# THE COMPARISON BETWEEN CONVENTIONAL AND INDUSTRIALIZED BUILDING SYSTEM FORMWORK TOWARDS SUSTAINABLE CONSTRUCTION

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Tesis ini dikemukakan sebagai memenuhi sebahagian daripada syarat penganugerahan
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*Istimewa Untuk Insan-Insan Yang Tersayang..*

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## ABSTRACT

Construction Industry Development Board Malaysia (CIDB) is responsible for promoting Industrialised Building System (IBS) in Malaysia. IBS which involves industrialised production of building elements or components as well as erection and assembly of these elements into desired building structure through mechanically using as little in-situ construction as possible, is as an alternative to the conventional system. Conventional formwork system is somewhat unsustainable as it always associates with low quality and productivity, high risk on workers safety, and excessive reliance on labours. On the other hand, IBS formwork system known as its systematic construction procedure, high quality of work, less workers and time needed to complete one cycle of formwork process, which is more sustainable. This study focuses on comparing sustainability of IBS formwork system to conventional formwork system. A survey has been conducted by distributing questionnaires and carrying out site survey on the selected construction sites which deal with formwork for both systems. Most of the respondents indicate that IBS formwork is more sustainable compared to conventional formwork due to the increasing number of repetitive used by 76.5%, reducing construction waste by 70%, increasing quality of work, reducing number of manpower by 70.1% and reducing the environmental effects on site. Based on the data analysed, IBS formwork construction is practising more sustainability aspects of construction compared to conventional formwork.

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# CHAPTER I

## INTRODUCTION

### 1.1 Background

In Malaysia, Industrialised Building System (IBS) has been promoted by Construction Industry Development Board Malaysia (CIDB) as an alternative to the conventional system. According to CIDB, IBS is a building systems in which structural components are manufactured in a factory, on or off site, transported and assembled into a complete structure with minimal additional site works (Trikha *et.al.*, 2004). The growing demand for affordable housing, increasing construction costs, lower productivity rate, and heightened concern for energy-efficiency has prompted the Malaysian construction players to realize the great benefits of industrialised building system.

IBS is not new in Malaysia construction scenario but it is not fully implemented. For example, the Federal government built some pilot projects using IBS such as the 3,009 units of flats in Jalan Pekeliling, Kuala Lumpur in 1966 and 3,741 units of flats in

Jalan Padang Tembak, Pulau Pinang in 1967 (Badir et al., 1998).The state of the local construction industry, with its low quality and productivity, safety and excessive reliance on unskilled foreign workers, is unsustainable and not in line with the future development of Malaysia. In order to remain competitive especially in the era of globalisation, the Malaysian government has formulated a roadmap called IBS roadmap 2003-2010 to promote the usage of IBS in the local construction industry governed by CIDB (Rahman, A.B.A., 2006).

Malaysia is presently promoting IBS as an answer to housing shortage problem by appointing CIDB as the key player in implementing the IBS. The government is taking the leading role to persuade the construction industry to engage more systematic approach and methodology in construction. The main advantages of using IBS, according to a report published by the Malaysian Ministry for Local Government and Housing Ministry in1997, include speed of construction, quality, and economic advantage, all of which are required to meet such a large demand for housing (Badir et al., 1998).

Construction industry has been accused of causing environmental problems ranging from excessive consumption of global resources both in terms of construction and building operation to the pollution of the surrounding environment. It can be more environmental friendly through reduction in resources, efficient energy consumption, reduce wastages and control pollutions. For example, by reducing the use of formwork especially timber, can preserve the natural resources and reduce the deforestation activities which is one of the causes of global warming. IBS construction may directly or indirectly promote sustainability construction. Moreover, IBS reduces air pollution as dust and suspended particles are greatly minimized at construction site. Besides that, noise pollution will be reduced as noise coming from erection and dismantling of the formworks is minimized. In fact, IBS can reduce the time dealing with temporary works in construction as it reduces the number of formworks used (Junid, S.M.S, 1999).

