PRODUCTIVITY OF CONSTRUCTION PROJECTS WITH INDUSTRIALIZED BUILDING SYSTEM (IBS) TECHNOLOGY ADOPTION

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By

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I hereby declare that all corrections and comments made by the supervisor(s)and examiner have been taken into consideration and rectified accordingly.

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ABSTRAK

Secara umumnya, penggunaan Sistem Bangunan Berindustri (IBS) dalam industri pembinaan di seluruh dunia mempunyai kesan yang positif dalam meningkatkan keseluruhan prestasi industri. IBS adalah suatu teknologi berinovatif yang melibatkan pengurangan buruh tapak, mengurangkan sisa buangan, mengurangkan bahan di tapak pembinaan, persekitaran yang lebih bersih, kualiti yang lebih baik, tapak-tapak binaan yang lebih kemas dan lebih selamat, projek lebih cepat siap serta teliti dalam kos pembinaan. Ini boleh menyumbang ke arah produktiviti negara terutamanya dalam industri pembinaan. Oleh itu, kajian ini bertujuan untuk mengenalpasti faktor paling relevan yang menyumbang ke arah produktiviti projek pembinaan dengan mengadaptasi teknologi IBS berdasarkan enam faktor-faktor utama. Faktor-faktor ini adalah berkaitan dengan peringkat-peringkat dalam projek pembinaan yang melibatkan reka bentuk, perancangan, kemungkinan, pembinaan dan operasi. Kaedah kajian soal selidik telah digunakan dalam penyelidikan ini dengan mengedar borang-borang soal selidik kepada kontraktor, perunding, pemaju atau agensi kerajaan melalui pejabat syarikat, tapak pembinaan dan surat-menyurat dalam talian. Faktor-faktor produktiviti telah disenaraikan berdasarkan persepsi para responden menggunakan kaedah kuantitatif. Daripada kajian ini, suatu rangka kerja telah dibina yang mengintegrasikan seluruh hasil kajian. Dapatan kajian ini menghasilkan beberapa cadangan bagi meningkatkan produktiviti dalam penggunaan teknologi IBS.

ABSTRACT

Generally, the adoption of Industrialized Building System (IBS) in the construction industry throughout the world has the positive impact in improving the overall industry performance. IBS is an innovating technology that involves a reduction of site labor, lower wastage, less site materials, cleaner environment, better quality, neater and safer construction sites, faster project completion as well as cost efficient in total construction. These can contribute towards the country's productivity in terms of the construction industry. Therefore, this research aims to discover the most relevant factor that contributes towards the productivity of construction projects with the adoption of IBS technology based on six major factors. These factors are related to the construction stages which involve design, planning, feasibility, construction and operation. A questionnaire survey method was used in this research, by distributing the questionnaire forms to contractors, consultants, developers or government agency by approaching them through the company office, site construction and online mailing. The productivity factors were ranked through the perceptions of the respondents using a quantitative analysis. From this research, the conceptual framework was developed and produced which integrates the overall results of the study. The result brings several recommendations in order to improve the productivity of IBS technology adoption.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

CIDB	**C**onstruction **I**ndustry **D**evelopment **B**oard
CITP	**C**onstruction **I**ndustry **T**ransformation **P**rogramme
IBS	**I**ndustrialized **B**uilding **S**ystem
NCIIC	**N**ational **C**onstruction **I**ndustry **I**nformation
RII	**R**elative **I**mportance **I**ndex
RMK11	**E**leventh **M**alaysia **P**lan

NOMENCLATURES

ai	Constant, Weighing Factor
xi	Variables Representing Respondents Frequency of Response
W	Weighing
A	Highest Weight
N	Total Number of Respondents

CHAPTER 1

INTRODUCTION

1.1 Background

The conception of Industrialized Building System (IBS) has received much attention in many developing countries. As Malaysia is categorized in a developing countries group, it also faces the demand of infrastructure development that adopts building technology such as IBS. The requirement to supply its population with affordable and quality houses has prompted the regime to promote the utilization of IBS as an alternative to conventional building system. IBS can be categorized as an old technology in developed country but yet considered as an emerging technology when reached developing countries such as the Asian region entities. The implementation of IBS in Malaysia has commenced since 1960's and propagated in 1998 when Cabinet of Ministers endorsed IBS Strategic Plan as the blueprint for the total industrialization of the construction sector.

