



**UNIVERSITI PUTRA MALAYSIA**

**BUILDING COST COMPARISON BETWEEN CONVENTIONAL  
AND SOME SELECTED INDUSTRIALISED BUILDING SYSTEMS**

**NUZUL AZAM HJ. HARON**

**FK 2002 45**

**BUILDING COST COMPARISON BETWEEN CONVENTIONAL AND  
SOME SELECTED INDUSTRIALISED BUILDING SYSTEMS**

**By**

**NUZUL AZAM HJ. HARON**

**Thesis Submitted to the School of Graduate Studies, Universiti Putra  
Malaysia, in Fulfilment of Requirement for the Degree of Master of  
Science**

**August 2002**



Abstract of thesis presented to the Senate of Universiti Putra Malaysia in  
fulfilment of the requirement for the degree of Master of Science

**BUILDING COST COMPARISON BETWEEN CONVENTIONAL AND  
SOME SELECTED INDUSTRIALISED BUILDING SYSTEMS**

**By**

**NUZUL AZAM HJ. HARON**

**August 2002**

**Chairman: Associate Professor Mohd. Razali Abd. Kadir, Ph.D.**

**Faculty : Engineering**

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 system (IBS). The new methods of construction can increase productivity and quality of work through the use of better construction machinery, equipment, materials and extensive pre-project planning. This study becomes very necessary since there is yet no organised body, which can provide the necessary information on the building cost comparison between the conventional and industrialised building system in Malaysia's construction industry.



The thesis addresses the building cost comparison of the conventional system and industrialised building system of IBS A, IBS B, and IBS C. It provides the detail building cost to show cost savings amongst the conventional system and the IBS. The data were collected through questionnaire survey and case studies, which consisted of residential and institutional buildings.

Through the t-test it is shown that there is a significant difference of cost saving for the conventional system as compared to the industrialised building system.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia  
sebagai memenuhi keperluan untuk Ijazah Master Sains

**PERBANDINGAN KOS BANGUNAN DI ANTARA KONVENSIONAL DAN  
BEBERAPA SISTEM BANGUNAN BERINDUSTRI YANG TERPILIH**

**Oleh**

**NUZUL AZAM HJ. HARON**

**Ogos 2002**

**Pengerusi : Profesor Madya Mohd. Razali Abd. Kadir, Ph.D.**

**Fakulti : Kejuruteraan**

Industri binaan di Malaysia, kini menyusur ke alam perubahan iaitu daripada industri yang menggunakan teknologi tradisional kepada yang lebih sistematik yang melibatkan jentera. Kaedah baru ini juga dikenali sebagai sistem bangunan berindustri. Kaedah baru binaan bangunan ini dapat meningkatkan produktiviti dan kualiti kerja menerusi penggunaan mesin, peralatan yang lebih baik, bahan binaan dan juga di peringkat perancangan projek. Kajian ini amat berguna memandangkan keadaan dimana masih tidak terdapat sebuah organisasi yang dapat menyediakan maklumat keperluan seperti perbezaan kos bangunan diantara sistem tradisional dengan sistem bangunan berindustri di dalam industri binaan di Malaysia.

Kajian ini menerangkan tentang perbezaan kos bangunan diantara sistem tradisional dengan sistem bangunan berindustri yang terpilih. Ianya menyediakan maklumat perbezaan kos secara terperinci dengan menunjukkan penjimatan kos diantara kaedah binaan tradisional dengan kaedah binaan berindustri. Data dikumpul melalui kajian soal-slidik dan juga kajian kes meliputi bangunan kediaman dan juga institusi pengajian.

Melalui 't-test' didapati terdapat perbezaan yang nyata berkenaan dengan penjimatan kos oleh sistem binaan tradisional berbanding dengan sistem binaan berindustri.

## **ACKNOWLEDGEMENT**

First of all, I would like to express my deepest thanks to The Almighty Allah s.w.t. for giving me the strength, patience and never ending courage in completing this project.

The author wishes to thank Associate Prof. Ir. Dr. Mohd. Razali Abdul Kadir, Ir. Salihuddin Hasim and Associate Prof. Ir. Dr. Md. Yusof Ismail for their concern and encouragement toward the completion of this study.

The author further wishes to express his appreciation to En. Mohd. Hanafi Atan of AMD Associate for their cooperation in this study. The author would also like to extend his sincere appreciation to En. Rahmat Kislán of Baktian Sdn. Bhd., En. Ng Keh Seng of PJD Concrete Products Sdn. Bhd. for their assistance in providing the building cost data.

