BUILDING CONSTRUCTION USING INDUSTRIALISED BUILDING SYSTEMS (STEEL FORMWORK SYSTEMS - TUNNEL FORMS)

LEONG CHEE HOE

THIS THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF BACHELOR OF ENGINEERING WITH HONOURS (CIVIL)

SCHOOL OF ENGINEERING AND INFORMATION TECHNOLOGY
UNIVERSITI MALAYSIA SABAH
2007

PUMS99:1

UNIVERSITI MALAYSIA SABAH

BORANG PENGESAHAN STATUS TESIS@

JUDUL: BUILDING CONSTRUCTION USING INDUSTRIALISED BUILDING SYSTEMS (STEEL FORMWORK SYSTEMS - TUNNEL FORM)

IJAZAH: Ijazah Sarjana Muda dalam kejuruteraan dengan kepujian (kejuruteraan AWAM)

SAYA LEONG CHEE HOE (HURUF BESAR) SESI PENGAJIAN: 2003/04

mengaku membenarkan tesis (LPSM/Sarjana/Doktor Falsafah) ini disimpan di Perpustakaan Universiti Malaysia Sabah dengan syarat-syarat kegunaan seperti berikut:-

1. Tesis adalah hakmilik Universiti Malaysia Sabah.
2. Perpustakaan Universiti Malaysia Sabah dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan tesis ini sebagai bahan pertukaran antara institutsi pengajian tinggi.
4. Sila tandakan (/)

☐ SULIT	(Mengandungi maklumat yang berdarjah keselamatan atau Kepentingan Malaysia seperti yang termaktub di dalam AKTA RAHSIA RASMI 1972)
☐ TERHAD	(Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)
☑ TIDAK TERHAD	

(TANDATANGAN PENULIS)

Alamat Tetap: 316-1, Batu 3½, Jalan Gombak, 53000, Kuala Lumpur

Tarikh: 23/4/07.

Disahkan Oleh

(TANDATANGAN PUSTAKAWAN)

MOHAMMAD RADZIF B. JAHARIN
Nama Penyelia

Tarikh: _____

CATATAN:- *Potong yang tidak berkenaan.
**Jika tesis ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa /organisasi berkenaan dengan menyatakan sekali sebab dan tempoh tesis ini perlu dikelaskan sebagai SULIT dan TERHAD.
@Tesis dimaksudkan sebagai tesis bagi Ijazah Doktor Falsafah dan Sarjana secara penyelidikan atau disertai bagi pengajian secara kerja kursus dan Laporan Projek Sarjana Muda (LPSM).

DECLARATION

I hereby certify that this thesis is a result of my own unaided work whereby references to other resources have been clearly and accurately recorded.

LEONG CHEE HOE

HK2003-2144

19 APRIL 2007

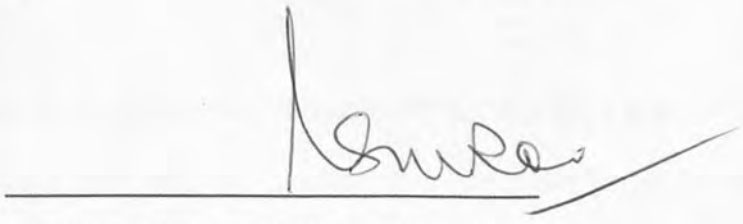
CERTIFIED BY

MR. MOHAMMAD RADZIF B. TAHARIN

SUPERVISOR

ASSOC. PROF. DR. NARAYANAN SAMBU POTTY

EXAMINER



PROF. DR. N.S.V. KAMESWARA RAO

CHAIRMAN

ACKNOWLEDGEMENTS

It is indeed a joyous moment to be able to complete this thesis on time. This task is by no means easy, having to put in so much of effort and time, and not to mention the amount of cash needed to fund the studies.

My utmost gratitude goes to no one else but to my supervisor, Mr. Mohammad Radzif Bin Taharin. Without his guidance, I would not have found the strength, patience and wisdom to complete this thesis. I am and will ever be thankful to have a supervisor who would make efforts to call up discussion and advise me in the completion of my tasks on time.

