APPLICATION OF BIM IN EARLY STAGE DESIGN COST ESTIMATION

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A thesis submitted in fulfilment of the

requirements for the award of the degree of

Master of Architecture

Faculty of Built Environment

Universiti Teknologi Malaysia

February 2014

To my mama, family and friends, thank you for the loves, supports, prayers, endurances and cares.

ACKNOWLEDGMENTS

In the name of Allah, the most Gracious, the most Merciful

I wish to express my sincere appreciation to my supervisor, Assoc. Prof. Dr. Mohamed Rashid Bin Embi, for his invaluable advice, assistance and guidance. Without his continuous supports and guidance, this thesis has come to reach this stage.

Also, a special thanks to Ir. Mohamad Pauzi Mohamed Kassim from Megajati Consult Sdn. Bhd. and Rosni Ghani who have had contributed their professional ministration and project information throughout the whole process of the thesis.

Furthermore, I would like to acknowledge the constant supports and aids by Amalina Abdullah who has had aided me in quantifying the project.

Also my infinite appreciation to Suryati A Samad, and Wan Sharizatul Suraya W. M. Rashdi from Prestariang Sdn. Bhd. for their assistance and cooperation in using Autodesk Revit.

Finally, my heartfelt gratitude goes to my beloved family, friends and the industry participants of the research who have had involved directly or indirectly during my ups and downs in completing this thesis. These generosities are meaningful for me in completing the thesis. Thank you.

ABSTRACT

Architects, in general, are very excited in designing a project, that they often become engrossed and deviated from the original budget. A quick solution, architects will frequently reduce the floor area and sometimes they even have to redesign the projects in order to keep within the clients' budget. This study explores the elements that could effectively and practically reduce and control the construction cost during the early stage of the design process. The aim of this research is to seek the impact of the selected design elements that can be manipulated by architects at the early design stage to control the project cost. This study has utilised building simulation technique to analyse the design elements variation and their impacts on the construction cost. The results from these simulations show that there are significant differences among the design elements where every changes gave impacts to the construction cost. After analysing the results acquired, it is concluded that floor area gives the greatest impact to the construction cost, followed by door and grid structures. Architects equipped with good decision-making skills and cost strategizes are seen as well-informed and reliable leaders especially when the projects encounter financial constraint. The result of this research can help architects to strategize the construction cost at early design stage in a more proficient and practical manner.

ABSTRAK

Arkitek, kebiasaannya, sangat teruja apabila merekabentuk sesebuah projek, sehingga seringkali mereka alpa dan tersasar dari anggaran peruntukan pembinaan sesebuah projek itu. Sebagai penyelesaian ringkas, mereka biasanya akan memilih untuk mengurangkan keluasan lantai bangunan tersebut atau merekabentuk semula bagi memastikan peruntukan pembinaan projek itu tidak melebihi peruntukan pelanggan. Oleh itu, kajian ini bertujuan untuk mengkaji impak elemen-elemen terpilih yang boleh dimanipulasikan oleh para akitek bagi mengawal dan menganggar kos projek pada peringkat awal proses rekabentuk. Kajian ini telah menggunakan simulasi bangunan untuk menganalisis perubahan element rekabentuk di mana setiap satunya memberi impak yang berbeza terhadap kos pembinaan keseluruhan. Selepas menganalisis keputusan yang diperolehi, adalah dapat disimpulkan bahawa keluasan lantai memberikan impak paling besar dalam kos pembinaan projek, diikuti dengan jenis pintu dan struktur grid. Arkitek yang memiliki kemahiran dalam membuat keputusan rekabentuk dan merancang kos pembinaan khususnya dilihat sebagai pemimpin yang cekap, efisien dan boleh diharap dalam memimpin sesebuah projek terutamanya projek yang mempunyai kengkangan kewangan. Hasil kajian ini boleh membantu para akitek dalam menyusunan strategi dan anggaran kos pembinaan pada peringkat awal rekabentuk dengan lebih mahir dan praktikal.

