

**ENHANCING SKILL WORKER REQUIREMENTS IN  
IMPROVING IMPLEMENTATION OF IBS IN  
CONSTRUCTON PROJECTS**

**AAWAG MOHSEN MOHAMMED**

**UNIVERSITI TUN HUSSEIN ONN MALAYSIA**

**ENHANCING SKILL WORKER REQUIREMENTS IN IMPROVING  
IMPLEMENTATION OF IBS IN CONSTRUCTION PROJECTS**

**AAWAG MOHSEN MOHAMMED**

A Thesis submitted in partial  
fulfilment of the requirement for the award of the  
Degree of Master in Construction Technology Management

Faculty of Technology Management and Business  
University Tun Hussein Onn Malaysia

January, 2016

## **DEDICATION**

This thesis is dedicated to my family for their endless efforts, love, support and encouragement. A special feeling of gratitude to my loving parents, whose words of encouragement and push for tenacity ring in my ears. I also dedicate this dissertation to my friends who support me throughout the process. I will always appreciate all they have done.

## ACKNOWLEDGEMENTS

All praise is due to Allah Almighty the creator of this universe, I am also grateful to him for giving me a good heal, strength, power and inspiration (Alhamdulillah).

This thesis owes its existence to the help, support and inspiration of several people. First and foremost, I would like to express my sincere appreciation and gratitude to my supervisor, Associate Professor Dr. Narimah Kasim for her guidance during my research. Her support and inspiring suggestions have been precious for the development of this thesis content. I would like again to thank her for providing me this great chance to work with her and I feel honored and lucky to have the opportunity to do so. Under her supervision, my research knowledge and self-confidence have increased. I have become more outspoken and brave in giving my opinion as well as sharing ideas with others. My deep and sincere appreciation also to all lecturers at Department of Construction Management, Faculty of Technology Management and Business, UTHM, for their support and trust in me to complete my Master of Science in Construction Technology Management.

Finally, my deepest gratitude goes to my family for their unflagging love and unconditional support throughout my life and my studies. You made me live the most unique, magic and carefree childhood that has made me who I am now. Above all, I owe it all to Almighty God for granting me the wisdom, health and strength to undertake this research task and enabling me to its completion.

## ABSTRACT

Skill worker is required and essential for implementing IBS construction projects in order to deliver and achieve projects within specific time and estimated cost. Skill worker in building and construction need to be implemented in terms of knowledge of materials, methods, and the tools involved in the construction or repair of houses, buildings, or other structures such as highways and roads. Many construction industries lack of skilled and professional labours to handle the progress of construction projects effectively and successfully. Therefore, it is important to study and find out the influencing factors for enhancing skills worker requirements in order to improve implementation of IBS in construction projects. This research focuses on enhancing skill worker requirements in improving implementation of IBS in Johor Bahru, Johor with contractors of G7 involved. The objectives of the research are to identify the influencing factors for enhancing skill worker requirements in improving implementation of IBS in construction projects and recommend ways to enhance skill worker requirements in improving implementation of IBS in construction projects. The quantitative approach was used to obtain information from contractors (G7) in enhancing skill worker requirements in improving implementation of IBS in construction projects. The questionnaires received from respondents were 85. The data from the questionnaires were gathered and analysed using Statistical Package for the Social Science (SPSS) version 22.0 software. The data collected was analysed into the form of percentage, tables, and charts as well. Labour with a good knowledge, skills and awareness of IBS implementation surely encourage appointed workers to handle and implement IBS projects properly. Effective and successful skill worker can improve implementation of IBS in Malaysian construction projects and accomplish projects on time with good quality, in addition to minimise the foreign work force and encourage the local labour which enhance the market share of construction industry affect and benefit the Malaysian economy.

## ABSTRAK

Pekerja yang berkemahiran amat diperlukan dan sangat penting dalam melaksanakan projek-projek pembinaan IBS supaya ia dapat disiapkan dalam jangka masa dan anggaran kos yang telah ditetapkan. Pekerja yang kompeten untuk pembinaan perlu mengaplikasikan kemahiran mereka dari segi pengetahuan tentang bahan, kaedah dan alat-alat yang terlibat dalam pembinaan, pembaikan rumah, bangunan, atau struktur lain seperti lebuh raya dan jalan raya. Banyak industri pembinaan kekurangan tenaga kerja mahir dan profesional untuk menangani projek-projek pembinaan dengan berkesan dan berjaya. Oleh yang demikian, adalah penting untuk mengkaji dan mengetahui faktor yang mempengaruhi peningkatan tenaga kerja mahir. Objektif kajian ini adalah untuk mengenalpasti faktor yang mempengaruhi peningkatan tenaga kerja mahir yang diperlukan dalam meningkatkan pelaksanaan IBS dalam projek-projek pembinaan dan mencadangkan beberapa cara bagi meningkatkan tenaga kerja mahir dalam penggunaan IBS dalam projek pembinaan. Kajian kuantitatif telah digunakan untuk mendapatkan maklumat daripada kontraktor (G7) dalam meningkatkan keperluan tenaga kerja mahir dan meningkatkan pelaksanaan IBS dalam projek-projek pembinaan. Data diperolehi adalah dengan menggunakan set soalan soal selidik dan melibatkan seramai 85 orang responden. Data yang diperolehi dengan menggunakan set soal selidik dan dianalisis dengan menggunakan perisian *Statistical Package for the Social Science (SPSS) version 22.0*. Data kuantitatif dianalisis untuk mendapatkan bentuk peratusan, dijadualkan dan ditunjukkan dalam bentuk carta. Hasil kajian menunjukkan pekerja yang mempunyai pengetahuan yang baik, kemahiran dan kesedaran yang tinggi dalam penggunaan IBS adalah dipilih untuk melaksanakan projek-projek IBS dengan lebih berkesan. Pekerja yang mempunyai kemahiran yang efektif dan berjaya mampu meningkatkan pelaksanaan IBS dalam projek-projek pembinaan di Malaysia dan menyiapkan projek tepat pada masanya dengan kualiti yang baik, mengurangkan tenaga kerja asing dan menggalakkan penglibatan pekerja tempatan. Selain itu, ia juga akan meningkatkan bahagian pasaran industri pembinaan dan memberi manfaat kepada ekonomi Malaysia.

## TABLE OF CONTENTS

<b>TITLE</b>	<b>i</b>
<b>DECLARATION</b>	<b>ii</b>
<b>ACKNOWLEDGEMENTS</b>	<b>iii</b>
<b>ABSTRACT</b>	<b>iv</b>
<b>ABSTRAK</b>	<b>v</b>
<b>TABLE OF CONTENTS</b>	<b>vi</b>
<b>LIST OF TABLES</b>	<b>vii</b>
<b>LIST OF FIGURES</b>	<b>viii</b>
<b>LIST OF ABBREVIATION</b>	<b>ix</b>
<b>LIST OF APPENDICES</b>	<b>x</b>
<b>CHAPTER 1 INTRODUCTION</b>	<b>1</b>
1.1 Background of Research	1
1.2 Problem Statement	3
1.3 Research Questions	4
1.4 Research Aim and Objectives	5
1.5 Significant of Research	5
1.6 Scope of Research	6
1.7 Research Methodology	6
1.8 Thesis Outline	8
1.9 Summary	9
<b>CHAPTER 2 LITERATURE REVIEW</b>	<b>10</b>
2.1 Introduction	10
2.2 Construction Industry Overview	11
2.2.1 Obstacles to Construction Growth	12