My second accolade goes to State Manager - Mr. Othman Bin Safar from CIDB Sabah State, Project Director - Mr. Wan NurMuhammad Wan Mustafa from Talam Mesra Sdn. Bhd. Project Manager - Mr. Chan Wing Keung from Elmar Engineering Services Sdn. Bhd., and Site Resident Engineer - Mr. Daniel Wong from Elmar Engineering Services Sdn. Bhd. for their guidance and support throughout the entire process of collecting data for my studies. I am really appreciates for the amount of time spent for the interviews section.

Last but not least, I would also like to thank others, who have helped me in one way or another, for without their help and support, this thesis would not be completed on time.

ABSTRACT

BUILDING CONSTRUCTION USING INDUSTRIALISED BUILDING SYSTEMS (IBS)

Industrialised Building Systems (IBS) is a relatively new method of construction in Malaysia. IBS is generally defined as the usage of prefabricated components with minimal site works required to erect a structure. Some IBS still using the in-situ method for construction but trying to minimum the site works. Although the whole concept of IBS has long been captured, implemented and improvised in many foreign countries, Malaysia is still slacking in sense that most players of the industry still prefer the traditional method and would only use IBS when the need arises. In Malaysia, there are 5 common structural types of IBS being used and this research will focus on the studies of Steel Formwork Systems. The objectives of this research are to identify the comparison of cost and time of completion between the implementation of IBS and conventional formwork systems in the local housing scene as well as to study the advantages and disadvantages of the IBS used in the Malaysian housing industry. Case studies being carried out to collect data from the two project site, one project from conventional formwork systems and another project from IBS. Data will be used for comparison purposes. Although efforts taken by the local authority and Construction Industry Development Board (CIDB) to enhance the usage of IBS in construction industry, but the components and products of IBS still have much room for improvement. As conclusion, some recommendations being made in order to further improve the popularity in implementation of IBS.

ABSTRAK

Sistem Bangunan Berindustri (IBS) merupakan satu kaedah pembinaan yang agak baru secara relative di Malaysia. IBS didefinisikan secara umum sebagai penggunaan komponen bangunan pasangsiap yang dapat meminimakan kerja-kerja di tapak bina. Sesetengah IBS masih menggunakan kaedah in-situ dalam kerja pembinaan, tetapi cuba untuk mengurangkan kerja-kerja di tapak pembinaan. Sungguhpun konsep IBS telah lama wujud dan telah digunakan serta diperbaiki oleh Negara-negara asing, Malaysia masih lagi ketinggalan dari segi penggunaan IBS kerana masih ramai kontraktor yang lebih suka menggunakan kaedah konvensional dan hanya akan menggunakan IBS jika perlu sahaja. Terdapat 5 jenis IBS yang digunakan di Malaysia and kajian in akan tertumpukan kepada salah satu jenis IBS sahaja iaitu Sistem Kotak Bentuk Besi. Objektif kajian ini ialah untuk mengetahui perbandingan kos dan masa pembinaan dalam implementasi antara IBS dan kaedah konvensional di industri perumahan tempatan serta kajian dalam kebaikan dan keburukan dalam penggunaan IBS di industri perumahan Malaysia. Kajian akan dijalani dengan pengumpalan data daripada dua tapak pembinaan. Satu tapak pembinaan daripada sistem konvensional dan satu lagi tapak daripada IBS. Walaupun kesungguhan oleh pihak berkuasa tempatan dan Lembaga Pembangunan Industri Pembinaan Malaysia (CIDB) dalam menggalakan penggunaan IBS di sector industri pembinaan, tetapi komponen dan hasil produk IBS masih ada ruangan untuk diperbaiki. Sebagai kesimpulan, cadangan-cadangan telah dibuat supaya dapat memperbaiki kepopularan dalam mengimplementasikan IBS.