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BIM	Building Information Modelling
BQ	Bill of Quantity
QS	Quantity Surveyor
MYR	Malaysian Ringgit
JKR	Jabatan Kerja Raya
PWD	Department of Public Works
CIDB	Construction Industry Development Board Malaysia

CHAPTER 1

INTRODUCTION

1.1 General Background

Cost remains as the most important criteria for clients in any building projects. Strategies in decision-making and design management should be carefully monitored in order to acquire the ideal building within the client's budget. Decision-making during early design stage often been highlighted as the main issue where it failures can be a hinder to pursue success in achieving client's target within a specific budget.

During early design stage in any building constructions, we are note that information of the projects is still inadequate, the design of proposed buildings is still uncertain and on going, thus the costing is still also uncertain. Therefore, the probabilities for architects to over design during this stage are very high and consequently the construction cost of the project will be carried away. Clients' need also might be drifted due to cost constrain, project requirement, personal preferences or other factors, thus the design shall be iterated hence resulting an additional budget to the construction cost.

One of the current challenges in construction field is how to reduce cost of construction wisely after decision has been made or first draft has been presented.

Typically, after a design has been confirmed, based on the cost information given by the quantity surveyors, architects will rescale the design and sometimes redesign the project as an attempt to meet the budget required by the client. It is a trial method where architects usually puzzle out few schemes to test the ramification of the design to the cost.

It is questionable for architects to do budgeting. As argued by Deutsch (2012), architects have only small amount of knowledge on cost estimation and they are seen incomplete as the leader of the construction team. In the practicing industry, architects typically do not provide cost estimates as part of their standard services. Nonetheless, architects need to provide some estimation to convince the clients that the proposed project is constructible within the budget.

According to Cheung & Skitmore (2006), clients are generally eager to know the probable building price in early design stage for budgeting purposes. Clients see architects as the project leader; thus, they will seek for architects' advice in managing the projects' cost. However, architects actually solely rely on quantity surveyors to do the calculation and cost management (Bredemeyer & Malan, 2006). In conjunction, architects will respond to the cost information given by the estimator to rescale the plan as an attempt to meet the budget required by the client (Johnston & Master, 2004).

Architects usually reduce the total floor areas and material selection when they were asking to reduce the construction cost, as there are no other methods to be chosen. This has been proved by a pilot survey that has been conducted where all respondents consist of professional architects, designers and engineers who are practicing in Malaysia chose to reduce floor areas and material selection to reduce construction cost. Nevertheless, there are actually numbers of elements that might

have influence on the construction cost yet never be highlighted in the practicing industry.

Bowen (2001b) stated that building costs are influenced by plan shape, size, building height and space utilization and efficiency (Figure 1.1). Surprisingly, materials selection is not included under the influential design factors. It is located under specific category; qualification, where this category known as important reason in defining projects' quality.

