CASE STUDY STEEL BRIDGE CONSTRUCTION

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ABSTRACT

Delay in construction is a norm in certain instances especially in large complex construction projects. With different kinds of delay causing different length of delays to the completion date of the project make it a real deal that needs attention by the authorities and the construction parties. Delay factors come in many forms that impact the project differently. In view of the Industrialized Building System (IBS) approach that aims to provide a better quality construction, solutions to the delay factors have to be relevant in both traditional and modern system. This research aims to find out the factors that are directly associated to IBS structures particularly steel bridge through observations and interview sessions with the technical workers involved. Structured interview questions are used in seeking for information. This is then followed by analysis made using the observations made at the factory and site. Discussions and rankings of associated delay factors are done to highlight the best solutions.

ABSTRAK

Kelewatan dalam pembinaan merupakan satu norma dalam keadaan tertentu terutamanya dalam projek pembinaan yang besar dan kompleks. Dengan pelbagai jenis kelewatan panjang yang serius menjadikannya perlu pada perhatian oleh pihak berkuasa dan pihak-pihak pembinaan. Faktor-faktor kelewatan datang dalam pelbagai bentuk yang memberi kesan kepada projek yang berbeza. Memandangkan Sistem Bangunan (IBS) iaitu pendekatan perindustrian yang bertujuan menyediakan pembinaan kualiti yang lebih baik, penyelesaian kepada faktor-faktor kelewatan perlu menjadi relevan dalam kedua-dua sistem tradisional dan moden. Kajian ini bertujuan untuk mengetahui faktor-faktor yang boleh dikaitkan dengan struktur IBS terutamanya jambatan keluli. Maklumat akan diperolehi melalui pemerhatian dan temubual dengan pekerja-pekerja teknikal yang terlibat. Soalan temubual berstruktur digunakan dalam mencari maklumat. Ini diikuti oleh analisis yang dibuat menggunakan pemerhatian yang dibuat di kilang dan tapak. Perbincangan dan kedudukan faktor kelewatan berkaitan dijalankan untuk mencari penyelesaian yang terbaik.

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PM	Production Manager
IBS	Industrialized Building System
CIDB	Construction Industry Development Board

CHAPTER 1

INTRODUCTION

1.1. Research Background

Productivity in construction is always evolving according to the requirements of civil and construction works. At the same time, economic instability affects the development of a country especially the construction sector. Civil engineering and construction is one of the largest and complex industries that contribute to the nations' economy upbringing (Mawdesley & Qambar, 2000). Productivity in full is very influential to the industries' financing in pre-construction, construction, and post-construction phases. A nation's economic status can be understood by simply looking at the size of the construction industry (Allmon et. al, 1998) which is none other affected by the productivity rate. Productivity itself gives vague definition due to its range of usage in three particular fields which are economy, technology and engineering. The definition of this term is very much dependent on what and how it is used (Pekuri et. al, 2011). It is observed that productivity is sometimes confused with profitability as both relates to one another. However, productivity involves the physical aspects of the works carried out and cannot be directly measured by monetary value.

In relation to productivity, project financing contributes to the input and also outcome of the project. In every project commencement, the owner will always take into consideration the profit that will be attained from the project. Regardless of type and size, profit is always the main focus. Profitability relates

to productivity in terms on how fast the project can be delivered to the client. In this case, the contractor and consultant ought to find ways in delivering project according to the completion date set in the contract. Based on PAM form (with quantities), item 15.1a, Practical Completion; works are considered complete once the Architect has acknowledge that the client can fully use the Works for their intended use. Logically, the earlier the Works is finished the sooner client can generate their income.