LIST OF ABBREVIATIONS

BS = British Standard

CAD = Computer Aided Design

CAM = Computer Aided Manufacturing

CIDB = Construction Industry Development Board

CMU = Concrete Masonry Units

C & S = Civil and Structure

D & B = Design and Build

IT = Information Technology

JKR = Public Work Department

JPN = National Housing Department

IBS = Industrialised Building Systems

MC = Modular Coordination

MIIE = Malaysian IBS International Exhibition

M & E = Mechanical and Electrical

RC = Reinforced Concrete

Seq. = Sequence

LIST OF SYMBOLS

N = Newton

% = Percent

RM = Ringgit Malaysia

ft^2 = Square foot

m^2 = Square meter

mm^2 = Square millimeter

$\therefore$ = Therefore

CONTENTS

CHAPTER 4: RESULT

CHAPTER 5: DISCUSSION

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

INTRODUCTION

1.1 Background

Prosperity and high economic growth in Malaysia have created a high demand for construction activities. As a consequence, this has attracted a huge number of foreign workers into this country to take up employment on site as unskilled labour doing manual jobs. Despite their contributions, the country is in a quagmire with a host of problems such low quality works, delays, wastages, social problems, diseases, etc. Malaysia construction industry has to transform from an industry employing conventional technologies to a more systematic mechanized industry.

Take the challenge for future competitiveness and increased growth potential of Industrialised Building Systems (IBS) in building construction. The IBS objectives, strategic direction, and recommended action plans which address current and future challenges impacting the potentials and opportunities available in the construction market, both locally and abroad. An advanced construction industry which is expected to be materialised will support the Government's plan to build Malaysia into a successful industrialised nation by year 2020.

"The Government is determined to ensure that every Malaysian will have access to affordable homes. During the period 1971-2003, the Government constructed 490,000 units of low-cost houses while the private sector constructed 509,000 units for

low-income families. The Government intends to provide an additional 100,000 units of affordable homes to be implemented through the Industrialised Building Systems (IBS)." Excerpts from the 2005 Budget Speech by YAB Dato' Seri Abdullah bin Hj. Ahmad Badawi (Prime Minister and Minister of Finance Malaysia). This system will ensure quality construction, save cost, create a safer and cleaner working environment as well as reduce the dependence on foreign labour.

In order to facilitate the collaborative work between academia and industry, the Construction Industry Development Board Malaysia (CIDB) was incorporated to launch a series of research agenda. The Malaysian construction industry is undergoing a transitional change from an industry employing conventional technology to a more systematic and mechanised. This new system is now known as the Industrialised Building Systems (IBS). The new method of construction can increase productivity and quality of work through the use of better construction machinery, equipment, materials and extensive pre-project planning.

1.2 Problem Statements

There is a need for more efficient and industrialised construction industry to move forward. At present, the expenditure on labour almost equals the cost of materials. Consequently, the need to reduce the manpower involved is obvious. There are several doubt arise in the industry to bring up the idea of these case studies:

i. What is Industrialised Building Systems (IBS)?

ii. Why the industries still using the conventional formwork systems as their preference?

iii. How IBS reduce cost of construction and save time of construction?

From the viewpoint of structural engineering there is an urgent need to address these problems, to look for innovative design solutions and develop new formwork systems. New and efficient formwork systems are likely to reduce time-consuming activities, costly labour activities and lead to a more industrialised construction.

1.3 Objective

Parallel to the literature study, two projects were chosen to be studied. These two projects contain a complete description of those construction projects and case studies. This thesis is aimed to achieve three major objectives.

i. To study the application of IBS in local housing projects. These case studies about IBS are focus on two difference methods of local housing projects in Malaysia to differentiate the project management works.

ii. To establish the building cost comparison between the conventional formwork systems and the IBS. The cost analysis on the selected projects will be performed to understand the cost advantages.

iii. To establish the building time completion comparison between the conventional formwork systems and the IBS.

1.4 Scope of Studies

The studies will be focused on the IBS in Kota Kinabalu, Sabah. Two low cost housing projects will be selected for the case studies. These studies focus directly on the cost advantages and faster time completion comparison between conventional formwork systems and IBS in Malaysia. These studies are limited to building works from substructure, superstructure up to roof level only. The infrastructure works are excluded from the studies.

CHAPTER 2

LITERATURE REVIEW

2.1 An Overview of IBS

An Industrialised Building Systems (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 a desired building structure through mechanical means using as little in-situ construction as possible. The elements are thus precast or prefabricated either in an off-site factory or in an on-site casting yard.

"Industrialised" is the term where modern systematic methods of design, production, planning and control as well as mechanised and automated manufacturing are applied. The term 'industrial building' has been used, and abused, ever since its introduction. To compose a straight forward and clear-cut definition of industrialised building is perhaps not as easy as one might imagine, since different forms and techniques exist.