Last but not least, my sincere thanks from the bottom of my heart to my beloved Mama, Papa, Sister, Brother and Ayu for their love, support and encouragement.



## TABLE OF CONTENT

|                 |      |
|-----------------|------|
| ABSTRACT        | ii   |
| ABSTRAK         | iv   |
| ACKNOWLEDGEMENT | vi   |
| APPROVAL        | vii  |
| DECLARATION     | ix   |
| LIST OF TABLE   | xiii |
| LIST OF FIGURE  | xiv  |

### CHAPTER

|          |   |    |
|----------|---|----|
| <b>1</b> | <b>INTRODUCTION</b>   |    |
| 1.0      | Introduction  | 1  |
| 1.1      | Problem Statement   | 3  |
| 1.2      | Research Objective  | 5  |
| 1.3      | Significant of Study  | 6  |
| 1.4      | Scope and Limitation  | 7  |
| 1.5      | Thesis Overview   | 8  |
| 1.6      | Closure   | 10 |
| <b>2</b> | <b>LITERATURE REVIEW</b>  |    |
| 2.0      | Introduction  | 11 |
| 2.1      | Industrialised Building System  | 12 |
| 2.1.1    | Building System   | 12 |
| 2.1.2    | Industrialisation   | 12 |
| 2.1.3    | Standardisation   | 14 |
| 2.1.4    | Modular Co-ordination   | 14 |
| 2.2      | Industrialised Building System (IBS) in Malaysia                                | 15 |
| 2.3      | Classification of Industrialised Building System                                | 15 |
| 2.3.1    | Conventional Construction Method  | 17 |
| 2.3.2    | Cast-In-Situ Construction Method  | 18 |
| 2.3.3    | Composite Construction Method   | 19 |
| 2.3.4    | Fully Prefabricated Construction Method   | 20 |
| 2.4      | Advantages of Industrialised Prefabrication Building System                     | 23 |
| 2.5      | Advantages and Disadvantages of Conventional and Industrialised Building System | 23 |
| 2.6      | Cost Estimating of Building Construction  | 25 |
| 2.6.1    | Factors Contributing to The Cost Building Construction                          | 26 |
| 2.6.1.1  | Construction Cost   | 27 |
| 2.6.2    | Estimating Methods for Building Cost  | 34 |
|          | Conference Estimate   | 37 |
|          | Financial Method  | 37 |
|          | Unit Method   | 38 |





|          |   |    |
|----------|---|----|
|          | Superficial Area Method   | 39 |
|          | Superficial Perimeter Method  | 40 |
|          | Cube Method   | 41 |
|          | Storey-Enclosure Method   | 41 |
|          | Approximate Quantities  | 43 |
|          | Elemental Estimate  | 44 |
|          | Resource Analysis   | 44 |
|          | Cost Engineering Method   | 44 |
|          | Cost Modelling Method   | 46 |
| 2.7      | Method of Cost Comparison in Other Industry                             | 51 |
| 2.8      | Method of Cost Comparison in Construction Industry                      | 54 |
|          | 2.8.1 Comparison of Standardised Identical Building                     | 55 |
|          | 2.8.2 Comparison of Standard Building with Local Modification           | 55 |
|          | 2.8.3 Comparison of Functionally Similar Building                       | 55 |
|          | 2.8.3.1 Gross Floor Unit Costs  | 57 |
|          | 2.8.3.2 Elemental Cost Analysis   | 59 |
| 2.9      | Cost Comparison Between Conventional and Industrialised Building System | 60 |
|          | Cost  | 61 |
|          | Speed   | 61 |
|          | Requirement   | 62 |
|          | Quality   | 62 |
| 2.10     | Closure   | 62 |
| <b>3</b> | <b>SEARCH METHODOLOGY</b>   |    |
| 3.0      | Introduction  | 64 |
| 3.1      | Methods of Data Collection  | 64 |
| 3.2      | Questionnaire Design  | 66 |
|          | 3.2.1 Pre-testing of the Questionnaire                                  | 66 |
|          | 3.2.2 Population and Sampling   | 67 |
| 3.3      | Case Studies  | 69 |
| 3.4      | Data Analysis   | 70 |
| 3.5      | Closure   | 70 |
| <b>4</b> | <b>RESULTS AND DISCUSSION</b>   |    |
| 4.0      | Introduction  | 71 |
| 4.1      | Results Analysis  | 72 |
|          | 4.1.1 Respondents' Background   | 72 |
|          | 4.1.2 Academic Discipline   | 72 |
|          | 4.1.3 Respondent's Current Position                                     | 73 |
|          | 4.1.4 Length of Time in Construction Industry                           | 73 |
| 4.2      | Company Information   | 74 |
|          | 4.2.1 Nature of Business  | 74 |
|          | 4.2.2 Paid-up Capital   | 75 |
|          | 4.2.3 Duration of Company's Experience in the Construction Industry     | 75 |
| 4.3      | Project Information   | 76 |