From a contractors' point of view, it can be seen that in international level construction projects, the contractors are faced with a dilemma in getting large profit from the project tendered (Han et. al, 2007). It is important for contractors to fully understand the politic, culture, economic structure of a construction project in order to avoid large loss in monies at the end of the project term. Profit can only be gained when the project is designed and engineers have considered all the options available, but it still depends on the economic status of the country. When project managers are able to understand the parameters that affects labor productivity rate, indirectly they can organize the project to fully manipulate the factors to their own gain. Cost of the project can then be controlled efficiently. Gross profit depends on two main variables which are the total cost expensed throughout construction period and the total income received by the contractor according to contractual agreements. However, in some instances inflations are not considered when calculating the pay which during unstable economic environment is very risky for contractors (Au & Chris, 1986). There are also methods in determining the viability of a project in terms of economic value through the use of Benefit Cost Ratio (BCR). This method can only be used while bearing in mind the time value of money. The following is the formula for calculating BCR.

BCR formula: It is considered in certain cases that cash flow can be negative (capital and expenses) and positive (benefit or revenue). Formula is based on (Lund, 1992)

$$BCR = Benefit \div Cost$$

From the productivity point of view, delay comes into consideration as it relates closely to the outcome of the project. In Malaysia, it is normal to have some projects to be delayed to about three months (Ali et. al, nd) or even be abandoned. Delay as defined by (Ali et. al, nd), is the postponement of the completion date of the project due to contractors, sub-contractors, consultant or even external factors. Studies have been made around the world by viewing the size of the construction projects as well. In Saudi Arabia, the delays that were studied focused more on government projects. The most accounted delays noticed were the projects undertaken by the Ministry of Housing and Public Works at 70% (Al-Kharashi & Skitmore, 2009). However, it was also reported that there is a slight improvement in delivering projects in Saudi Arabia suggesting that counter measures has been applied to avoid the condition from worsening. This is a proactive measure as governmental projects are public related and uses the funds gain from the tax paid by the public.

There are several types of delays known to occur in construction industry which are compensable delay, excusable delay, and non-compensable and non-excusable delay (Alias et. al, 2007). These delays can be solved with different contractual solutions to the contractor in EOT application and monies. The factors that relates to these types of delays must be studied in order to determine which of the delay type is very much related to the project. The factors can be external depending on the circumstances and type and project. The fact that there are solutions even provided based on contract shows the significance of delay impact to the project and that actions can be taken to reduce the danger towards client and contractors. This then leads to the question "Can delay be eradicated totally from occurring to large and complex projects?"

In general, one of the most common practices to ensure that a project is completed although delayed is to apply for extension of time (EOT). Extension of time is basically a liability borne by the client and the contractor in order for the project to be realized. As mentioned above, in Saudi Arabia, EOT was a common practice which produces bad effects in the following: (1) confusion in country's development plan, (2) disruption to the originally distributed budget

for development, and (3) inconvenience towards the public. According to PAM form item 21 and 23, the EOT can only be requested by the contractor under certain conditions which include 21.1; if the possession of site by the contractor is delayed by the client, Architect shall grant EOT under clause 23.8f or any section in accordance to clause 21.1 and 21.2. On another note, EOT can also be applied under the conditions of inclement weather, strike by construction workers, war damages and etc. where most of these conditions are special and very secluded. In all, it is not easy for the contractor to apply for EOT without any legitimate reason and that any delay should be borne by the contractor for its negligence of not being able to plan Works accurately.

Construction industry is vast and comprises different types of structures either buildings; low rise and high rise or infrastructures; roads and bridges. However the question that arises is how far does the different type of structures relate to the delay of a particular construction project? In reality what measures that can be used to determine this relationship should be established for better control. However, logically when the project's design and construction becomes even more complicated and complex and involved many moving parts, the possibility of a delay is prominent. In this research the case study is focused on the construction of a "Link Bridge'. The bridge is fully IBS whereby the parts are made of steel fabricated in a factory and installed on site.

1.2. Problem Statement

Project management is a crucial element that is used in any construction either simple or complex. A project needs to be managed professionally to reduce the effects of delay to other interconnected projects if any. In brief, to ensure that a project is successful, there has to be a managerial role. When relating the functionality of project management towards a construction project, it can be viewed that the project manager leads the thinking, problem solving, and cost supervision of the overall project. The outcome of the project very much depends on the ability of the project manager and the engineer in managing the resources. In view of the statements given above, delay in work done is the scope used in measuring the capabilities of both project managers

and engineers at site. This is primarily because the success of a project depends highly on 3 main focuses in management which are time, cost and quality.