IBS projects in Jalan Pekeliling, Kuala Lumpur and Rifle Range, Penang had used Danish System and French Estoit System respectively. Buildings constructed by this method also have a short construction time and standard quality. Unfortunately, the level of IBS usage in the local construction industry is considerably low about 15% in 2003 and 10%, which is less than one-third of total completed construction project using at least one IBS product, in 2006 (Kamar et al., 2010). Practically in Malaysia, the usage of using IBS technology is not giving a trend because of the main two factors which are the low labor cost in Malaysia and most of the IBS projects still using the traditional approach (Nawi et al., 2011).

The Ministry of Works, through the Construction Industry Development Board (CIDB), has developed the Construction Industry Transformation Programme (CITP) to empower and strengthen the construction industry as adopted in the thrusts of the Eleventh Malaysia Plan (RMK11) (CITP, 2016). One of the four strategic thrusts which aim to transform the construction industry is raising the overall productivity level of the industry. According to Bernolak (1997) (in Pekuri, et al., 2011) productivity means *"how much and how good we produce from the resources used,".*

In general, productivity is often defined as a relationship between output produced by a system and quantities of input factors utilized by the system to produce that output (Van Beveren, 2012). Here, the output can be any outcome of the process, whether a product or accommodation, while input factors consist of any human and physical resources utilized in a process. It follows that, in order to increment productivity, the system must either produce more or better goods from the same resources, or the same goods from fewer resources.

1.2 Problem Statement

Productivity is the primary engine of growth towards Malaysia's high-income target. Improving construction productivity can go some way toward eliminating time and cost overruns (Nasirzadeh and Nojedehi, 2013). Today, the construction industry has one of the lowest productivity levels in the economy that requires some collaborative practices (Fulford and Standing, 2014).

According to Schoenherr et al. (2012), because of its central consequentiality to competitiveness and world prosperity, the topic of productivity has been a matter of interest since the commencement of industrialization. Productivity is perhaps one of the most important and influential basic variables governing economic production activities, including the construction industry (Yi and Chan, 2013). According to McGeorge and Zou (2012), high productivity can be a significant source of competitive advantage in the construction industry. Due to the size of the construction industry, productivity trends in this industry have notable effects on national productivity and on the economy as a whole (Carson and Abbott, 2012). In fact, the construction industry is related to labor productivity with the consideration on how vital it is to success or how it can be measured, analyzed or improved (El-Gohary and Aziz, 2013).

Efforts to produce better performance and increasing productivity in construction requires an understanding of the various indicators of productivity as a path to understanding the performance of the project (Nasir et al., 2012). Besides that, efforts to improve productivity in the construction industry can essentially be done by reducing project cost overrun and also project completion delay (Alinaitwe et al., 2013).

In this study, the perspectives of the productivity pertaining the adoption of IBS technology is based on the main 3 factors which are time, cost and quality based on the work of Kim et al., (2012). Furthermore, productivity can be divided into 6 main resources which are manpower, money, machine, material, time, and information. Thus, the 6 factors are the main contribution towards productivity and the quality.

The relatively low productivity level reflects the industry's need to adopt modern technologies, materials, and practices, and reduce its belief on low-skilled construction workers. Rising cost of labor will enhance the cost of housing. According to Construction Industry Development Board (CIDB) Malaysia, 69% (552,000) out of total 800,000 of registered workers as at June 2007 is foreign workers (CIDB, 2016). Moreover, Jarkas (2012) and Yun et al. (2012) also argue that while the introduction of IBS technology is never straightforward, productivity measures are even more complex because they face resistance from a broad range of stakeholders. IBS involves various consideration of, not only technological and environmental factors but also the dynamics of social change in relation to productivity (Zabihi et al., 2013).