CIB W24 [International Council for Research and Innovation in Building and Construction, work group 24, 1996] has made an effort and offers the following, quite general, definition: **Industrialised Building** is the term given to building technology where modern systematised methods of design, production planning and control as well as mechanised and automated manufacture are applied.

2.1.1 Building System

A system is defined as "a set of parts with holistic potential." In other words, a set of parts organised to act as a whole. The parts of any system may be tangible or intangible, hardware or software, products or policies. When the term "building system" is used, it usually means a generating system for building, or, in other words, a set of buildability parts which may be combined or assembled in a variety of different ways to create a variety of different building configurations. A comparison between industrial manufacturing and industrial building can further elucidate some aspects and principles which have to be applied in the building industry.

In an industrialised building industry, the products are not buildings but building system. A building system is a set of parts and rules where the details are solved before actual buildings are planned [Richard, 2002], the same parts and their details are reused for a large number of buildings which are different as products but generated by a similar process. Therefore, construction is not reinvented each time a building is planned, as it is still the case.

The main functions of the building generate its subsystems: structure, envelope, partitions, equipment and services. The subsystems can be integrated in the same component or subassembly. When they are produced independently, their integration can be provided through modular coordination interfacing rules and connectors.

By aiming at the performance rather than the form, the criteria will permit a more open and creative selection of technologies. Performance criteria open new opportunities for ingenuity and innovation in the development of new methods and technology [Ehrenkrantz, 1989].

Table 2.1: Features of Industrial Manufacturing and the Parallels in the Building Industry

Features of industrial manufacturing	Requirements on industrial building
Centralised manufacturing	Prefabrication of building components in Factories
Mass production / increased flexibility of production	Development of variable standard component
Manufacturing based on standard solutions and production of variants	Standardisation of building elements with flexibility in the design
Specialisation	Concentration towards certain segments of the market
Integration of planning, manufacturing and marketing	Interaction of planning, design, production, and production processes as well as marketing
Optimised processes and organisations	Optimisation of planning and production processes by considering automation and mechanisation

Source: International Council for Research and Innovation in Building and Construction, work group 24, 1996

2.2 Historical Perspective

Prefabrication of building components is not new concept: Even the building blocks of the great Egyptian pyramids were prefabricated to the correct size at the quarry to reduce the weight for the transportation. Traditional form houses in Europe were since the Middle Ages partly prefabricated and built in 3 feet modules and the building industry in USA very early planned to produce a kind of turnkey prefabricated timber houses as a box system.

The concept of IBS is not new and can be traced back to as early as 1624 when panellised timber houses were shipped from England to the new settlements in North America. The Industrial Revolution of the 1700s provided the construction industry with technological boost. But in UK the well known Crystal Palace represents the first fully dimensional coordinated, prefabricated building system based on cast-iron components covered with a climatic screen of glass.

The Crystal Palace from 1851 is considered the 'mother' of all Industrialised Building Systems: Extremely simple layout and design based on a 24 feet grid system and constructed of two materials: Cast iron and glass. The 72,000 square meter exhibition building was designed and built in 6 months only, an achievement that even today 154 years later would be remarked [CIDB, 2000].

The real step forward for the prefabricated concrete housing technique took place in Europe shortly after the Second World War. People were prepared and able to pay more for living space and at the same time youngster wanted to move out from their parents' home much earlier than before. This created a demand for new housing that the conventional construction systems had no possible way to satisfy.

The Building Authorities in many European countries, especially in Finland, the Netherlands, France and Denmark, realised that the only way to overcome the lack of quality housing facilities due to the increasing demand was to industrialised the housing production. Such as a concept would also ensure that a rapidly growing building sector still could produce houses of high quality and at the same time with an increasing productivity.

The development of steel and other pre-engineered materials promoted the race to build tall structures, particularly in the United States where steel frames are often combined with precast panels in building skyscrapers. While steel structures of road and railway bridges were common in pre-independence Malaya, the use of precast concrete in the local construction industry arrived much later.

In 1966, the Malaysian government launched two pilot projects - the Pekeliling Flats in Kuala Lumpur and the Rifle Range Road Flats in Penang; both using precast concrete elements to build these high rise low cost flats. Following these pilot projects, PKNS acquired precast concrete technology from Praton Haus International, Germany and built numerous housing projects ranging from low cost houses to high cost bungalows from 1981-1993 [Hashim, 1998].