2.2.2	Lack of Manpower	14
2.3	Industrialised Building System (IBS) Implementation in Malaysian Construction Industry	16
2.3.1	History of IBS in Malaysia	17
2.3.2	IBS Definition	19
2.4	Classification of IBS	20
2.4.1	Precast Concrete System	21
2.4.2	Steel Form Work System	21
2.4.3	Steel-frame Building and Roof Trusses	22
2.4.4	Prefabricated Timber Framing System	23
2.4.5	Block Work System	24
2.5	Essential Characteristics of IBS	25
2.5.1	Closed System	25
2.5.2	Opening Building System (OBS)	26
2.5.3	Modular Coordination	26
2.5.4	Standardisation and Tolerances	27
2.5.5	Mass Production	27
2.5.6	Good Organisation	28
2.5.7	Transportation	29
2.5.8	Specialisation	30
2.6	Summary	30
<b>CHAPTER 3 RESEARCH METHODOLOGY</b>		<b>31</b>
3.1	Introduction	31
3.2	Research Design	31
3.2.1	Quantitative Research	32
3.3	Questionnaire Design	33
3.3.1	Population and Sampling	34
3.3.2	Pilot Test	35
3.4	Data Collection	35
3.4.1	Literature Review	37
3.4.2	Questionnaire Survey	37
3.5	Data Analysis	38
3.6	Summary	38



<b>CHAPTER 4 RESULTS AND DISCUSSION</b>	<b>40</b>
4.1 Introduction	40
4.2 Pilot Test	40
4.3 Response Rate	41
4.4 Data Analysis Method	42
4.5 Reliability	42
4.6 Data Editing and Coding	43
4.7 Demographic Profile	44
4.7.1 Position	44
4.7.2 Type of Projects Have been Done	45
4.7.3 Experience in Construction Industry	46
4.7.4 Projects have been Built / Experienced By using IBS	48
4.7.5 Based on Experience How Durable IBS in Construction Industry	49
4.8 Influencing Factors for Enhancing Skills Worker Requirements	51
4.8.1 Discussion of Findings	53
4.9 Recommend Ways for Enhancing Skill Worker Requirements	54
4.9.1 Discussion of Findings	56
4.10 Summary	57
<b>CHAPTER 5 CONCLUSION AND RECOMMENDATIONS</b>	<b>58</b>
5.1 Introduction	58
5.2 Summary	58
5.2.1 Objective 1: To identify the influencing factors for enhancing skill worker requirements in improving implementation of IBS in construction projects	59
5.2.2 Objective 2: To recommend ways for enhancing skill worker requirements in improving implementation of IBS in construction projects	60

5.3	Contribution to Knowledge	60	
5.4	Limitation of Research	61	
5.5	Recommendations	61	
5.6	Closure	61	
<b>REFERENCES</b>		<b>63</b>	
<b>APPENDICES</b>		<b>70</b>	
<b>APPENDIX</b>	<b>A</b>	<b>QUESTIONNAIRE</b>	<b>71</b>
<b>APPENDIX</b>	<b>B</b>	<b>VITA</b>	<b>75</b>

**LIST OF TABLES**

4.1	Pilot Testing Result	41
4.2	Response Rate	42
4.3	Testing Reliability Result	43
4.4	Position	44
4.5	Types of Projects Have Been Done	45
4.6	Experience in Construction Industry	47
4.7	Projects Have Been Built / Experienced by Using IBS	48
4.8	Based on your Experience How Durable Using IBS for the Projects in Construction Industry	50
4.9	Descriptive Statistics of Influencing Factors for Enhancing Skills Worker Requirements	51
4.10	Descriptive Statistics of Recommend Ways for Enhancing Skills Worker Requirement	54

## LIST OF FIGURES

1.1	The Review of Research Method, Activities and Output	7
2.1	Industrialised Building System (Sufian 2009)	16
2.2	Typical Project Using Steel Framing System (Sufian, 2009)	22
2.3	Typical Project Using Timber Forming System (Sufian, 2009)	23
2.4	Typical Project Using Block Work System (Sufian, 2009)	24
3.1	Research Process	36
4.1	Position	45
4.2	Types of Projects Have Been Done	46
4.3	Experience in Construction Industry	47
4.4	Projects Have Been Built / Experienced by Using IBS	49
4.5	Based on your Experience How Durable Using IBS for the Projects in Construction Industry	50

## LIST OF ABBREVIATION

IBS	Industrialised Building System
IT	Information Technology
BRT	Business Round Table
CIMP	Construction Industry Master Plan Malaysia
US	United States
CIDB	Construction Industry Development Board
NHP	National Housing Policy
GBI	Green Building Index
OBS	Open Building System

**LIST OF APPENDICES**

Appendix A	Questionnaire	71
Appendix B	VITA	75

## CHAPTER 1

### INTRODUCTION

This chapter briefly outlines the discussion on the research background and the research statement problems. It also states the aim of the research, research questions and objectives. In addition, significance of research, scope of research and brief methodology considered is also discussed. Lastly, it describes the structure of the thesis.

#### 1.1 Background of Research

Industrialised Building System (IBS) has been introduced to cope with a growing demand of affordable housing, solving issues associated with foreign labours and improving image, quality and productivity of construction industry. The limited take up on IBS have triggered many research initiatives attempting to scrutinised the barriers and seek the way forward. For contractors, the demand to use IBS is less attractive due to cost and risk issues, lack of professional trained in IBS, limited information technology (IT) adoption and lack of guidance (Pan *et al.*, 2008; Blismas, 2007). Nawi *et al.* (2012) stated that, many private companies in Malaysia have teamed up with foreign experts from Australia, United States of America (USA), Netherlands and Japan to offer precast solutions to their projects.

Lack of expertise can cause of time and cost overrun in the projects that IBS has been applied without appropriate study during the planning phase. IBS is costly for construction companies compared to conventional construction methods. This result is the same with Rahman & Omar (2006) and Bing (2001) mentioned that higher cost was the main obstacle of using IBS for construction companies. Higher cost mostly resulted from lack of expertise, lack of technologies, lack of standards and government incentives as well as limited suppliers. Another common barrier is design alteration during or after construction. Design changes are always costly even in the conventional method, but it depends on in which phase of project change occurs. In the IBS method, because components are produced in factories in large amounts, therefore, any design alternations would be extremely costly. Then applying IBS needs the careful design process and several controlling processes before the construction phase to ensure there is no mistake and minimize the chance of any changes after the design phase (Gibb, 2001).

Skills worker in building and construction need to be implemented in terms of knowledge of materials, methods, and the tools involved in the construction or repair of houses, buildings, or other structures such as highways and roads. It is the construction worker who is basically responsible for special hospital structures, building shopping malls and many other commercial as well as residential buildings. There are a range of careers that a person can choose from with respect to the construction business. These construction professionals include electricians, carpenters. Workers must be able to keep up with the physical demands of the job, which can be very rigorous. As they often work in teams, teamwork and skills are also important. Self-motivation can be important for construction workers who are self-employed or who must market their services. A desire and ability to work hard is also imperative for construction workers.

The problem of skilled labour shortage in the United States of America construction industry was predicted more than two decades ago. A report written by the Business Round Table (BRT) (1983) describes a technical skilled labour shortage as one of the main challenges in the United States (US) construction sector would be facing the last decade of the past century. The report predicted shortages of construction labour in both the open-shop environment and the union environment due to contractor's lack of interest in training and owners ignorance. According to Bennett (2001), the shortfall is a



result of demographic issues, normal attrition, and the construction industry's poor image. However, these factors, along with construction users' fixation on cost per hour rather than total cost, have also contributed to degraded skill levels in workers. Currently, there is an extraordinary struggle for a very ordinary workforce. In South Africa, the skills shortage has been acknowledged by Government and industry (Singh, 2007). The skills deficit appears to be on a path where demand will continue to outstrip supply as a result of the substantial growth in infrastructure investment. The step change in announced private sector projects in 2005 and 2006 resulted in additional skills requirements, the precise nature of which was beyond the scope of the study. Government-initiated projects also suggest a significant number of small (by value) municipal, provincial and national projects that will require more skills spread over several projects rather than a concentration of skills in fewer large projects.