## 1.2 Objective of the Study

The primary aim of this study is to identify the degree of sustainability between conventional formwork and IBS formwork system construction. In order to meet the aim, the following objectives are stated:

1.2.1 to identify the current on going conventional and IBS formwork construction projects.

1.2.2 to determine quantitatively whether or not IBS formwork system applies more sustainability aspects in construction compared to conventional formwork system.

## 1.3 Scope of Study

This study focuses on the following:

1.3.1 selected construction site which use conventional formwork system and IBS formwork system in Malaysia especially for high rise residential building.

1.3.2 people who involved directly and indirectly in selected IBS formwork and conventional formwork construction in Malaysia such as contractor, developer, engineer and quantity surveyor.

1.3.3 how IBS formwork system can promote sustainable construction compared to conventional formwork.

## 1.4 Expected Outcome

From this study, the following findings may be expected:

1.4.1 current conventional and IBS construction projects will be identified.

1.4.2 the study will verify whether IBS formwork system in construction is more sustainable than conventional formwork system in construction.

1.4.3 IBS may be assumed as promoting sustainability construction compared to conventional system in terms of environmental effects, social and economical in Malaysian construction sector.

## 1.5 Research Hypothesis

Construction processes and activities produced and created lots of construction wastes and adversely effect the environment. According to Environment Resources Limited, (1980), conventional formwork is associated with 3-D syndrome which are Dirty, Difficult and Dangerous. This system is specify as 'Dirty' because it consumes a lot of construction materials which produced wastage such as wood, cement and other materials. It is 'Difficult' because it requires a number of processes and involved a lot of machineries while constructing it and while it is 'Dangerous' because the system is labour intensive and workers are exposed to high risk tasks at the site such as erecting the formwork in the high-rise building and while involved in concrete casting. Moreover, this formwork system consumed a lot of time such as time needed to produce the formwork, erecting and dismantling it.

On the other hand, a new and alternative system called IBS formwork system contributes less 3-D syndrome in construction site. The system can reduced construction time and cost because of the less number of labour required while dealing with it. It also indirectly lower the environmental impacts by reducing the construction wastes and exposure to pollutions by reducing the time needed at construction site.

Therefore, this research intends to establish that the IBS formwork used in construction site is more towards practicing sustainable construction compared to conventional formwork.

## 1.6 Structure of the Thesis

The structure of this thesis is divided into 5 chapters. In chapter one, a brief introduction to the overall thesis and its contents are presented in this Chapter.

Chapter two reviews the background studies or related literature that directly influences and guides our general understanding of the area of concern. This chapter consists of definitions and descriptions of IBS construction system, conventional construction system and sustainable constructions. By reviewing all the information, it helps to develop thorough understanding on sustainability concepts and potential of its application in Malaysian construction industry.

Chapter three outlines the methodology used for this study, which involved two methods; site survey and observation and questionnaire. For site survey and observation, several construction sites was selected especially involved with IBS formwork system and some for conventional formwork system. For second method, questionnaires were distributed to selected individuals who had experience dealing with both formwork systems. All data received from the questionnaires was analysed statistically.

Chapter four consists of the analysis and discussions from data received from the two methods conducted. The data from questionnaires is analysed by using Average Index and Mean. General conclusion given at the end of the chapter is based on data received.

The overall study is presented in the last chapter of the thesis, which outline the conclusion of the study and some suggestions on the sustainability aspects for construction practises. Recommendations for future research on sustainable construction in Malaysia construction industry conclude the thesis.

# CHAPTER II

## LITERATURE REVIEW

### 2.1 Introduction

This chapter generally mentioned about previous and current researches related to the study. This study will be based on comprehensive literature reviews from various sources such as textbooks, journals, conference papers, proceeding papers, reports and websites. They have also guided the study to develop thorough understanding on sustainability concepts and potentials of its application in construction. This chapter consists of definitions and descriptions of IBS construction system, conventional construction system by focussing on formwork system and sustainable constructions.