|       |  |     |
|-------|--|-----|
| 4.4   | Building Cost Information                                  | 84  |
| 4.4.1 | Mean Weighted Rating                                       | 85  |
| 4.5   | Discussion on Results Analysis                             | 88  |
| 4.6   | Closure  | 97  |
| <br>  |  |     |
| 5     | CASE STUDY   |     |
| 5.0   | Introduction   | 99  |
| 5.1   | IBS A Case Study   | 100 |
| 5.1.1 | Objective of IBS A   | 100 |
| 5.1.2 | Advantages of IBS A  | 101 |
| 5.1.3 | The Advantages of IBS A Compared to<br>Conventional System | 101 |
| 5.1.4 | Building Cost Information                                  | 103 |
| 5.1.5 | Cost Comparison  | 106 |
| 5.1.6 | Conclusion   | 107 |
| 5.2   | IBS B Case Study   | 111 |
| 5.2.1 | Quality Control  | 112 |
| 5.2.2 | Installation   | 112 |
| 5.2.3 | Building Cost Information                                  | 112 |
| 5.2.4 | Cost Comparison  | 116 |
| 5.2.5 | Conclusion   | 117 |
| 5.3   | IBS C Case Study   | 119 |
| 5.3.1 | IBS C  | 119 |
| 5.3.2 | The Advantages of IBS C                                    | 120 |
| 5.3.3 | Building Cost Information                                  | 122 |
| 5.3.4 | Cost Comparison  | 123 |
| 5.3.5 | Conclusion   | 126 |
| 5.4   | Closure  | 127 |
| <br>  |  |     |
| 6     | CONCLUSIONS AND RECOMMENDATIONS                            |     |
| 6.0   | Conclusions  | 128 |
| 6.1   | Recommendations  | 139 |
| <br>  |  |     |
|       | <b>REFERENCE</b>   | 140 |
|       | <b>APPENDIX A (QUESTIONNAIRE)</b>                          | 147 |
|       | <b>APPENDIX B (MODEL DEVELOPMENT)</b>                      | 154 |
|       | <b>APPENDIX C (BUILDING COST DATA)</b>                     | 164 |
|       | <b>VITA</b>  | 169 |

## LIST OF TABLE

| <b>Tables</b> |  | <b>Page</b> |
|---------------|--|-------------|
| 2.0           | A Summary of Selected System Attributes  | 32          |
| 2.1           | Estimating Types   | 35          |
| 2.2           | Methods of pre-tender  | 36          |
| 2.3           | Average Construction Cost perUnit(Gross Floor Area)  | 58          |
| 2.4           | Comparison of wall Component of Conventional Housing Against Industrialised Building System                | 59          |
| 3.0           | Summary of Analysis Conducted  | 74          |
| 4.0           | Result of The Practicing Estimating Method in Malaysia's Construction Industry                             | 85          |
| 5.0           | Building Cost Comparison Between Conventional Construction Method and IBS A (Double Storey Terrace)        | 105 (a)     |
| 5.1           | Building Cost Comparison Between Conventional Construction Method and IBS A (Single Storey Terrace)        | 105 (b)     |
| 5.2           | Building Cost Comparison Between Conventional Construction Method and IBS B (Low Cost Single Storey House) | 115 (a)     |
| 5.3           | Building Cost Comparison Between Conventional Construction Method and IBS A (Four Storey School Building)  | 122 (a)     |
| 5.4           | Mean Difference Between One Unit Four-Storey School Building of Conventional and System C                  | 124         |
| 5.5           | Significant Difference Between One unit Four-Storey School Building of Conventional System and IBS C       | 125         |