## **1.2 Problem Statement**

In line with the 2006 – 2015, by 2015 the percentage of IBS used in construction projects should be above 80%. Furthermore, Malaysia will push the nation out of the middle income trap and create high income society towards developed nation status by the year 2020 (Hill *et al.*, 2013). Construction industry practitioners seem reluctant to use IBS as their construction method. Their reluctance to use the system is surprising its benefits have been pointed out by researchers. Warszawski (1999) highlighted that by adopting IBS, some saving in manual labour on-site can be achieved, increasing construction speed and providing higher construction quality.

Thanoon *et al.* (2003) also underlined cost saving, faster construction time and improvement of overall construction quality as the result of IBS implementation. These proved that, the use of IBS is advantageous as it fulfills the basic goal of construction, time, resources and quality. For instance, Badir (2002) studied the building system technologies in Malaysia and examined problems and constraints associated with this technology. The study concluded that the problems related to IBS technology were the higher initial capital investment and the needs for expert labour to deal with heavily

mechanised approach in IBS. Therefore, extra cost was needed to train existing semi-skilled labour to be highly skilled labour.

Improving skills worker requirements in enhancing implementation of IBS in construction projects is an essential to overcome issues that occur nowadays in construction projects field that cause delay in projects delivery, drawbacks, effective high cost as well as quality. Many construction industries lack of skilled and professional workers to handle effectively and successfully the progress of construction projects, so it is important to study and find out the challenges in improving skills worker requirements in order to improve implementation of IBS in construction projects. The limited take up on IBS have triggered many research initiatives attempting to scrutinised the barriers and seek the way forward. For contractors, the demand to use IBS is less attractive due to cost and risk issues, lack of professional trained in IBS, limited information technology (IT) adoption and lack of guidance (Pan *et al.*, 2008; Blismas, 2007). Therefore, this research seek to investigate skills worker requirements in improving implementation of IBS in construction projects.

### **1.3 Research Questions**

It is essential to develop research questions in order to help on focus the area of research. Following are some research questions that arise when conducting the research:

- (i) What are the influencing factors for enhancing skill worker requirements in improving implementation of IBS in construction projects?
- (ii) What will be the ways to enhance skill worker requirements in enhancing implementation of IBS in construction projects?

## **1.4 Research Aim and Objectives**

The aim of this research is to enhance skills worker requirements in improving implementation of IBS in construction projects. Therefore, in order to achieve the above aim, the following objectives have been identified:

- (i) To identify the influencing factors for enhancing skill worker requirements in improving implementation of IBS in construction projects.
- (ii) To recommend ways for enhancing skill worker requirements in improving implementation of IBS in construction projects.

## **1.5 Significance of Research**

Currently the main challenges in construction projects are lack of innovation, soft-skills, motivation, poor knowledge, technology skills as well as lack of training. Familiarity with IBS concept and its benefits is vital to its success because IBS requires different approach in construction industry. The barriers of IBS implementation in construction projects can be summarised and categorized in several themes, which are standardisation, and quality issues, issues in consumer perception, issues in professional perception, technology, training and education, finance and costing, incentive and communication issues as well.

The result of the research can contribute a new knowledge in construction industry by giving possible strategies of implementing the IBS in construction projects. The study intends to provide an inquiry into the current practices of implementing IBS in construction industry because it contributes to the infrastructural development which is significant to the development of its economy. If there is a failure in the construction industry, it manifests into weak infrastructure which affects productivity and the economy as a whole. The purpose of this study is to identify the ways for enhancing skills worker requirements in improving implementation of IBS in construction projects. It provides more knowledge about IBS as whole in construction industry and more information technology skills as well. The findings of this research can be used to serve

as a guideline or benchmark for the construction industry concerning the current usage of IBS implementation and challenges in construction projects. The study would also help the practitioners to enhance ways of IBS usage in construction projects. Lastly, the findings of this research can be helpful to contribute to parties of construction industry focusing on the enhancing of skills worker requirements for implementation of IBS in construction industry.

## **1.6 Scope of Research**

The scope of this research is focused on enhancing of skill worker requirements and recommend ways in improving implementation of IBS in construction projects. The research focuses on contractor G7 which includes project engineer, manager, site supervisor and engineers; towards acquiring the utilisation of IBS in construction projects in Johor Bahru, Johor, Malaysia. The transformation of the whole industry depends on the readiness of contractors as project implemented to use IBS. G7 contractors employ many professional such as huge number of workforce, sub-contractors and specialists in their projects. G7 contractors dominate the IBS market as they have better capability to invest in mass production with the updated and advanced technology. Large number of contractor involve in IBS is G7 (Kamar and Hamid, 2011).

## **1.7 Research Methodology**

To achieve the research objectives, a research method was adopted. In the adopted research method includes literature review by reviewed academic research journals, dissertations, textbook and eventually the available information in the internet. Literature review is the previous studies which were conducted to compare the current use of IBS in construction projects, identifying influencing factors for enhancing skill worker requirements in improving implementation of IBS in construction industry and recommend ways for enhancing skill workers requirements by implementation of IBS in construction projects. Quantitative approach was used to

identify the influencing factor for enhancing skill worker requirements for improving IBS in construction industry. The selected relationship between research methods and outputs of related activities are shown in Figure 1.1.

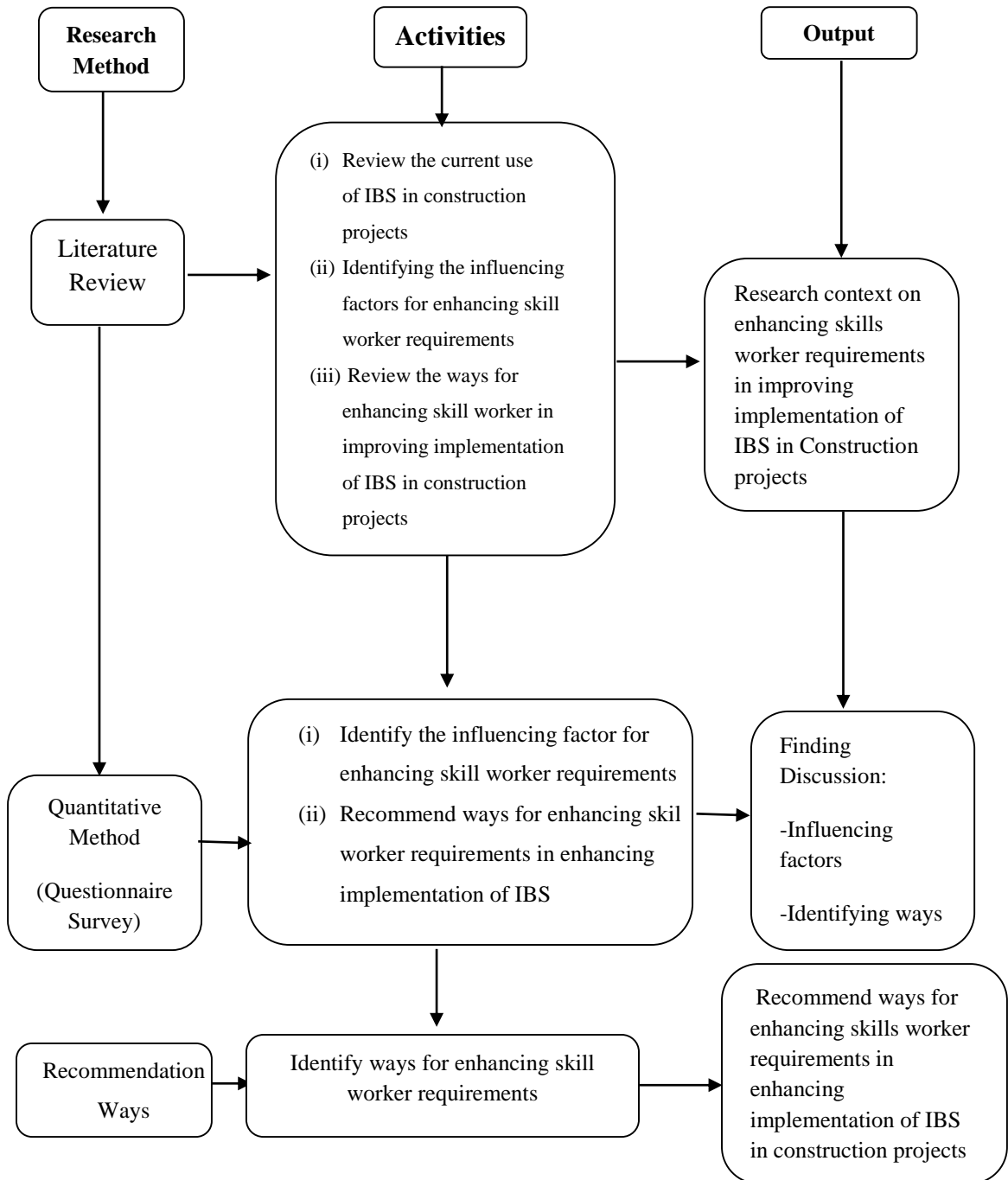


Figure 1.1: Review of Research Method, Activities and Output

## **1.8 Thesis Outline**

The thesis consists of five (5) main chapters. The chapters' organisations are as follows:

