UNIVERSITI PUTRA MALAYSIA

CONSTRUCTABILITY FACTORS IN THE MALAYSIAN CONSTRUCTION INDUSTRY

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By

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DEDICATION

To my first teachers:

My FATHER and my MOTHER

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

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Advances have been made in the theory and implementation of constructability in many developed countries such as the United States, United Kingdom and Australia. This is not observed in the Malaysian construction industry. This research aimed to narrow this gap. The first objective of this study is to establish statistical models to describe constructability implementation in the Malaysian construction industry so that an insight on the factors contributing to the constructability implementation can be established. The second objective is to evaluate the independent factors affecting constructability implementation in the Malaysian construction industry.

The research findings were based on an industry wide questionnaire survey and four case studies: two highways projects, a cable stayed bridge and a sport complex. These case studies underpinned the results of the survey. A series of logistic predictive models were developed to assist managers in predicting the probabilities of successful implementation of the constructability concepts in their organizations,

based on the estimates and the odds ratios of the independent factors. This provides a quantitative approach to constructability implementation in the Malaysian construction industry.

The study reveals that five out of the eight examined factors significantly ($p<0.50$) affect constructability implementation. These are organization type, level of education, design experience, construction experience and engineers' attitude. The five significant factors can be used to enhance the Malaysian construction industry. The first significant factor of education level is more difficult to control than the other factors. The second and third significant factors of design experience and construction experience can be controlled through acquiring of knowledge and better access to information. The fourth significant factor of the engineers' attitude towards constructability implementation can be enhanced through publishing constructability guides. The fifth significant factor of organization type entails targeting engineers in client and consultant organizations more than the engineers in contracting and construction management organizations.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

FAKTOR KEBOLEHBINAAN DALAM INDUSTRI PEMBINAAN MALAYSIA

Oleh

MEKDAM A. NIMA

Jun 2001

Pengerusi: Profesor Madya Ir. Dr. Mohd Razali Abdul-Kadir

Fakulti: Kejuruteraan

Banyak kemajuan telah dicapai dalam teori dan peningkatan kebolehbinaan di dalam industri pembinaan di kebanyakan negara-negara maju seperti Amerika Syarikat, United Kingdom dan Australia. Perkara ini tidak berlaku di Malaysia. Dengan demikian, tujuan utama penyelidikan ini adalah untuk mengurangkan jurang tersebut. Objektif utama projek ini adalah untuk membina model statistik untuk menerangkan pengunaan kebolehbinaan di dalam industri pembinaan di Malaysia. Objektif kedua ialah untuk menilai faktor-faktor tersendiri yang berkaitan dengan pengunaan kebolehbinaan di dalam industri pembinaan di Malaysia.

Kajian ini dibuat berdasarkan soalselidik berkaitan dengan industri berserta dengan empat kajian kes: dua projek lebuhraya, satu jambatan berkabel dan juga sebuah kompleks sukan. Kajian kes ini menyokong keputusan hasil soalselidik. Satu siri model logistik telah dibentuk untuk membantu pengurus meramal kemungkinan kejayaan dan pengurusan konsep kebolehbinaan dalam sesuatu organisasi,

berdasarkan anggaran kasar dan juga kadar faktor tersendiri. Ini akan memberikan satu analisis kuantitatif terhadap pengunaan kebolehbinaan dalam industri pembinaan di Malaysia.

Kajian ini mendapati lima daripada lapan faktor yang dikaji memberi kesan yang bererti ($P<0.05$) kepada pengunaan kebolehbinaan. Ia terdiri daripada jenis organisasi, tahap pembelajaran, pengalaman merekabentuk, pengalaman dalam pembinaan dan juga persepsi jurutera. Lima faktor tersebut boleh digunakan untuk meningkatkan keupayaan industri pembinaan di Malaysia. Faktor ketara yang pertama adalah daripada segi tahap pembelajaran dimana ia sangat sukar dikawal berbanding dengan faktor lain. Faktor ketara yang kedua dan ketiga adalah faktor pengalaman merekabentuk dan juga pengalaman pembinaan dimana ia bergantung kepada pencarian pengetahuan dan kemudahan mendapatkan maklumat. Faktor ketara yang keempat adalah sikap jurutera terhadap pengunaan kebolehbinaan yang mana ia boleh dibentuk dan ditingkatkan melalui buku panduan. Faktor ketara kelima adalah jenis organisasi yang lebih memfokus kepada jurutera-jurutera dari organisasi perunding dan klien berbanding dengan jurutera-jurutera dari organisasi pembinaan dan pengurusan pembinaan.