## LIST OF FIGURE

| <b>Figure</b> |  | <b>Page</b> |
|---------------|--|-------------|
| 1.0           | Thesis layout  | 9           |
| 2.0           | Components of Industrialisation in Construction  | 13          |
| 2.1           | Classification of Conventional Construction Method                                       | 17          |
| 2.2           | Classification of Cast In-situ Construction Method                                       | 19          |
| 2.3           | Classification of Full Prefabricated Construction Method                                 | 22          |
| 2.4           | Diagrammatic Representation of a Unit Rate   | 30          |
| 2.5           | Hierarchical Structure of Cost Data  | 31          |
| 2.6           | Cost Modelling   | 50          |
| 3.0           | Guidelines for Data Collection   | 65          |
| 3.1           | Parts of The Questionnaire   | 68          |
| 4.0           | Academic Discipline of The Respondents   | 72          |
| 4.1           | Respondent's Current Position  | 73          |
| 4.2           | Nature of Business   | 74          |
| 4.3           | Paid-up Capital  | 75          |
| 4.4           | Project Type   | 76          |
| 4.5           | Type of Residence  | 77          |
| 4.6           | Height of Residence Building   | 77          |
| 4.7           | Structural Construction Method   | 78          |
| 4.8           | Advantage of Building System   | 79          |
| 4.9           | Disadvantage of Building System  | 80          |
| 4.10          | Project Completion   | 81          |
| 4.11          | Method of Estimating   | 82          |
| 4.12          | Type of Contract   | 83          |
| 4.13          | Mode of Payment  | 84          |
| 4.14          | Building Cost Saving   | 86          |
| 4.15          | Building System Recommended by Respondent for The Future                                 | 87          |
| 5.0           | IBS A Panel Mould  | 104         |
| 5.1           | Preparing Mould Design   | 104         |
| 5.2           | Dismantled IBS A Panel Concrete from The Mould   | 104         |
| 5.3           | Completed Panel IBS A  | 105         |
| 5.4           | Cost GFA per (ft <sup>2</sup> ) for Conventional System and IBS A of Single Storey House | 106         |
| 5.5           | Cost GFA per (ft <sup>2</sup> ) for Conventional System and IBS A of Double Storey House | 107         |
| 5.6           | IBS B Panel used for Single Storey Low Cost House  | 113         |
| 5.7           | Assembling The IBS B Panel with Ready Made Tongue and Groove System                      | 113         |
| 5.8           | External and Internal Wall of IBS B for Single Storey Low Cost House                     | 114         |
| 5.9           | Single Storey Low Cost House Project using IBS B   | 114         |
| 5.10          | Completed project of Single Storey Low Cost House using IBS B                            | 115         |

|      |   |     |
|------|---|-----|
| 5.11 | Cost GFA per (m2) for Conventional System and IBS B of One Unit Single Storey House     | 116 |
| 5.12 | Average Cost GFA per (m2) for Conventional System and IBS C of One Unit School Building | 123 |

# CHAPTER I

## Introduction

### 1.0 Introduction

The Malaysian construction industry is undergoing a transitional change from an industry employing conventional technology to a more systematic and mechanised industry employing the latest computer and communication technology. This is vital for the future health of the industry, given the trend towards global competition and the advent of k-economy.

As we enter the era of the k-economy, a world of stiff competition awaits us. Global players compete to provide unique services, processes, materials and systems which promise better quality, higher speed and at better costs. There is a deep concern that the construction industry as a whole is underachieving. It has for many years maintained the time-tested but labour intensive traditional approach in construction and investing too little in research and development and training even in this knowledge (Ali, 2000).

As Malaysia progressively marches towards industrialisation, the role of the building industry is greatly enhanced with the idea to transform the aspirations and needs of the people into reality. In the 7<sup>th</sup> Malaysia Plan, some 800,000 houses shall be built, to fulfill the government's pledge of a home for every Malaysian. There is thus an urgent need to mass produced quality housing, affordable to all Malaysians. New and innovative

approaches and technology in the design and construction of houses are needed to enable the nations to achieve this target (National Housing Department, 1997). In the Malaysian context, the government's policy on housing is that, the traditional building practices must be replaced by Industrialised Building System (IBS), which could save on labour, cost and time of construction and confers quality and durability (Elias, 2000)