### **(i) Chapter 1: Introduction**

This chapter consists of introduction to research, background of research, problem statement, research questions, research objectives, scope of research, significance of research and research methodology.

### **(ii) Chapter 2: Literature Review**

This chapter discusses on improving worker skills requirements in enhancing implementation of IBS in construction industry including its definition, features, types, barriers, history as well as challenges in implementing IBS in construction industry.

### **(iii) Chapter 3: Research Methodology**

This chapter discusses on research approaches and strategies, and research procedures used as well as the process of both data collection and analysis of research were developed.

### **(iv) Chapter 4: Data Analysis and Findings**

This chapter explains data analysis from questionnaire survey and further discusses in detail and findings highlighted accordingly.

### **(v) Chapter 5: Conclusion and Recommendations**

In this chapter, conclusion draws out and the limitations of the research will be highlighted. Furthermore, this research discusses the findings and provides recommendations for future research.

## **1.9 Summary**

This chapter has identified the current usage issues of IBS in construction projects. Moreover, identify the influencing factors for enhancing skill worker requirements in improving implementation of IBS in construction projects and recommending ways for enhancing skill worker requirements to improve implementation of IBS. In this chapter it also includes section of research questions, research objectives, significance of research, and scope of research, summarised methodology and structure of the thesis. The next chapter will focus on the literature review which is the finding from previous research.

## CHAPTER 2

### LITERATURE REVIEW

#### 2.1 Introduction

Skills shortages within the construction industry are not a new phenomenon with the industry seeing a recurrent problem over the last thirty years due to the cyclical nature of the industry (Oyegoke *et al.*, 2009). With the anticipated growth of the industry between 2013 and 2015 (CIOB, 2013), and with the importance of new specialist markets such as the low carbon economy, there are major concerns for the future prosperity of the industry and its capacity for growth should the skills crisis continue. With previous research consistently highlighting the importance of the UK skills agenda and the importance of more modern, competitive and efficient industry.

Industrialised Building System (IBS) is defined as a construction technique in which components are manufactured in a controlled environment (on or off site), transported, positioned and assembled into a structure with minimal additional site work. Those parts of building that are repetitive but difficult, time consuming, labour intense to cost at site are design and detailed as standardised components at factory. IBS also involve onsite casting using innovative and clean mould technologies (steel, aluminum and plastic). IBS offers benefits in term of cost and time certainty, attaining better construction quality and productivity, reducing risks related to occupational safety and health, alleviating issues on skilled workers and dependency on manual foreign labour and achieving ultimate goal of reducing overall cost of construction (Oyegoke *et al.*, 2009).



## 2.2 Construction Industry Overview

Actually there are various definitions of the Industrialized Building System (IBS) in Malaysia. This indicated that no agreed definition of the IBS since there have few type of definition from different author (Mohamad Rofzdi, 2009). IBS can be considering as the building built by using pre-fabricated components. The component was systematically manufactured either by using machine or other forms of mechanical equipment. The component was manufacturing off site and delivered to construction sites for assembly and erection (Rahman and Omar, 2006). Chung and Kadir (2007) has defined that the IBS is a mass production of building components either in factory or at site. It depends on the specification of the standard shape and dimension to transport to the site to be re-arranged according to certain standard to form a building. Construction Industry Development (2003) defined IBS as a construction technique included components which are manufactured in a controlled environment either on or off site, transported, positioned and set up into a structure with minimal additional site works.

There was no commonly accepted or agreed definition of IBS. Several authors have defined IBS as process or a technique. Blimas *et al.* (2006) and Pan *et al.* (2008) defined that IBS is often referred by literatures as off –site construction, off-site production, industrialised and automated construction. Warszawski (1999) explained in detail that an industrialised process is an investment in equipment, facilities, and technology with the objective of maximising production output, minimising labour resource, and improving quality while a building system is defined as a set of interconnected element joint together to enable the designated performance of a building. Lessing *et al.* (2005) explained IBS as “an integrated manufacturing and construction process with well-planned organization for efficient management, preparation and control over resources used, activities and results supported by the used of highly developed components”. Rahman *et al.* (2006) defined IBS as “a construction system that is built using pre-fabricated components. The manufacturing of the components is systematically done using machine, formworks and other forms of mechanical equipment. The components are manufactured offsite and once completed will be delivered to construction sites for assembly and erection”. Almost all the

definitions of IBS mentioned the prefabricated, off-site production and mass production of building components as a main characteristic of IBS. The scope of IBS focuses the construction of building rather than civil structure or engineering projects. For the purpose of this research, IBS is best defined according to CIDB Malaysia (2001) as “construction system in which components are manufactured in a factory, on or off site, positioned and assembled into a structure with minimal additional *in situ* activities.

The uses of IBS as a method of construction in Malaysia is evolving. Many private companies in Malaysia have teamed up with foreign expert to offer solutions to their IBS project (Eastern Pretech, BPB Malaysian Gypsum, Lafarge and Duralite) (CIDB, 2003). Many had acquired enough knowledge through technology transfer to build up own capacity in IBS technologies (PKNS Engineering, Setia Precast and Global Globe). In fact, Malaysian was also keen on developing own IBS technologies (Zenbes, CSR, IJM Formwork, Pryda, Baktian and HC Precast). The local IBS manufacturers were mushrooming, although yet to operate in full capacity. The current IBS systems used in Malaysia housing projects are large panel systems, steel frame, precast frame and formwork system. The IBS system is largely used for private residential projects in Shah Alam, Wangsa Maju and Pandan (Sarja, 1998), Dua Residency, KL, Taman Mount Austin and Tongkang Pecah, Johor (CIDB, 2006).

### **2.2.1 Obstacles to Construction Growth**

Despite the all documented benefits and strong support of the government, unfortunately application of IBS due to some criteria did not take off as planned. In order to understand the poor effective implementation and distribution of the IBS some researchers have investigated and identified a number of obstacles which among them lack of knowledge and awareness. Cost related issue is one of significant barrier in IBS project execution. Based on IBS Steering Committee (2006), most of IBS construction (especially pre casters) requires high initial investment capital to purchase new machinery, mould, importing foreign technology and wages of skilled workers for installation process. Moreover a specialized equipment and machinery (Thanoon *et al.*, 2003a; Nawi *et al.*, 2005) a Research and Development (R&D) centre, support services

and testing labs are also needed by an IBS company in the private sector (Nawi *et al.*, 2007a). This situation has made the IBS business more risky as all these facilities need continual funding or extra capital investment compared to the conventional labor-intensive method.