United Nations Bruntland commission in 1990 defined sustainability as "meeting the needs of the present generation without compromising the ability of future generations to meet their own needs". For many reasons, it is difficult to meet its current needs in ways that are truly sustainable. By understanding this, it is the goal of the sustainability to reduce the use of resources and work toward the ultimate goal of

sustainability. It is a simple idea of ensuring a better quality of life for everyone, now and for generations to come. The construction industry has a huge contribution to improve our quality of life. Construction, building materials and associated professional services together account for some 10% of Gross Domestic Product (GDP) and provide employment for around 1.5 million people (Abu Bakar Jaafar, 1990).

Construction Industry Development Board (CIDB) has been appointed to represent Malaysian government in promoting the sustainable construction concepts by encouraging all the construction players to be involved. For example, CIDB introduced IBS to be implemented in their construction site. In addition, they will be given a rebate or tax exemption by CIDB for their commitment to achieve sustainability (Rahman, A.B.A., 2006).

## 2.2 Conventional System

In conventional construction method (reinforced concrete frames and brick as infill), beam, column, wall, and roof are cast in situ using timber formworks while steel reinforcement is fabricated on site. This method of construction is labour intensive and involves three separate trades, namely, steel bending, formwork fabrication, and concreting. Skilled carpenters, plasterers, and brick workers are also involved in this method. The process can be hampered by bad weather and unfavourable site conditions (Illingworth, 2000).

The conventional building system is generally divided into two major components. The first component is the structural system, which includes cast in-situ column-beam-slab frames. These frames are constructed through four operations, namely, erection of timber formwork and scaffolding, erection of steel bar, pouring of fresh concrete into form and dismantling of formwork and scaffolding. These operations are labour intensive, tedious and require a lot of on-site coordination. The second component consists of brick and plaster as the non-structural infill material. (Elliot, 1996)

Conventional or also known as traditional system has its own characteristics which are the basic construction method in construction industry in the world. The characteristics of conventional method include:

- Use cast in-situ system- All building components are being built and cast on site with high usage of construction materials and load of site works.
- Labour-intensive practices.
- 3-D syndrome which are Dirty, Difficult and Dangerous. Conventional system is known with the 3-D syndrome. All sites work that are being done which involved many types of construction materials and machineries and high number of workers will make the construction site messy and crowded. This will lead to Dirty and Dangerous environment (Environment Resources Limited, 1980).

## 2.3 Industrialised Building System (IBS)

An industrialised building system (IBS) may be defined as a building system which involves industrialised production of building elements or components as well as erection and assembly of these elements into desired building structure through mechanical process using as little in-situ construction as possible (Trikha *et.al*, 2004). The most comprehensive definition of IBS was clarified by Junid (1986). He mentioned that an IBS in the construction industry includes the industrialised process by which components of a building are conceived, planned, fabricated, transported and erected on site. The system includes a balanced combination between the software and hardware components. The software elements include system design, which is a complex process of studying the requirement of the end user, market analysis, development of standardised components, establishment of manufacturing and assembly layout and process, allocation of resources and materials and definition of a building designer conceptual framework. The software elements provide a prerequisite to create a conducive environment for industry to expand.

In Malaysia, CIDB has advocated the use of pre-fabricated materials in the construction of high end houses as it can give developers a cost saving of at least 20%. Under this system, the industry operate more like a manufacturing sector where most parts of building is made up of manufactured components and installed on site. The system can be either Open or Closed system. Closed system is a system where all elements of industrial production of components are used for specific designs for specific projects. The system does not allow for the interchangability of components from different factories. On the other hand, Open System is a system which allows the production of building components by various factories and to be compatible with each other to be used in any building project. The successful implementation of open industrialisation building system requires a modular coordination. Modular coordination is an international system of dimensional standardisation in building where buildings and components are sized in term of a basic unit or module (Trikha *et.al* , 2004).

The construction for IBS can be categorized into three methods; cast–in situ, composite and fully prefabricated as shown in **Figure 2.1** below.