Prefabrication is a key towards increasing buildability. However, pre-cast concrete components and prefabricated reinforcement are still not commonly used in the private sector. This, to a great extent, is due to uncertainties about their cost and their ability to meet the aesthetic and other design requirement of developers (Tan E.P., 1997)

The construction cost of a building using pre-cast components should be assessed in its overall context. The traditional method of costing by material quantities with a fixed factor for labour cost can lead to incorrect estimation. For example, if labour usage is halved, this will more than compensate for a 10 percent material increase. More importantly, work completion will be faster. Furthermore, if properly designed and executed, pre-cast can eventually result towards better quality of work. The overall cost impact of pre-cast has therefore to take all these factors into consideration. With the rising costs of labour and less assurance of dependable skilled manpower, the trend is that pre-cast construction will become increasingly competitive compared to cast-in-place construction (CIDB, 1997)

## 1.1 Problem Statement

The Malaysian construction industry grew from 11% to 14% between 1992 to 1996 but dropped sharply in 1998. The construction boom increased the demand for workers from 250,000 in 1990 to some 750,000 in 1998. The large workforce includes a 50% increase in the number of foreign workers brought into the country. The recession however caused the slowdown of the industry, resulting in the retrenchment of workers and a large number of uncompleted projects. Thus there is a need to improve productivity in the construction industry, which will necessitate the use of new materials and construction techniques (CIDB, 2000).

Industrialisation involves the rationalisation of the whole process of building. It includes the process of design, the forms of construction used, and the methods of building adopted. This is to ensure that the design is well integrated. There must also be proper co-ordination between the three processes viz. supply of materials, fabrication, and assembly. All these factors will contribute towards speedier construction. Hence, resulting less labour on-site and less cost (Friedman and Cammalleri, 1993).

Cost research in the construction industry involves the investigation of all matters, which affect the costs of construction, either initially or throughout the building's life. The research may be done for the benefit of the client, contractor or developer or to suit the needs of professionals in the industry. Some of the research that has been undertaken in the past has been directly related to improving the quality and scope of the



professional services offered to the industry. Empirical evidence rather than rule-of-thumb should be practised here. It is hoped that there will be better understanding, which will allow better service to be provided with a greater level of confidence (Ashworth A., 1994)

In so far there is yet no organized body, which can provide information readily on a guideline or benchmark for building cost comparison especially between conventional and industrialised building system in Malaysia's construction industry. Hence, the focus of this particular study.

## **1.2 Research Objective**

With respect to the afore-mentioned research questions, the objectives of this study are as follow:

1. To establish the method of cost estimating for building construction
2. To establish the building cost comparison between conventional and some selected industrialised building systems.

### **1.3 Significance Of Study**

The building industry in Malaysia today has undergone many innovations. It is important therefore at this present time that many aspects of the building industry are studied (Nuzul et al., 2002). One of which is to study about the building cost comparison between conventional and some selected industrialised building system.

Usually, the developer or client will try to get information from consultants on what system to be used in their project (conventional or industrialised building system). The consultants will suggest to the developer or client according to their past experiences. There is no organised body, which can provide information readily on guideline, or benchmark for building cost comparison especially between conventional and industrialised building system in Malaysia's construction industry.

Hence, it is timely that a study to establish the cost of building construction between conventional system and industrialised building system is made. In addition, this study will also attempt to establish the costs of building construction using different building construction methods.

The findings of this study can be used to serve as a guideline or benchmark for the construction industry concerning building cost and cost comparison of conventional method against industrialised building system. The study would also help to build a better understanding of the building costs system that are being practised in Malaysia. They could assist

developers and consultants to choose whichever is better either conventional or industrialised building system in terms of building cost saving.

#### **1.4 Scope and Limitation**

- 1) Only Conventional and Industrialised Building System in Malaysia will be considered in this study
- 2) The study is limited to client or developer, consultant, contractor and supplier
- 3) The study is limited to building cost only (infrastructure cost and overall construction costs are excluded)

## **1.5 Thesis Overview**

This thesis contains six chapters. The summary of each chapter is described as below.

Chapter I, gives a brief description of the Malaysian construction industry. The aims, objectives, and justification of this study are specified. It includes also the overall content of the whole thesis.

Chapter II, includes a literature review in the field of building construction cost and the building cost comparison of Conventional and Industrialised Building System. In addition, a classification of industrialised building systems is also included.

Chapter III, sets the methodology followed during this study. The design and implementation of questionnaire survey and case studies are given. The analytical methodology adopted is also briefly described.