Lack of knowledge among the approving authorities has resulting misunderstanding and misinterpreting of IBS and its relation to the current building regulation. Contractors in Malaysia suffer from lack of past experience in IBS and their professionals have lack of technical knowledge in this area (Hamid *et al.*, 2008). And, this problematic issue among the designers contributes to the project delays due to the extra time taken to produce details drawing (Hazreeni *et al.*, 2010). This shortage of perception also affects customers and their demands so that IBS product is still perceived by them in terms of lack of flexibility, problematic accommodation such as leaks and faults, low quality finish and use of unfamiliar materials (Nawi *et al.*, 2007b). All these factors create a dilemma among clients or designers to apply IBS to their housing projects because of a fear of customer rejection (Kamar *et al.*, 2009). And, this has hindered building approval and caused unnecessary delay in the development process. While, familiarity with IBS will expedite design approval and it is vital to ensure successful IBS project (CIMP, 2007). On the other hands, Malaysia still lacks skilled workers generally and particularly in IBS projects. Under IBS system the demand for on-site manual labourers become less, but the skill level of IBS workers is more demanding compared to the conventional construction methods. Therefore, more intensive training programmes are needed in the specialized IBS skills. As this need requires more time and investment (Thanoon *et al.*, 2003a; Rahman and Omar, 2006); therefore, contractors prefer to stick to the traditional construction method and not to practice IBS (Thanoon *et al.*, 2003a; Nawi *et al.*, 2007a).

### 2.2.2 Lack of Manpower

Construction industry has a major role on generating wealth through a constant growth in GDP's contribution and influenced in the development of social and economic infrastructures and buildings, but its total energy and resource consumption and carbon emission raise a growing awareness regarding this industry. The issues of sustainability also have been strongly highlighted in the Construction Industry Master Plan (2005-2015) as a significant importance for the Malaysian construction industry. In this regard, the Malaysian Green Building Index (GBI) has been developed recently in order to promote sustainability in built environment. On the other hand, the industry is under a constant pressure to deliver and to tackle issues on performance, safety, shortage of labour, environment and sustainability, dependency on Malaysian construction industry has been urged to use innovative construction technique and to shift from traditional practice to Industrialized Building System (IBS) construction. Unfortunately, against all attempts the level of IBS usage in construction was only 15% in 2003 (CIDB, 2003b) and reached 10% in 2006 which is less than one third of total completed construction project using at least one IBS products (CIDB, 2007). While, unique characteristics of IBS in terms of cost and time certainty, attaining better construction quality and productivity, reducing risk related to occupational safety and health, alleviating issue on skilled workers and dependency on manual foreign labour and achieving ultimate goal of reducing overall cost of construction suggest its contribution in the sustainability challenge facing the construction industry. Thus, the main objectives of the study are determining main issues in green and sustainable construction through IBS and then investigating the role and contribution of IBS in green and sustainable construction in order to identify potential solution for IBS to achieve its prospective in the area of green construction and sustainability (Fauzi, 2009).

IBS requires high construction precision. Previous studies have indicated that most local professionals and contractors lack technical knowledge and experience in the IBS (Kamar *et al.*, 2009; Hamid *et al.*, 2008; Nawi *et al.*, 2007a; CIMP, 2007; Nawi *et al.*, 2005; CIDB, 2003). Furthermore, many local authorities are not fully conversant with modular co-ordination and standardization concept associated with IBS design and

assembling procedures (IBS Workshop, 2011). This has hindered building approval and caused unnecessary delay in the development process. Due to the lack of knowledge and awareness, these local authorities tend to misinterpret IBS current building guidelines adding to further delays in approval (Kamar *et al.*, 2009). The skill level of IBS workers is more demanding compared to the conventional construction methods. Under this system, the demand for on-site manual labourers, particularly carpenters, bar benders and concreters becomes less. The system demands more machine-oriented skills, both on sites and in factories. Thus, this leads to a transformation requiring the restructuring of human resource in an organization in terms of training and education. Malaysia still lacks skilled workers generally. As such, more intensive training programmes are needed in the specialized IBS skills like system integrating or assembling. However, this need requires more time and investment (Thanoon *et al.*, 2003a; Rahman and Omar, 2006). In an IBS project, the role of the contractor is shifted from that of a builder to that of an assembler on site (Shaari and Elias, 2003). This requires contractors to be equipped technologically with IBS knowledge and skill. The needs are made more imperative if the contractors were to promote their IBS products and compete in the industry. From July to September 2002, the situation was suddenly worsened when many trained foreign workers were forced to leave the country after a wide spread crackdown on illegal foreign workers (Thanoon *et al.*, 2003a). The “new batches” of foreign workers did not possess the required skill in IBS and had to be retrained (Thanoon *et al.*, 2003a).

Warszawski (1999) classified the building system into a few types which depend on the particular interest of their users and producers. His classification uses construction technology as a basis for classifying different building systems. In this manner, four major groups can be distinguished such as system using timber, steel, cast *in situ* concrete and precast concrete as their main structural as well as space enclosing materials. These systems can be further classified according to geometrical configurations of their main framing components that are the linear or skeleton (beams and columns) system, planar or panel system and three dimensional or box systems. Figure 2.1 shows the IBS system.

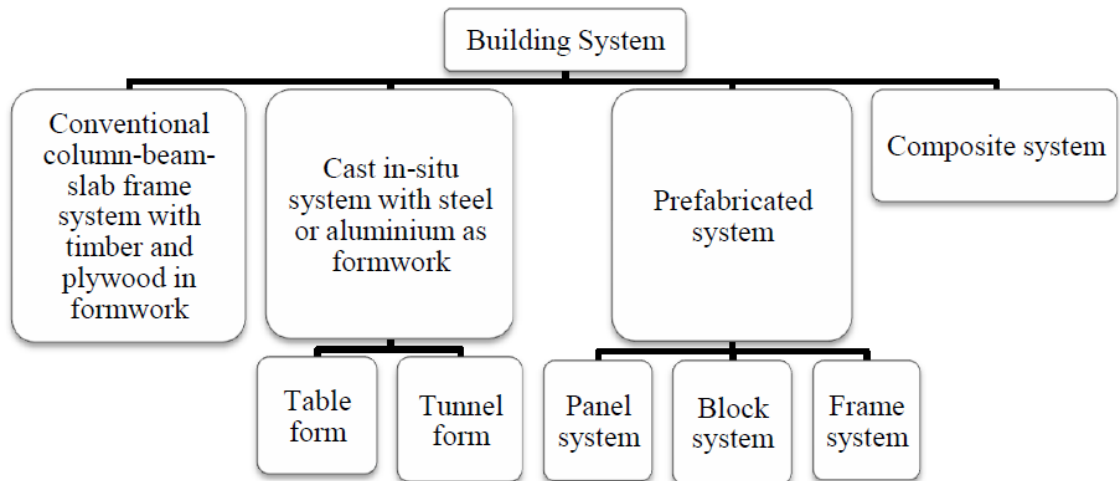


Figure 2.1: Industrialised Building System (Sufian 2009)

### 2.3 IBS Implementation in the Malaysian Construction Industry

Over the past decade, the level of IBS usage in Malaysia is still very low even though its implementation has started since early 1960's. Construction industry practitioners seem reluctant to use IBS as their construction method. Their reluctance to use the system is surprising its benefits have been pointed out by researchers. Warszawski (1999) highlighted that by adopting IBS, some saving in manual labour on-site can be achieved, increasing construction speed and providing higher construction quality. Thanoon *et al.* (2003) also underlined cost saving, faster construction time and improvement of overall construction quality as the result of IBS implementation. These proved that, the use of IBS is advantageous as it fulfils the basic goal of construction; time, resources and quality. For instance, in 2002, Badir studied the building system technologies in Malaysia and examined problems and constraints associated with this technology. The study concluded that the problems related to IBS technology were the higher initial capital investment and the needs for expert labour to deal with heavily mechanised approach in IBS.

Therefore, extra cost was needed to train existing semi-skilled labour to be highly skilled labour. In 2007, Chung has investigated current awareness of the usage of IBS in Malaysia and his study has analyzed ways to improve the implementation of IBS in terms of the current policy and guideline available to implement the usage of IBS in the local construction industry.