The success of precast, steel and hybrid construction contributed to the rapid creation of numerous beautiful and quality structures; particularly during the 1995-1998 periods. These include the construction of the Bukit Jalil Sports Complex and Games Village, the Petronas Twin Towers and the LRT lines and tunnels. IBS's benefits are inherent in the beautiful structures of the Putrajaya precincts and in the projects to improve Kuala Lumpur's infrastructure.

REFERENCES

1. Andres, Cameron & Smith, Ronald. 2004. *Principles And Practices Of Commercial Construction.* 7th edition. United States of America: Pearson Education Inc.

2. Antill, James & Woodhead, Ronald. 1990. *Critical Path Methods In Construction Practice.* 4th edition. United States of America: A Wiey-Interscience Publication.

3. Chudley, Roy. 1999. *Construction Technology.* 3rd edition. Pearson Education Limited.

4. Clifford J.S & Richard E.M. 2004. *Construction Management Fundamentals.* International edition. Singapore: McGraw- Hill.

5. Ehrenkrantz, Ezra. 1989. *Architectural Systems.* New York: McGraw Hill.

6. Gould, Frederick & Joyce, Nancy. 2002. *Construction Project Management.* Professional edition. United States of America: Pearson Education Inc.

7. Hashim, Mohd. Suffian. 1998. *"The Industrialised Construction System – Pengalaman PKNS Engineering & Construction Berhad (PECB)"* in Colloquium on Industrialised Construction Systems. CIDB.

8. Holm, Lee & Schaufelberger, John. 2005. *Construction Cost Estimating Process And Practices.* United States of America: Pearson Education Inc.

9. MacGinley, T.J & Choo, B.S. 2003. *Reinforced Concrete.* 2nd edition. Great Britain: Spon Press.

10. Mosley, W.H. & Bungey, J.H. 1999. *Reinforced Concrete Design.* 5th edition. Great Britain: PALGRAVE.

11. Peng, C.S. 1986. *The scenario of industrialized building systems in Malaysia. Proceedings of a UNESCO/FEISEP Regional Workshop.* UPM, Serdang.

12. Peurifoy, Robert & Oberlender, Garold. 2004. *Estimating Construction Costs.* 5th edition. Singapore: McGraw-Hill.

13. Richard, R.B. 2002. *Prospective building systems for developing countries,* Proceedings of CIB W107-Creating a Sustainable Construction Industry in Developing Countries. CIB and CSIR. Spier-South Africa.

14. Schaufelberger, John & Holm, Lee. 2002. *Management of Construction Projects.* United States of America: Pearson Education Inc.

15. Trikha, D.N. 2004. *Industrialised Building Systems.* UPM, Serdang.

16. Warszawski, A. 1999. *Industrialised and Automated Building Systems.* Technion-Isreal Institute of Technology. E & FN Spon.

17. British Cement Association. 1993. *The Concrete On Site Series.* 1st edition. Great Britain.

18. *British Standard 1997* – Part 1. London: BSI.

19. CIDB Malaysia & APEC Technology Foresight Centre, Bangkok 2000, "Malaysian Construction Industry: Technology Foresight Report", Proceedings of the CIDB Workshop on Technology Foresight, CIDB, Kuala Lumpur.

20. Construction Industry Development Board (CIDB). Malaysian Standard Method Of Measurement For Civil Engineering Works.' Lembaga Pembangunan Industri Pembinaan Malaysia'.

21. Construction Industry Development Board (CIDB) 2003. Industrialised Building Systems Roadmap 2003-2010. CIDB.

22. Construction Industry Development Board (CIDB) 2003b. IBS Survey 2003. CIDB.

23. Construction Industry Development Board (CIDB) 2003c. Industrialised Building Systems Strategic Plan, CIDB.

24. Construction Industry Development Board (CIDB) 2003b. Realising the Industrialisation of Malaysian Construction Industry – Construction Intropective. IBS Digest, July-September, CIDB.

25. Construction Industry Development Board (CIDB) 2005. IBS Score Calculation Samples. IBS Digest, April-Jun, CIDB.

26. Construction Industry Development Board (CIDB) 2005. Precast Installation Procedures. IBS Digest, July-September, CIDB.

27. International Council for Research and Innovation in Building and Construction, work group 24, 1996.