Chapter IV, the outcome of analysis, results and discussion for the building systems are presented and discussed.

Chapter V, the case studies are discussed. These case studies are cost comparison of building projects carried out under Ministry of Housing and Local Government, Public Works Department and others Private Sector.

Chapter VI, presents a summary of the findings and conclusions drawn from this research and recommendations for future research.

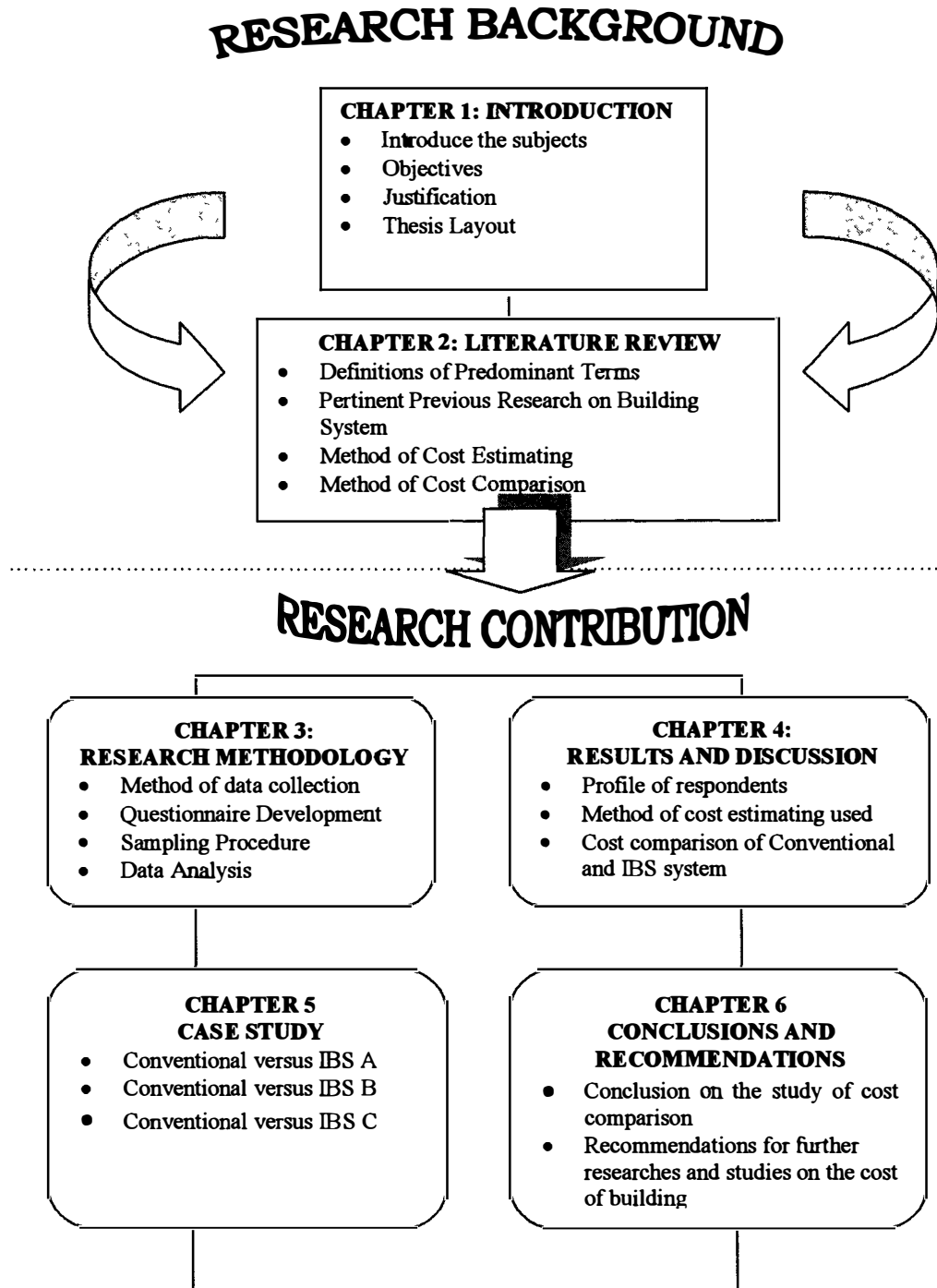


Figure 1.0 Thesis Layout