Implementation stage carries largest scale of project life cycle including variety of physical work such as design, fabrication work at factory, logistics task (e.g transportation, supply chain management, vendor), installation and erection work at site, and commissioning. In other words, there are several activities of implementation which can be categorized as upstream activities and downstream activities. Upstream activities can be list as design, planning, and production works. On the other hand, procurement system, supply chain, transportation system, legislation and regulation can be classified as downstream activities in implementing IBS. Different activities of a project can proceed subsequently with different speeds in design and consequent stages, but all must come together in testing and commission stage for the finish building.

### **2.3.1 History of IBS in Malaysia**

The initiative to use and introduce IBS in Malaysia started off back in the early sixty, when the Minister of Housing and Local Government visited some European countries and evaluated their buildings systems performance. Din (1984) reported that, it was then that the two pilot projects using IBS concept was carried out in 1964 where the first pilot project was 7 blocks of 17 story flats and 4 blocks of 4 story flats which comprise of 3000 units of low cost flats and 40 units of shop lots in Kuala Lumpur. The project implemented large panel system using the Danish System with IBS concept of construction.

The second pilot project was built in Penang, with the construction of 6 blocks of 17 storey flats and 3 blocks of 18 storey flats, comprising 3,699 units and 66 shop lots, using French Estiot System. With reference to the two pilot projects, it is found out that in terms of comparison of performance between IBS system and conventional system

based on cost productivity and quality factor, the overall performance of IBS is more competitive than the conventional method.

Since 1980's there are intensive marketing strategy launched by the Malaysian government to introduce modular coordination, Trikha (1999) reported that its acceptance has received poor response for the building industry. As a result, an event partial introduction of IBS such as lintels and staircase has not been possible.

Previously in the 7<sup>th</sup> Malaysian plan, the country intended to construct about 800,000 units of houses for its population using the IBS construction. Indeed, 585,000 units were planned for the low and low medium cost houses. However, the achievements are disappointing with only 20 percent completed houses reported due to use of conventional construction method. According to Ismail (2001), although the government introduced numerous incentives and promotions to encourage housing developers to invest in such housing category, the response is not so positive. Under the 7<sup>th</sup> Malaysian Plan, the enforcement of Modular Coordination through the Construction Industry Standard 1 and 2 only applies to the low cost housing projects initiated by the Ministry of Housing and Local Government Malaysia (CIDB, 2003a). The enforcement by the local authorities did not apply to all the parties involved in construction contribute to the failure of the implementation in Malaysia. Furthermore, the incentives that promised to be given to developers by the government does not clearly stated in the law of Malaysia. This nonconformance leads to the use of conventional method which is less risky to the developers.

In year 2001, the Government set the Malaysian Standard 1064 in order to standardise the IBS components in terms of dimensions. However, the MS 1064 still have a lot of loop holes that still can be improved. The important specifications such as type of materials, design standard, conception types, construction method and the system implementation are not included. These items will ensure the quality of IBS components can be improved and the contractor can implement a standardised system easily and this will encourage the use of IBS in Malaysia especially in the private sector. However, the standards must not be too rigid as to allow for technological improvements in construction method, systems and etc.



According to findings of Lim (2006), many innovations in materials and components are made before their application in the building process. In most cases, construction firm acts as system integrators and catalyst for transforming new technologies into marketable products. These play an important role modifying and developing new technologies that impact as feedback loop to producers in the upstream. The forces for technology for adaptation are strongest among materials, component manufacturers and high quality equipment for production purposes. Property developers and government policy makers also feed the stream for innovation by funding in research and development activities.

IBS has been introduced in Malaysia since early 1960s when Ministry of Housing and Local Government of Malaysia visited several European countries and evaluate their housing development program (Thanoon *et al.*, 2003). After their successful visit in 1964, the government had started first project on IBS, just a year later aims to speed up the delivery time and built affordable and quality houses. This project was awarded to JV Gammon & Larsen and Nielsen using Danish System of large panel pre-cast concrete wall and plank slabs. The project was completed within 27 months from 1966 to 1968 including the time taken in the construction of the RM 2.5 million casting yard at Jalan Damansara (CIDB, 2006; CIDB, 2003; and Thanoon *et al.*, 2003). A similar system was constructed almost at the same time at Edmonton, North London and about 20,000 BRECAST dwellings were constructed throughout UK from 1964 to 1974 (CIDB, 2006). Nonetheless, the building design was very basic and not considering the aspect of serviceability such as the local needs to have wet toilet and bathroom (Rahman and Omar, 2006).

### **2.3.2 IBS Definition**

In the Malaysian context, Construction Industry Development Board (CIDB) has defined IBS as a construction technique in which components are manufactured in a controlled environment (on or off site), transported, positioned and installed into a structure with minimal additional site works (CIDB, 2013). Furthermore, IBS can

be defined as a concept of mass production of quality building by using new building systems and factory produced building components (Badir and Hashim, 2002). Earlier researchers like Parid (2003) defined IBS as a system which use industrialized production method either in the production of component or assembly of the building or both. Trikha (1999) defined IBS as a system in which concrete components are manufactured at site or in factory are assemblies to form the structure with minimum in situ construction. Esa and Nurudin (1998) in the first IBS colloquium in Malaysia, defined IBS as continuum beginning from utilizing craftsmen for every aspect of construction to a system that make use of manufacturing production in order to minimize resource wastage and enhance value end users. IBS was defined by Abdullah and Egbu (2009) as a method of construction developed due to human investment in innovation and on rethinking the best ways of construction work deliveries based on the level of industrialization. The level of industrialization in IBS can be classified as pre-building system, modern construction, advance automation and volumetric construction (Abdullah and Egbu, 2009). In his work on IBS risks, Hassim (2009) defined IBS as an organizational process-continuity of production implying a steady flow of demand, standardization, integration of the whole production process, a high degree of organization of work, mechanization to replace human labor.

#### **2.4 Classification of IBS**

In Malaysia, CIDB (2003) has classified IBS into five (5) categories, which are pre-cast concrete framing panel and boxy system, steel formwork systems, steel frame system, timber frame system as well as block work system. IBS is a construction process that utilizes techniques, products, components or building systems which involved prefabricated components and on-site installation. From the structural classification, there are five IBS main groups that are used in Malaysia as shown in following subsection, which mainly based on classification by CIDB with some modification to it.

### **2.4.1 Precast Concrete Systems**

Precast Concrete System is defined as any precast components that are used in construction industry. This is included all types of precast concrete systems as defined and it include as follows:

- (i) Precast concrete framing, panel and box systems
- (ii) Precast concrete wall system
- (iii) Building with precast concrete slab

The precast concrete framed system is one of the most popular forms of industrialised building system. The precast concrete framed building consists of slab, beam and column component that are fabricated or manufactured off-site using machine and formwork. The advantage of the system is high degree of flexibility in term of larger clear distance between columns; as a result longer span gives bigger open space and greater freedom of areas.

Precast concrete wall system consist a structural framework of the building composed of pre-cast slab and load bearing wall. The load bearing walls and slabs are manufactured off-site in simple and uncomplicated with a lesser degree of flexibility whereas the removal of load bearing wall are restricted during the service life. With careful design and good coordination between erectors and designers, the erection process can be very fast with the number of wet trade in-site can be reduced significantly (Oyegoke *et al.*, 2009).

### **2.4.2 Steel Formwork System**

This system categorized as an IBS because the process of construction is carried out using a systematic and mechanized method that is by using reusable steel formwork panels. The system allows the rapid on-site placement of cast in suit concrete of form beams, columns, slabs and walls. The system is better preferred for the construction of walls instead of column and beam due to many repetitive of similar wall components in wall frame buildings. Steel formwork components are normally available in standard

panel sizes and stiffened using built in stiffeners or tie rods to resist lateral concrete pressure during concreting. It offers faster speed of erection, comparatively lower cost and simplicity in equipment. It also provides good accuracy and smooth internal finishing that eliminate the need of plastering (Oyegoke *et al.*, 2009).

