A SYSTEM DYNAMIC MODEL FOR DECISION SUPPORT SYSTEM IN LEAN CONSTRUCTION

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This study is dedicated to my beloved parents who have always loved me unconditionally and whose good examples have taught me to work hard for the things that I aspire to achieve.

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ABSTRACT

Construction waste is considered a major contributor of total construction cost. Considering this major cost, identifying the underlying resources that contribute to construction cost is the foremost step toward providing sustainable and practical method to manage construction waste. Due to the dynamic nature of construction projects, any financial decision taken in the project has substantial effect in subsequent phases of construction. Therefore, careful management of construction cost can significantly improve overall project effectiveness. Thus, capturing the dynamic relationships between different key parameters of construction cost is an indispensable necessity. Regarding construction costs, the use of system dynamic modeling enables constructional industrialists to manage their projects more efficiently with respect to waste management. This thesis proposed a system dynamic model to deal with the complexities, interrelationships, and dynamics of waste management on construction industries. The dynamic model is constructed by Vensim PLE software to represent the weekly budget rate, construction budget, and scheduled plans of a conventional construction project. The proposed model is also used to investigate different scenarios to adopt firm policies in construction industry. The obtained results are also evaluated and compared in terms of cost and time. The results of this research indicates that the labour has the most significant impact on increased construction budget, cost incurred by waste, and weekly change in budget.

ABSTRAK

Sisa pembinaan dianggap sebagai penyumbang utama kepada kos pembinaan keseluruhan. Oleh yang demikian, sumber yang berkaitan dengan kos pembinaan harus dikenalpasti dalam menentukan kaedah yang praktikal dan lestari bagi mengurus sisa pembinaan. Keputusan berasaskan kepada faktor kewangan akan memberi impak kepada fasa pembinaan yang seterusnya memandangkan keadaan projek pembinaan yang bersifat dinamik. Pengurusan kos pembinaan yang berkesan akan memberi kesan yang positif kepada keseluruhan projek pembinaan. Oleh itu, hubungan dinamik antara parameter kos pembinaan adalah sangat diperlukan. Penggunaan model sistem dinamik dapat membantu pihak industri untuk menguruskan projek mereka dengan lebih efisien terutamanya dalam aspek pengurusan sisa pembinaan. Kajian ini mencadangkan model sistem dinamik bagi menangani kerumitan, hubung jalin dan pengurusan sisa pembinaan yang dinamik dalam sektor pembinaan. Model dinamik tersebut telah dibina dengan menggunakan perisian Vensim PLE dan ia mengambilkira kadar bajet mingguan, kos pembinaan, dan jadual pembinaan yang konvensional. Model yang dicadangkan ini juga telah digunakan untuk mengkaji senario berbeza berdasarkan kepada polisi industri pembinaan sedia ada. Keputusan kajian telah diperiksa dan dibandingkan terhadap faktor kos dan masa. Hasil kajian ini mendapati faktor buruh akan memberikan impak yang paling signifikan terhadap kenaikan kos pembinaan, kos sisa pembinaan dan perubahan bajet mingguan.

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LIST OF ABBREVIATIONS

PCR	Planned cost of resource
CR	Cost of resource
WR	Waste of resource
ACR	Adjustment cost of resource
RA	Resource adjustment
MA	Machine adjustment
REA	Rebar adjustment
CA	Cement adjustment
LA	Labour adjustment
PA	Plan adjustment
CIW	Cost incurred by waste
CPR	Construction plan rate
SA	Schedule adjustment
PBR	Planned budget rate
CB	Construction budget
CBR	Change in budget rate
BA	Budget adjustment
COR	Completion ratio
WCB	Weekly change in budget
RM	Ringgit Malaysia
CLD	Causal loop diagram
MBMS	Model base management system
DBMS	Data base management system
DGMS	Dialog generation and management system
DSS	Decision support system

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CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter presents an overview of the study. First, the background of the study is discussed. After that problem statement, objective, scope and significance of the study are presented. The summary and the main structure of this project are provided at the end of this chapter.

1.2 Background of the Study

One of the most important research concerns in the field of construction is to manage and control waste, which has recently attracted great attention through organizations. Conventional construction operates in a highly competitive market, so there is great interest to develop new and effective methods to increase organizational effectiveness. It is crucial for industries to consider all the components of a lean strategy in their mission.

According to Achanga *et al*.(2006), it is critically important to consider the basic components of lean construction with regard to the development of lean production systems and the advances of lean construction research. He presents the key concepts of strategic management and industry structure analysis. He discusses the implementation of lean construction with regard to a firm's strategic planning as

well as the conditions for the industry to lessen the barriers for lean construction implementation.