Understanding the 6 critical factors affecting the productivity of both positive and negative can be used to prepare a strategy to reduce inefficiencies and to improve the effectiveness of project performance. Therefore, knowledge and understanding of the various factors affecting construction productivity are needed to determine the focus of the necessary steps in an effort to reduce project cost overrun and project completion delay, thereby increasing productivity and overall project performance.

1.3 Aim and Objectives

The aim of this study is to determine the implementation of IBS from the perspective of productivity in terms of money, manpower, machine, materials, time and information, in terms of how these factors can contribute towards the productivity and quality of IBS. The perception of the contractor and consultant as respondents who is involved in most of the construction industry are consequential in order to achieve the aim of this case study.

The objectives of this study are:

i. To analyze the characteristics of IBS in terms of its productivity in construction projects.
ii. To determine the factors that contribute towards the productivity of IBS in construction projects.
iii. To investigate the major factors that impacted on the productivity of IBS in construction projects based on a model development.

1.4 Scope and Limitations

Questionnaire and interview survey methods are utilized in this study. A set of questionnaire was developed to explore and quantify the related and relevant factors of productivity in the adoption of IBS technology. The questionnaire is intended to obtain the opinion and awareness of respondents about productivity in IBS especially to the company who does not adopt the IBS system. The contractor and consultant registered with CIDB are selected as respondents in this survey as they play important roles in the construction industry. They additionally deal with project management activities and responsible for the installation of components (assembler) at the site. A survey was conducted and questionnaires were distributed to the respondents to the respondents of this study. Data from the survey was analyzed and interpreted as the findings of this study.

1.5 Benefits and Importance of the Research

The research seeks to explore the significance of utilizing IBS in the construction projects that may give many benefits in terms of productivity since the productivity of construction has to be of an emerging trend in developing countries. This study adopts a perspective that attempts to explore the relevancy of productivity in the adoption of IBS technology. It is important to study the level of productivity compliance pertaining IBS as productivity is related to the six factors that influence this condition. Consequently, this study fills the gap between the theory and practice of IBS technology adoption and its application in productivity dimensions.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The study integrates existing discoveries from the literature and then considers the applicability of this literature to the study. This has been performed by doing some researching on characteristics and factors that contribute most in IBS in terms of productivity in construction projects.

Industrialized 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 works (Thanoon et al., 2003). This structural of the building include precast framing, panel, steel formwork and frame systems, and prefabricated timber framing systems. IBS definition could be summarized as an innovative process of building construction using the concept of mass-production of industrialized systems, produced at the factory or on site within controlled environment, that includes the logistic and assembly aspect under a proper planning and coordination design process towards enhancing the end users desired values. IBS promotes sustainability from the controlled production environment, minimization of waste generation, extensive usage of energy efficient building material, effective logistics and long term economic stability which can contribute to better investment in environment technologies.

IBS is the term to represent the prefabrication and construction industrialization concept in Malaysia (Kamar et al., 2011). IBS or it is well known as prefabrication is being widely used in European countries, Japan and Singapore (Tam et al., 2007). The implementation of IBS in Malaysia has started since 1960's and it became popular only in 1998 when Cabinet of Ministers endorsed IBS Strategic Plan as the blueprint for the total industrialization of the construction sector. IBS has been applied in Malaysia since mid 60's by the use of precast concrete beam-column element and penalized system. IBS projects in Jalan Pekeliling, Kuala Lumpur and Rifle Range, Penang had used Danish System and French Estoit System respectively (Thanoon et al., 2003).

However, the industry is under a constant pressure to deliver and to tackle issues of performance, safety, shortage of labor, environment, and sustainability, depending on foreign labor and demand in affordable housing. These factors can contribute and give effect towards the productivity in using IBS. Unfortunately, the level of IBS usage in the local construction industry is considerably low about 15% in 2003 (IBS Survey, 2003) and 10% which is less than one-third of total completed construction project using at least one IBS product, in 2006 (CIDB, 2007). Practically in Malaysia, the usage of using IBS technology is not giving a trend because of the main two factors which are the low labor cost in Malaysia and most of the IBS projects still using the traditional approach.