### 2.4.3 Steel-framed Building and Roof Trusses

According to Sufian (2009), steel is a strong and stiff material that suitable for the construction and reparative frame building with architectural detailing with high flexibility in providing long-spanning structure. It normally used in for multi-story frames for all and slander building such as high constructability and simplicity of construction as well as greater construction speed. Just recently, steel roof trusses showed their capability in housing industries whereby the cost became competitive as compared to timber roof trusses. An example, typical project using steel framing system as shown in Figure 2.2.



Figure 2.2: Typical Project Using Steel Framing System (Sufian, 2009)

#### 2.4.4 Prefabricated Timber Framing System

In the early 1970s, single story low cost terrace houses were mostly out of plain wooden framing and plank sitting on those three feet high plastered brickwork and taking advantages of the simple raft foundation due to the light weight super structure. The houses construction for the low cost development at rural area or remote town. Today, this type of construction has been classified as one of IBS. The prefabricated timber framing system is normally used in the conventional roof truss and timber frames as shown in Figure 2.3. The timber is pre-fabricated by joining the members of the truss by using steel plate. It is important that all members are treated with the anti-precast chemical. Then, the installation is done on site by connecting the prefabricated roof truss to the reinforcement of the roof beams (Oyegoke *et al.*, 2009).



Figure 2.3: Typical Project Using Timber Forming System (Sufian, 2009)

### 2.4.5 Block Work System

Referring to Sufian (2009), this system depends on modular dimension at the design stage, which identical to lego blocks to some extent. Furthermore, it applies load bearing walls. By incorporating the columns and the beam as integral part of the walls for all house types. The elements of block work system include interlocking concrete masonry units and lightweight concrete blocks. The elements are fabricated and cured in the factory. The elements are normally used as bricks in structures and interlocking concrete block pavement. Depends on the design, the amount that can be saved on a wall can range from between 10 percent to 30 percent saving in wall construction, faster in project completion, no beam and column, less foundation construction. An example, typical project using block work system as shown in Figure 2.4.



Figure 2.4: Typical Project Using Block Work System (Sufian, 2009)

## REFERENCES

- Abdul Rahman, H. & Hanid, M. (2009). A Literature Review of the Advantages and Barriers to the Implementation of Industrialised Building System (IBS) In Construction Industry. *Malaysian Construction Research Journal*, 4(1), 10-14.
- Abdullah, M. R. & Egbu, C. O. (2009). Industrialised building system in Malaysia: issues for research in a changing financial and property market. In *Proceedings of the BUHU 9th International Post Graduate Research Conference (Vol. 1, pp. 15-25)*. University of Salford.
- Abidin, A. R. B. Z. (2007). Simulation of industrialised building system formation Affect Employees' Well-being? *Industrial Relations: A Journal of Economy and Society*, 47(3), 355-389.
- Ahamad, M. S. S. and Hanafi, M. H. (2011). Quantitative analysis on the level of IBS acceptance in the Malaysian construction industry. *Journal of Engineering Science and Technology*, 6(2), 179-190.
- Ahamad, M. S. S. and Hanafi, M. H. (2011). Quantitative analysis on the level of IBS acceptance in the Malaysian construction industry. *Journal of Engineering Science and Technology*, 6(2), 179-190.
- Al-Aghbari, M. (2005). Factors affecting construction speed of industrialized building system in Malaysia (Doctoral dissertation, Universiti Putra Malaysia).
- Ali and Kadir, A. M. (2006). Optimizing production line of IBS by using simulation model. Master Thesis, Universiti Teknologi Malaysia (UTM), Johor Bahru.

- Ali, M. C., Zin, R. M., Hamid, Z. A. and Ayub, A. R. (2010). Quality cost in the construction industry—preliminary findings in Malaysia. *Journal of Design and Built Environment*, 29-43.
- Ali, M. C., Zin, R. M., Hamid, Z. A. and Ayub, A. R. (2010). Quality cost in the construction industry—preliminary findings in Malaysia. *Journal of Design and Built Environment*, 29-43.
- Azman, M. N. A., Ahamad, M. S. S. And Hilmi, N. D. (2012). The Perspective View of Malaysian Industrialized Building System (IBS) under IBS Precast Manufacturing. The 4th international engineering conference towards engineering of 21st century, (pp. 78-96).
- Badir, Y. F., Kadir, M. A. & Hashim, A. H. (2002). Industrialized building systems construction in Malaysia. *Journal of Architectural Engineering*, 8(1), 19-23.
- Bakhtyar, B., Zaharim, A., Sopian, K. & Moghimi, S. (2013). Housing for Poor People: A Review on Low Cost Housing Process in Malaysia. *WSEAS Transactions on Environment and Development*, 9(2).
- Bamberger, M. (2012). Introduction to mixed methods in impact evaluation. *Impact Evaluation Notes*, 3, 1-38.
- Bendat, J. S. and Piersol, A. G. (2011). *Random data: analysis and measurement procedures* (Vol. 729). John Wiley and Sons.
- Brown, G. D., Gardner, J., Oswald, A. J. and Qian, J. (2008). Does Wage Rank Building maintenance: Malaysian Perspective. *International Journal of Engineering Science and Advanced Technology*, 2(6), 1684.
- Chong, L. P. (2006). *Implementation Strategy for Industrialised Building System*. PhD thesis, Universiti Teknologi Malaysia.
- Chung, L. P. & Kadir, A. M. (2007) *Implementation Strategy for Industrialised Building Systems*. PhD thesis, Universiti Teknologi Malaysia (UTM), Johor Bahru.
- Chung, L. P. (2006) *Implementation Strategy for Industrialized Building System*. Unpublished Report for Master Science Construction, UTM, Johor, Malaysia.



- CIDB (2003). *Industrialized Building System (IBS) Roadmap 2003-2010* Construction Industry Development Board (CIDB), Kuala Lumpur.
- CIDB (2007). “Implementing IBS Roadmap: Mid-term review of IBS Roadmap 2003-2010”, Construction Industry Development Board (CIDB), Kuala Lumpur, 2007.
- CIDB (2007). *IBS Digest at Malbex in IBS Digest. Special Issues on 24th Malaysian International Building Exposition: (Malbex 2007).*
- CIDB (2011). *The Current State of Industrialised Building System (IBS) Construction Forward. Proceedings of 1st IBS Roundtable Workshop. CIDB. Combat consistent housing shortage in developing countries: Towards an appropriate system for India.* In World Congress on Housing. Available at: <http://atiwb.gov.in> (Vol. 4).
- Construction Industry Development Board (CIDB) (2003), *IBS Roadmap 2003-2010*, Construction Industry Development Board Malaysia (CIDB), Malaysia.
- Construction Industry Development Board (CIDB) (2007). *Construction Industry Master Plan 2006-2015* Kuala Lumpur: Construction Industry Development Board (CIDB), Kuala Lumpur.
- Creswell. J. W. (2012). *Educational Research: Planning, Conducting, and econometric methods for transportation data analysis.* CRC press.
- Esa, H. & Nuruddin, M. M. (1998). *Policy on Industrialised Building System–Report on Colloquim on Industrialised Construction System.* Kuala Lumpur. *Evaluating Quantitative and Qualitative Research: Fourth Edition*, Boston: Pearson Education.
- Field, A. (2009). *Discovering statistics using SPSS.* Sage publications. for housing construction (Doctoral dissertation, Universiti Teknologi Malaysia).
- Grace, D. (2014). *Intersectionality-informed Mixed Method Research: A Primer.* Health Sociology Review, 19(4), 478-490.
- Hair, J., Anderson, R., Tatham, R. & Black, W. (2010). *Multivariate Data Analysis 7th edition*, Prentice Hall.