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LIST OF ABBREVIATIONS

2MCI	Model of Constructability Implementation in the Malaysian Construction Industry
ASCE	American Society of Civil Engineers
A/E	Architect/Engineer
BCA	Building and Construction Authority, Singapore
CAD	Computer Aided Design
Caltrans	California Department of Transportation
CIDB	Construction Industry Development Board, Malaysia
CII	Construction Industry Institution, USA
CIIA	Construction Industry Institution, Australia
CIRIA	The Construction Industry Research and Information Association, UK
Ci	Constructability Concept Symbol
CM	Professional Construction Manager
E/C	Engineering/Construction Contractor
E/P/C	Engineering/Procurement/Construction Contractor
FIDIC	International Conditions of Contract
j	Number of the Constructability Concept
k	Respondent Number
PC	Personal Computer
PMC	Project Management Consultant
QA	Quality Assurance
QC	Quality Control
RE	Resident Engineer
SPSS	Statistical Package for Social Science
SX	Vertical Summations of Xj
SY	Vertical Summations of Yj
Xj	Importance Degree of Concept Cj from Respondents Viewpoint
XX	Horizontal Summations of Xj
Yj	Application Degree of Concept Cj in Respondents Organisations
YY	Horizontal Summations of Yj

CHAPTER ONE

INTRODUCTION

1.1 General Introduction

Construction is considered to be one of the largest and most challenging industries in the world. It touches all aspects of human lives by providing factories, airports, roads, hospitals, schools, canals, bridges, and all sorts of structures and facilities to be used for the comfort of man and the betterment of life.

With the development of technology and the emergence of the metropolitan society led by the industrial revolution, the construction industry flourished and became increasingly complex. A person used to conceive a project, design it and build it on his own. Nowadays, there are specialists in the construction industry who contribute in every aspect of the construction process.

As discussed in Chapter Five of this thesis, a construction project is dependent upon numerous parties that contribute in one form or another to its successful completion. In order to coordinate the efforts of many participants in a construction project and to meet budgeting and scheduling requirements, the construction industry established the field of Construction Management to be used as a tool to ensure the successful completion of construction projects. Since then, the field of Construction Project Management passed through remarkable developmental stages and became one of the most important subjects to be studied and researched. Unfortunately, the

same may not be said about the discipline of constructability whereby application and research has started only recently.

"Constructability" is a relatively new term attracting the attention of many industrial and academic organizations. In the developed countries, and within the last twenty years, a measurable interest has developed in the constructability concept.

American and British references differ in the definition of the term "constructability". American literature refers to it as "constructability" whereas British literature refers to it as "buildability". It must, however, be indicated that the term "constructability" may be used for all types of "structural and civil" construction work, whereas the term "buildability" may be associated with the construction of buildings only. For this reason and for the purpose of this thesis, the term "constructability" will be used throughout, except on certain occasions where quotations from British literature are made. Even in the USA, and until 1987, researchers were not unanimous about the use of the term "constructability". Some researchers write it: "constructibility", while others write it "constructability".

1.2 Historical Background

Construction Engineering is one of the oldest practical arts in the world. There is evidence of construction engineering works that dates as far back as fifty centuries ago. Engineering, long before it was called engineering, made its contribution to human societies in works such as irrigation, flood control, drainage, road and building construction. In every civilization, there are men who are eager and willing

to use the resources in nature to provide conveniences to their society.

1.2.1 Engineering in Antiquity

The Committee on Construction and Management of the American Society of Civil Engineering wrote in one of its journals, a legend about constructability (ASCE, 1991). The legend states that Hamid, one of the superintendents building the Great Pyramid, complained to the pharaoh that the blocks coming in were designed so large that installation into their final positions was too difficult, required too many men, led to unsafe work practices, and took too long. He also complained about the cutting of the blocks at the quarry. The blocks were not always true shapes, the surfaces were too rough, and required much rework at the site to make them fit. The blocks arrived at the site too late. The pharaoh, as a result of these complaints, insisted on an aggressive constructability program. He brought in Hamid to sit down with the designers and block suppliers. The designers were forced to consider rigging and manpower constraints, and accordingly reduced the size of the blocks. The quarry had to improve their quality control and deliver on time. Further, the ensuing pyramids were installed 13.5% faster at an overall saving of cost of 23.8%. These improvements lasted until the lessons learned were lost and design and construction went back to their old ways (ASCE, 1991).

1.2.2 Beginning of the Absence of Constructability

Until the early nineteenth century, architects were the master builders. They performed the design, purchased the materials, hired the craftsmen, and managed the construction. Some architects spent their entire lifetime working on a single project. There were no such things as project schedules and cost control. The architect or master builder possessed simple technology and very few types of construction materials. It should be pointed out that often the owners were not interested in a return on their investment in a tangible sense. The projects might have been monuments to their ego, such as the Pyramids, the Palace of Versailles, and the Taj Mahal (Goldhaber et al., 1977).

As industry expanded and the demand for commercial usage increased, investors began to put into their consideration new constructions as means to increase revenues. Obviously these mandated new methods were faster and more effective for completing a project. Investors could no longer wait a lifetime for returns on their investments. In the course of advancement in technology, the owners demanded more complex projects that could incorporate functional requirements of light, power, vertical transportation, central air-conditioning, and plumbing. More equipment and materials became available. New construction techniques enabled constructors to considerably reduce project schedules from a lifetime to a few years. Special skills were evolved, and architects became concerned primarily with functions and appearances, while designers specialized in specific design disciplines (Goldhaber et al., 1977).