Bridge construction nowadays has been made simpler by incorporating Industrialized Building System (IBS). IBS is being used either partially or fully when completing the construction of a bridge or building. This however depends highly on the materials used. In a particular project that is the subject of study in this research, the bridge is made of steel. The steel is fabricated in a factory, transported to site, and then the parts are installed. In practical, IBS is supposed to reduce the time spent in building and constructing. As mentioned in previous research concerning IBS, the success of IBS relates to the rapid construction, high quality product, under budget project completion, technology of plant and equipment, etc. (Ismail et. al, 2012).

In a project that uses the IBS concepts; several positions that must be paid attention to are the project manager, production manager, and engineer on duty. They are the people responsible in ensuring the project proceeds according to plan. The problem associated to this statement is the lack of understanding and awareness on the importance of completing the project in time and on budget or lower. It is understood that some of the external factors may cause the project progress to be beyond control, however that cannot be an excused when taking charge of a project. This can be backed by the theory where delay factors may be resulted by the client, contractor, consultant, or externally (Ali et. al, nd). Even so, the construction industry has been in Malaysia for so long, but the quality in terms of delivering the project can still be unsatisfactory.

1.3. Research Aims and Objectives

The aim of this research is to understand which suggested delay factors affect the construction of the link bridge the most.

The following are the objectives if this research:

1. To identify the common causes of delay in Malaysian construction industry.
2. To determine the factors of delay associated with steel bridge construction
3. To rank the causes of delay in bridge construction accordingly.

1.4. Scopes and limitations

The scope of this research is based on a current bridge project under construction in Petaling Jaya. The bridge is constructed using steel components which are fabricated in a factory in Meru Industrialization area. Case study method is used to determine the relevant factors that contribute to the delay in installation works of the steel bridge. The case study is explanatory in context where the causes of delay is identified and its' effects will be explained accordingly. As mentioned before the method of construction that is being studied also relates to the controversial IBS method that has its ups and downs.

For this research only two individual responsible for the realization of the bridge construction are interviewed. This is primarily due to their direct involvement in the production phase and installation phase of the link bridge. The interview session is aimed to provide a clear choice of factors that contributed to the delay of the bridge installation. In other words the delay causes are already identified prior to the interview session. The factors studied will be associated to the start of the installation week and to 10 weeks after the initial installation date which are from 30th June 2014 to 5th September 2014.

Regular site visit to both the factory and construction site will be included in the research analysis to strengthen the determination of the already short listed delay factors. Trip to the factory is done 2 days in a week while at the construction site visit is done only when there is installation happening. This

can also show the relationship between production of the steel components and the installation of those components. The visits done will highlight details recorded for references. The highlight will include the currently fabricated components and those that are kept pending. However, it must be clearly understood that only the delay factors that is in relation to the production and installation phase of the bridge will be analyzed.

Based on the already existing research on delays in projects, some delay factors are determined to be fitting for the bridge case study. Those delay factors are (1) man power issue, (2) communication issue, (3) weather, and (4) workers' competencies. These factors are generated in an interview session that is done with the production manager of steel fabricator and the engineer of the particular project. The questions asked may differ in terms of scope of study; either production or installation respectively. However, the aim of the questions is still the same which is to identify the most obvious delay factors towards steel bridge construction.

1.5. Significance of Study

The research done will contribute to the identification of the common delays in bridge construction which can also provide some hint on the problems related to the failure of using IBS in construction. This is not to say that IBS is not compatible with the Malaysian construction industry but rather shows that it is still a long way to fully utilize the method bearing in mind the external factors that slows down the accepting of this method. Improvements can be made to avoid the prolonged problems in relation to IBS implementation based on the delay factors which very much is related to people involved in the construction industry. From the study made, proactive actions can be taken to lessen the impact of delay factors towards ant construction projects

It can be focused on people responsible for the delay; where it can be related to the managerial skills of the engineer, production manager, and workers involved in the installation phase of the bridge components. Form this point onwards training and contractual method in preventing delays will be more

relevant and detailed. This is basically because no project manager ever wants the project in charged off gets delayed either short term or long term. The success of the project is the measure of the project manager's and engineer's skills in controlling project flow.