- Hamid, Z., Kamar, K. A. M., Zain, M., Ghani, K. & Rahim, A. H. A. (2008). Industrialized Building System (IBS) in Malaysia: the current state and R&D initiatives. *Malaysia Construction Research Journal*, 2(1), 1-13.
- Hamzah, N. H., Nafi, M. N. A., & Yacob, J. (2010). A Study on the Acceptance of IBS in Construction Industry in Kelantan: Application of Logistic Regression Analysis.
- Hassim, S., Jaafar, M. S. & Sazalli, S. A. (2009). The contractor perception towards Industrialised Building System risk in construction projects in Malaysia. *American Journal of Applied Sciences*, 6(5), 937.
- Howell, G. & Ballard, G. (1998). Implementing lean construction: understanding and action. In Proc. 6 th Ann. Conf. Intl. Group for Lean Construction. Implementation for Malaysian construction industry (Doctoral dissertation, Universiti Teknologi Malaysia).
- Jaafar, M., Abdul Aziz, A. R., Ramayah, T. And Saad, B. (2007). Integrating information technology in the construction industry: Technology readiness assessment of Malaysian contractors. *International Journal of Project Management*, 25(2), 115-120.
- Kamar, A. M., Hamid, Z. A., Azman, N. A. & Ahamad, M. S. S. (2011). Industrialized Building System (IBS): Revisiting Issues of Definition and Classification. *International Journal of Emerging Sciences*, 1(2), 120-132.
- Kamar, K. A. M., Alshawi, M. & Hamid, Z. (2009, January). Industrialised building system: the critical success factors. In 9th International Postgraduate Research Conference (IPGRC), University of Salford, Salford (pp. 29-30).
- Kamarul A. M. K., Zuhairi A. H. M. Z. M. Z., Ahmad H. A. R. & Mohd K. G. (2010). MBAM Online News “Skilled Manpower Shortage Need Urgent Attention” by Siti Sakinah Abdul Latiff on 4 August 2010, [www.MBAM.org.my](http://www.MBAM.org.my).
- Kampempool, S. & Suntornpong, E. (1986). Residential Housing. The challenge in the building industry of Thailand. Proceedings towards Industrialisation in the Building Industry, UPM Serdang.

- Kiong, N. B. and Akasah, Z. (2012). An Overview of Precast Concrete System for Building maintenance: Malaysian Perspective. *International Journal of Engineering Science and Advanced Technology*, 2(6), 1684.
- Kline, R. B. (2011). *Principles and practice of structural equation modeling*. Guilford Press.
- Koch, G., Kunze, C. And Seidl, J. (2005). Loam Construction - From a niche product to an industrial building system. In *The World Sustainable Building Conference*.
- Lim, P. C. & Kadir, A. M. (2006). *Implementation Strategy for Industrialised Building System*, Master Theses. Universiti Teknologi Malaysia (UTM), Skudai.
- Lou, E. C. W. & Kamar, K. A. M. (2012). Industrialized Building Systems: Strategic outlook for manufactured construction in Malaysia. *Journal of Architectural Engineering*, 18(2), 69-74.
- Majid, T. A., Azman, M. N. A., Zakaria, S. A. S., Yahya, A. S., Zaini, S. S., Ahamad, M. S. S. and Hanafi, M. H. (2011). Quantitative analysis on the level of IBS acceptance in the Malaysian construction industry. *Journal of Engineering Science and Technology*, 6(2), 179-190.
- Masod, W. M. S. (2007). Declaration of thesis/undergraduate project paper and copyright. Meinshausen, N., and Bühlmann, P. (2006). High-dimensional graphs and variable selection with the lasso. *The Annals of Statistics*, 1436-1462.
- Masod, W. M. S. (2007). Declaration of thesis/undergraduate project paper and MIGHT (2004). *Industrialized Building System (IBS): greater efficiency for greater capacity*. FUSION (Malaysian Industry-Government Group for High Technology); Issues 8 Oct 2004.
- Mohamed N. A. A., Taksiah A. M. & Mohd S. S. A. (2012). Drivers and Barriers to Industrialised Building System (IBS) Roadmaps in Malaysia, *Malaysian Construction Research Journal*, ISSN 1985 -3807, Vol. 9 (1).
- Nawi, M. N. M., Nifa, F. A. A., Abdullah, S. & Yasin, F. M. (2007). A preliminary survey of the application of IBS in Kedah and Perlis Malaysian Construction industry. In *Proceeding in conference in Sustainable building, Malaysia*.

- Nelwamondo, F. V. and Marwala, T. (2008). Key issues on computational Intelligence techniques for missing data imputation-a review. In Proceedings of World Multi Conference on Systemics, Cybernetics and Informatics (Vol. 4, pp. 35-36).
- Nelwamondo, F. V. and Marwala, T. (2008). Key issues on computational Onyeizu, E. N., Hassan, A. and Bakar, A., (2011). The Utilisation of Industrialised Building System in Design Innovation in Construction Industry. Applied Sciences, 15(2), 205-213.
- Parid. W. (1997). Global trends in research. Development and Construction Proceeding of the International Conference on Industrialized Building System (IBS 2003): Construction Industry Development Board (CIDB) Malaysia Kuala Lumpur, 1997.
- Rahman, A., Baharuddin, A., & Omar, W. (2006). Issues and Challenges in the implementation of Industrialised Building Systems in Malaysia.
- Rashid, K. A. (2009). Industrialised Building Systems: the JKR perspectives. Malaysia Construction Research Journal, 4(1), 1-9.
- Roy, A. U. K., Ahadzi, M. and Saha, S. (2007). Mass-industrialized housing to combat consistent housing shortage in developing countries: Towards an appropriate system for India. In World Congress on Housing. Available at: <http://atiwb.gov.in> (Vol. 4).
- Roy, A. U. K., Ahadzi, M. and Saha, S. (2007). Mass-industrialized housing to Shaari, S. N. & Elias I. (2003) Promoting the Use of Industrialized Building System and Modular Coordination in the Malaysian Construction Industry. Bulletin Ingenieur, page 7-9.
- Tabachnick, B. G. & Fidell, L. S. (2007). Using Multivariate Statistics Fifth Edition. Boston: Allynand Bacon.
- Teddle, C., & Tashakkori, A. (2010). Overview of contemporary issues in mixed methods research. Sage handbook of mixed methods in social and behavioral research, 2, 1-44.

- Thanoon, W. A., Peng, L. W., Kadir, M. R. A., Jaafar, M. S. & Salit, M. S. (2003). The essential characteristics of industrialised building system. In International Conference on Industrialised Building Systems, Vol.10, pg. 11.
- The Malaysian Insider online (2010). "Foreign Workers Levy Hike in 2011" 20th May 2010 by Asrul Hadi Abdullah Sani, logged on [www.malaysianinsider.com](http://www.malaysianinsider.com).
- Trikha, D. N. (1999). Industrialized building systems. Prospects in Malaysia Proceedings World Engineering Congress: Malaysia, 1999.
- Waleed, A. M. T., Lee, W. P., Kadir, M. R. A., Jaafar, M. S. & Salit, M. S. (2003). The Essential Characteristics of IBS. In International Conference on IBS, Malaysia.
- Wong, P.M. (2011). Workers Shortage Could Hit ETP Plan. The Star Online 16 march 2011. Available on [www.thestar.my](http://www.thestar.my), 2011.
- Yunus, R. (2012). Decision making guidelines for sustainable construction of industrialised building systems. Construction Innovation: Information, Process, Management, 12(4), 447-463.
- Zaini, O. (2000). Malaysian Construction Industry. Challenges and Demand. Malaysian Structural Steel Association Convention, Kuala Lumpur.
- Zakaria, M.Y. (2006) "Challenges in Providing Local Skilled Construction Workers" Universiti Teknologi Malaysia.
- ZAWAWI, M. B. (2009). Effectiveness of industrialised building system (IBS) implementation for Malaysian construction industry (Doctoral dissertation, Universiti Teknologi Malaysia).
- Zikmund, W., Babin, B., Carr, J. & Griffin, M. (2012). Business research methods. Cengage Learning.