.7	29.7	32.4
	Agreed	23	62.2	62.2	94.6
	Extremely Agreed	2	5.4	5.4	100.0
	Total	37	100.0	100.0	

Development role

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Extremely Not Agreed	1	2.7	2.7	2.7
	Not Agreed	2	5.4	5.4	8.1
	Slightly Agreed	13	35.1	35.1	43.2
	Agreed	15	40.5	40.5	83.8
	Extremely Agreed	6	16.2	16.2	100.0
	Total	37	100.0	100.0	

Planning and scheduling

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Slightly Agreed	9	24.3	24.3	24.3
	Agreed	19	51.4	51.4	75.7
	Extremely Agreed	9	24.3	24.3	100.0
	Total	37	100.0	100.0	

Project management : Site, logistic and machineries

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Slightly Agreed	5	13.5	13.5	13.5
	Agreed	20	54.1	54.1	67.6
	Extremely Agreed	12	32.4	32.4	100.0
	Total	37	100.0	100.0	

Design management and integration

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Slightly Agreed	6	16.2	16.2	16.2
	Agreed	27	73.0	73.0	89.2
	Extremely Agreed	4	10.8	10.8	100.0
	Total	37	100.0	100.0	

Effective communication

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Slightly Agreed	3	8.1	8.1	8.1
	Agreed	24	64.9	64.9	73.0
	Extremely Agreed	10	27.0	27.0	100.0
	Total	37	100.0	100.0	

Coordination and control of processes

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Slightly Agreed	5	13.5	13.5	13.5
	Agreed	23	62.2	62.2	75.7
	Extremely Agreed	9	24.3	24.3	100.0
	Total	37	100.0	100.0	

Training and education

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Slightly Agreed	16	43.2	43.2	43.2
	Agreed	17	45.9	45.9	89.2
	Extremely Agreed	4	10.8	10.8	100.0
	Total	37	100.0	100.0	

Continues improvement and learning

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Slightly Agreed	13	35.1	35.1	35.1
	Agreed	19	51.4	51.4	86.5
	Extremely Agreed	5	13.5	13.5	100.0
	Total	37	100.0	100.0	