Since this research is done based on case study method, the analysis and recommendations can be used to further enhance the work quality of any related construction and steel production companies. A more reliable and practical work completion method can be drafted for the success of any future bridge project of the same kind. Work technology from other country can be used or innovated to improve site and factory conditions especially those related to human quality. This will then allow contractors to focus on tackling other related problems still occurring at the construction site.

Apart from highlighting delay factors, the research will also provide with understanding in choosing the right form of contract. The fact behind this is that, actions either proactive or preventive are made by referring to terms mentioned in a contract in relation to the problems faced at site. In short, the right form of contract can be applied to an IBS project which involves with bridge construction.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The review made in this research writing will be based on several topics which are found to be relevant and influence the outcome of this research. The scope explained in this review will include (1) types of construction work being accessed, (2) relationship between profit and productivity, (3) general collection of existing delay factors, and (4) types of delays. In any construction regardless of type and scale there will always be delays whenever the projects succumb to internal and external challenges. It depends on the technical skills that each personnel have to offer in order to save the project from worsening. In previous research it is said that the project manager skills account for about 34-47% of the success of the project (Frank, 2002).

Property and infrastructure development are related to construction industry that is known to be multiparty, complicated, uncertain, and dynamic (Essam, 2006). This being said shows that the industry itself is prone to delays. In response to such fallback the Industrialized Building approach was introduced as it can save cost provide quality construction, and prevents delays. In one previous research done by (Abdul et. al, 2006), it was found that in terms of actual labor productivity, conventional method was 70% less productive compared to IBS. This strengthens the reason to why IBS projects should not suffer from delays. However, is this really the case?

2.2 Definition of Case Study

Case study is one of many research methods that are used to discover relevant topics of interest in relation to the cases or projects studied. Some social scientists believe that this method is only suited for exploratory phases (Yin, 2011). However, it is argued that other suited phases include the explanatory and descriptive phases. This method is done in order for researcher to find the relevance in the case studied (Fidel, 1984). The author of the same journal also highlighted some of the phenomena that can be studied using the case study methods; (1) case with large variety of relationship between factors, (2) no basic determinants to differentiate which factor is the most dominant, and (3) both factors and relationship can be observed.

In another note, case study is often used in social science disciplines which include business management, marketing, and psychology (Crosthwaite et. al, 1997). Theses all relates to construction projects as a whole. However, some may dispute over the ability of the case study to present findings that may generalize other situations or cases of the same scope. (Baxter & Jack, 2008) Explained qualitative case study as an approach to explore a phenomenon using various data sources where each case is studied through the use of different lenses in order to be understood.

In case studies, there are also the different designs and types that constitute the main characteristics of a case study. These characteristics are what that set apart this method in collecting data qualitatively. Some of the types of design as mentioned by (Baxter & Jack, 2008) are explanatory, exploratory, and descriptive case study designs. Explanatory design is used to answer questions that arise in particular to the case being studied. It described any available causal link the case associates to in real life interventions. Exploratory as it sounds aims to explore the case. It will however, produce no real and clear single set of outputs. Lastly is the descriptive design where the phenomenon and its parameters, factors, and criteria are described in view of any relevant link to the real life context which suits the phenomenon.

On another note, previous researcher even found other categories that are worth mentioning which are idiographic and hypothesis-generating case studies (Levy, 2008). Idiographic case study which is defined as to describe, explain, and interpret a single case study without having develop any broader theoretical generalization. Hypothesis-generating case study on the other hand aims to generalize theoretical suggestions with the study of multiple cases.