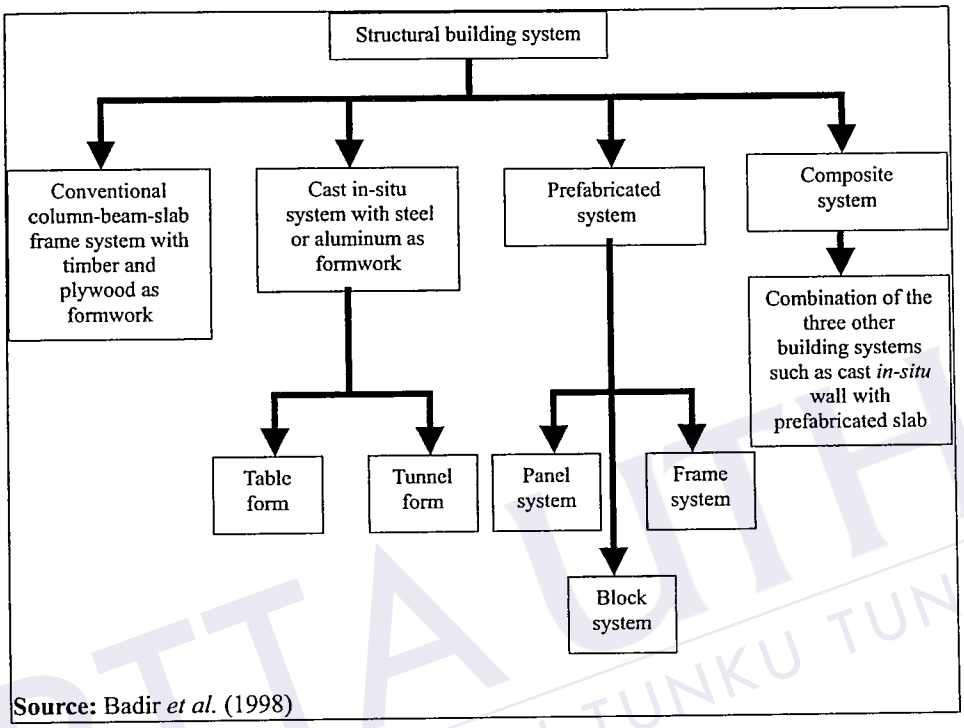


**Figure 2.1**: Types of building systems in Malaysia

Adoption of IBS can lead to faster completion of construction projects. This is possible as on-site and off-site activities are undertaken in parallel or running at the same time. According to Elliot (1996), the time saving in the delivery and concrete pouring may be 75-95 percent, in delivery and fixing loose reinforcement around 90-95 percent and in construction of superstructure in the range of 25-50 percent. A few IBS projects claim time saving of about 75 percent in completion of projects under favourable circumstances.

The quality of the final plant-cast (industrialized-cast) or site-cast prefabricated components is normally much superior compared to the on-site cast-in-situ components because of controlled conditions. The accuracy in dimension and complex shapes and finishes can be achieved when using IBS.

According to Junid, S.M.S (1999) IBS construction may directly or indirectly promote sustainability construction. IBS is environmentally friendly as dust and suspended particles are greatly reduced at site. Beside that, noise pollution will be minimized as noise coming from erection of the scaffoldings and formworks and also when dismantling then. In fact, IBS can reduce the temporary works in construction as it reduces the number of formworks used.

One specific scheme being developed with European Commission (EC) funding has been quoted as having the following potential anticipated benefits (Edwards, B. et al, 2001):

- 50% reduction in the amount of water used for construction of a typical house;
- 50% reduction in the use of quarried materials used in the construction;
- At least 50% reduction in the energy consumption.

The effect of a building on local ecology and species is going to be strongly influenced by design and landscaping which should be largely independent of whether the building is procured through traditional or prefabrication routes. However, one issue that could be important is the damage caused by pollution during construction. Prefabricated buildings should have more control associated with factory based prefabrication, which should reduce the risk of some of the pollutions to the local environment (BRE).

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