Lean thinking forces attention on how value is generated rather than how many activities are managed. Where the current project management views a project as the combination of activities, lean thinking views different factors through the entire project in the production system, which is considered a large operation. It is difficult to optimize a large production system in construction (a project) because of complex interaction between the parts.

Unquestionably, the construction sector is influenced by many factors which for successful implementation of such project these factors are required to be considered and analysed (Arditi *et al*., 1997). Construction industries experience problems in productivity, innovation, slipping schedules, rework, mistakes, disputes, and increased construction costs. These are all symptoms of waste in the construction process. Ballard (2008) found out that workers in the construction industry only use about 20 percent of their available time to increase the size of the building. Lean construction may be the cure here. By prioritizing lean construction wastes regarding their influence, construction industries are able to undertake waste minimization efforts with confidence.

1.3 Problem Statement

Today, one of the most important problems is that there is no clear understanding of how individual decisions influence the performance of construction industries (Ballard et al., 1997). As a consequence, such problems need to be considered accurately.

Another major problems are lack of attention to resources and environmental condition. By assuming a world in which the resources are all infinite and have no waste, decision making regarding to waste management has no role. But in the real world, resources are not free. With this regard, environmental condition should also

be taken into account. Therefore, construction industries must make decisions about managing resources, and impact of environmental factor. Based on the dynamic nature of lean construction, the system dynamic is completely suitable to deal with these issues. Thus, this research is going to apply a system dynamic for a decision supporting system for lean construction.

1.4 Research Questions (RQ)

This study intends to answer the following questions:

RQ1 What are the significance factors in incurring waste in term of cost and time?

RQ2 How does the interaction between these factors with other resources affect cost and time of the construction projects?

1.5 Objective of the Study

Successful implementation of lean strategies in construction industries is one of the most important issues. Inappropriate implementation of such strategy might have negative consequences for company's effectiveness. Thus, considering resource management that has a great impact on company's effectiveness is vital for success, the interaction between the significance factors with different resources should be modelled clearly. Due to the dynamic nature of the lean manufacturing within the construction industry, a decision taken at each stage of the process impacts the decisions of other stages.

1.5.1 Research Objectives (RO)

The specific objectives of the study are listed as below:

RO1 Prioritizing selected resources and factors that are effective for construction cost and time of the projects.

RO2 To develop a system dynamic model for implementing lean strategy on construction industry.

1.6 Scope of the Study

This study focuses on the construction industry to determine lean manufacturing for a selected construction company. The data that used in this study is historical data that gathered from Rinting Perwira Sdn. Bhd.

Throughout this study, a system dynamic model of selected construction company is constructed for evaluating the priorities of waste in the company. The proposed model only captured the construction budget, cost incurred by waste, change in budget and change in schedule. The system dynamic model is implemented using Vensim PLE 6.

1.7 Significance of the Study

The construction industry is a one-time project-based effort, highly fragmented and complex. It is designed to meet customer needs with limited, budget, resources and performance specifications (Banik, 2011).

The main purpose of construction waste management is to reduce cost of the projects. Construction waste are associated to several resources and interaction of these resources influences cost and time of the projects. For this reason, considering interaction among these factors and company's resources are critical. System

dynamics modelling is a powerful engineering tool that can explore the effects of different waste reduction strategies. Therefore, this study attempts to consider interaction among factors and resources as well as application of lean in reduction of construction waste. Thus, the major significance contribution of this research is to incorporate better alternatives for reduction of construction waste in management decision making.

1.8 Structure of the Thesis

The first chapter of this study is introduction that provides a description of study through explaining background, problems and issues, objectives and significances of the study. The second chapter is literature review that explains about some relevant terms and concepts related to the study and investigate previous works and different methodologies that are used in the mentioned area. In the third chapter, the case study and research design are discussed. The base model for construction waste management is presented in Chapter 4, which also discusses the development of the dynamic model for lean construction. Different scenarios are designed and analysed in Chapter 5. Finally, the conclusion of the study and future research directions are mentioned in Chapter 6.

1.9 Conclusion

This chapter provides a structure for the study. The background presented in this chapter gives sufficient context to understand the intention of the study. In addition, the significance and effect of this study on solving the existing problem is illustrated. It is expected that conducting this study will be successful in examining dynamic behaviour of the conventional construction industry and bringing beneficial results for managing waste in order to decrease cost and time of the project.

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