2.3 Industrialized Building System (IBS) Construction

The Industrialized Building System as defined by (CIDB, 2012), is basically the production of components either off-site or on-site through the utilization of techniques, products, or system other than the conventional construction methods. It is also mentioned in the same web page that there are 5 IBS classifications that are available in Malaysia which are (1) Pre-cast Concrete Framing, (2) Steel Formwork Systems, (3) Steel Framing Systems, (4) Prefabricated Timber Framing Systems, and (5) Block Work Systems. Each system behaves in the same scope which is prefabrication. IBS is perceived as an alternative to maintain the sustainability of construction industry (Yunus & Yang, 2011). In addition, the IBS is well known for its cleaner and safer construction conditions as explained by (Zainal Abidin, 2007). There will be lesser noticeable site wastages and environmental problems.

The reason to the introduction of such construction system is the abilities it has that can improve the conventional method while producing output based on the increasing demands. Some of the advantages are highlighted by (Oliewy et. al, nd) includes social benefits, reduced cost, and quality finish. In a writing by (Syariazulfa Kamaruddin et. al, 2013), through economic review made, many believed that building using IBS is cheaper than using the traditional method. On another note, (Sashitharan et. al, 2014) also highlighted in performance wise IBS uses less construction time as the components are prefabricated either at the factory or ant site.

However, some studied too have highlighted the barriers faced by IBS in term of implementing it and the acceptance of the industry in Malaysia. Those

barriers comprise of (1) constructability issues, (2) lack of technology and readiness issue, (3) lack communication, (4) poor skill and knowledge, etc. (Nawi et. al, 2011). In short the barriers can be summarized into these scopes which are cost and finance, skills and knowledge, project delivery, perception of clients and professionals, and lack of government incentives. Moreover, in another research by (Yunus & Yang, 2011) the same can be observed but rather on the multiparty scenario.

Regardless of the advantages the IBS portrays, the poor acceptance and the lack of technological readiness cause the implementation to be rather slow and ineffective. This in other words, shows that IBS is also a system that is prone to delays as some of the barriers include the lack of skills and knowledge. Here there is the significance in reaching for the study of the relationship between the failures in IBS implementation and factors causing delay.

2.4 Delay Factor Categories

Delay is a noun defined as 'period of time by which something is late or postponed'. In construction, it is often that contractors try to find reasons to back up their mistake whenever delay occurs. However, it is not very easily done as there are the types of delay that can be blamed on either other people or the external factors. In this writing the main type of delays that affect construction industry can be termed and classified according to different sections. These sectional classifications can be (1) people related delays or (2) contractual based delay.

2.4.1. People Related Delay

People related delays are the delays that are caused by people who involved in the construction project. Since a construction project is multiparty, there may be problems in the execution of the project itself. When this happens, it is important to identify who is responsible so that proper action can be taken. In a research done by (Odeh & Battaineh, 2002), delay factors are classified into (a) client-related factor, (b) contractor-related factor, (c) consultant-related factor, (d) material-related factor, (e) labor and equipment factor, (f) contractual factor, and lastly (g) external factors. In another study by (Sambasivan & Wen, 2007) the same delay factor was used to study delay in Malaysia construction industry. This proves that this sort of classification can be used as this research references. Out of all the mentioned class only 4 will be discussed in detailed which are (Ali et. al, nd):

2.4.1.1. Client-Related Factor

This type of delay factor has to do with the mistakes or actions done by the client that caused the delay to occur. Some of the examples include payments of completed work, owner interference, slow decision making and unrealistic contract duration imposed by owner.

2.4.1.2. Contractor-Related Factor

Factors related to this type of classification encompass problems in site management, improper planning, inadequate contractor experience, mistake during construction, and delays made by sub-contractor. Sub-contractor related delays are also placed under this classification because the main contractor is responsible in handling the sub-contractor.

2.4.1.3. Consultant-Related Factor

According to (Sambasivan & Wen, 2007) and (Odeh & Battaineh, 2002), include contractual management, the long wait for testing and inspection result, the delay in preparation and approval of construction drawings. This may also be