Accordingly, the Ministry of Works, through the Construction Industry Development Board (CIDB) has developed the Construction Industry Transformation Programme (CITP, 2016) to empower and strengthen the construction industry as adopted in the thrusts of the Eleventh Malaysia Plan (RMK11). There are 4 strategic outcomes that in the CITP. The outcome across each of the four strategic thrusts are:

I. CITP aims to deliver an industry culture that is ingrained with quality, safety, and professionalism.
II. Malaysia will be seen as a model for the emerging world in terms of sustainable infrastructure.
III. The construction industry will more than double its productivity, and the increase in productivity will be matched by higher wages.
IV. Malaysian construction industry champions will be nurtured, and they will lead the charge both locally and globally.

One of the four strategic thrusts which aim to transform the construction industry is raising the overall productivity level of the industry. Productivity in construction is usually taken to mean labor productivity, that is, units of work placed or produced per man-hour. It also can be defined as the ratio of earned to actual hours which depends on the method used to measure productivity and on the extent to which account is taken of all the factors which affect it (Shehata and El-gohary, 2011). Economists and accountants define productivity as the ratio between the total input of resources and total output of product (Hanna et al., 2005). Productivity estimate is an essential element to estimate duration and cost of a construction operation. In construction, productivity is measured at different levels of detail for different purposes

(Song and AbouRizk, 2008). The loss of construction productivity is usually attributed to various factors, rather than a single one.

In addition, factors affecting construction productivity are rarely independent of the others, some factors may be the result of the same cause, or one factor may trigger the occurrence of others (Dai et al., 2009). Although several types of research have been conducted to determine the effects of different factors on labor productivity, they are faced with some major defects. The previous studies had investigated the effects of one of the influencing factors on the productivity and they are not able to account for the effect of all the influencing factors. The productivity is influenced by several factors which have complex interactions with each other. Furthermore, in the previous researchers, the effect of workforce productivity on the project performance criteria in terms of time, cost and quality were not investigated.

As stated in CITP, as of 2015, there are six productivity-related issues still plague the construction industry. These are:

1. Largely low-skilled workforce and inadequate or mismatch in training and development.
2. Over-reliance on low-skilled foreign labor.
3. Limited adoption of modern practices, mechanization, and IBS.
4. Limited adoption of information technology such as BIM.
5. Lack of data and information-driven decision-making.
6. High proportion of subscale SMEs, including Bumiputera SMEs and entrepreneurs.

The CITP aims to tackle these outstanding issues through the initiatives listed below:

Initiative P1: Continue investment in human capital development in construction.

Initiative P2: Enhance control and balance of workforce supply.

Initiative P3: Accelerate adoption of IBS, mechanization and modern practices.

Initiative P4: Roll out technology advantage across project lifecycle.

Initiative P5: Enhance availability of strategic information via National Construction Industry Information (NCIIC).

Initiative P6: Advance SME/Bumiputera capacity and capacity building.

Productivity is the primary engine of growth towards Malaysia's high-income target. Improving construction productivity can go some way toward eliminating time and cost overruns. Today, the construction industry has one of the lowest productivity levels in the economy. The contribution of the productivity is based on the main 3 factors which are time, cost and quality. Hence, productivity can be divided into 6 main resources which are manpower, money, machine, material, time, and information. Thus, the 6 factors are the main contribution towards productivity and the quality. The relatively low productivity level reflects the industry's need to adopt modern technologies, materials, and practices, and reduce its belief on low-skilled construction workers. Rising cost of labor will enhance the cost of housing. According to Construction Industry Development Board (CIDB) Malaysia, 69% (552,000) out of total 800,000 of registered workers as at June 2007 is foreign workers. Moreover, Jarkas (2012) and Yun et al. (2012) also argue that while the introduction of IBS technology is never straightforward, productivity measures are even more complex because they face resistance from a broad range of stakeholders.