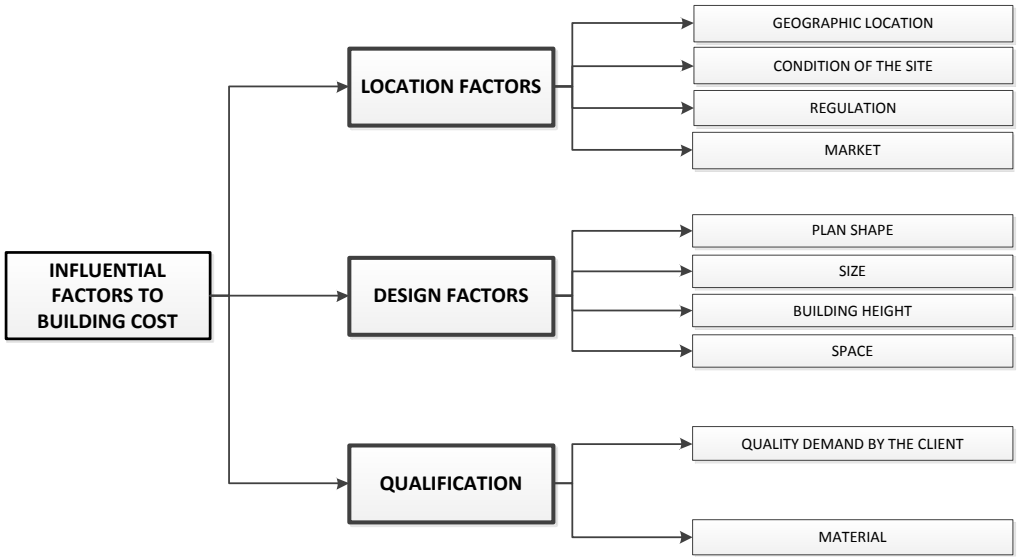

Figure 1.1: Building Cost Influential Factors (Bowen, 2001b)

Termansen (2010) claimed the traditional method used by the architects is very time consuming, it cost 60 per cent of the time used throughout the project to design and estimate and redesign again in order to meet the client's budget. According to Goldman (2006), for a two million dollars project, typically there will be 50 to 75 times of cost changes. This happens due to various reasons including design decision, design iteration, project changes and market fluctuation.

Cost normally monitored in two major phases, one is during design stage, and the other one is during construction started. Decision making during early design stage often been highlighted as a central issue, which impedes the pursuit of success in construction projects.

There is a high risk to the construction cost if the design of the project is not being properly managed during early design stage (Saifulnizam & Coffey, 2010). The cost of construction project is impacted significantly by the decision taken at the design stage (Arafa & Alqedra, 2011). As consequences, architects and designers should really take a serious look during early design stage when making a decision.

Currently, with the very common method of cost estimating, quantification of building project seems to be very time consuming (Alder, 2006). As supported by Rundell (2006), he claims that the common method requires 50 per cent to 80 per cent of cost estimator's times on each project and the estimation might be having some errors in calculation. Design changes, inaccurate drawn data provided, incomplete information given at early design stage by clients and consultants and various oversight due to manual calculation might become the reasons of why the common quantification method seems to be very time consuming. Thus, computer-generating system — in this case, Building Information Modelling (BIM) — should be implemented to reduce the time consume as well as producing a better, accurate and more sensible outcome. By experimenting cost in modelling, it is possible to identify and evaluate the impacts of selected design elements to the construction cost more explicitly and allows architects to design with having costing in mind. Another important issue is, architects can learn and understand easily the cause and impact of the changing design elements towards costing.

This study would like to find building elements that have strong influence to the construction cost, which can be manipulated by the architects to reduce construction cost more practical. It is anticipated that the findings of this study could offer a sensible way for architects to strategize cost management during early design stage. It is expected to help architects and designers to be well informed on the overall impact of design elements towards costing.

1.2 Problem Statement

In preliminary design stage, architects usually try to fulfil clients' wish and aim to get clients' eyes by making them impressed with some outstanding ideas. These eye-catchy projects sometimes cost more than the required budget, thereby clients request for some cost reduction.

Typically, after a design has been confirmed, based on the cost information given by the quantity surveyors, architects will rescale the design as an attempt to meet the budget required by the clients. Base on square foot figures, architects will work out few try and error method to test the ramification of the design to the overall cost. It will bring more benefit to the industry if architects acquainted with the impact of the design elements towards costing. By having this consciousness, architects will have a sensible costing understanding in mind while designing a good building project.

1.3 Research Questions

1) What are the building elements that can be manipulated by architects to reduce the construction cost during preliminary design stage in designing a building project?
2) What are the impacts of the building elements to the construction cost?
3) Are there any significant relationship between building elements and construction cost?

1.4 Objective of Study

1) To understand the significant relationship between building elements and construction cost.
2) To acquainted with the impact of the design elements towards costing
3) To have costing consciousness when designing a project.

1.5 Scope of Study

The research is based on case study. The study is focusing on a project that has been completed and has a complete data including drawings and costing. The selected building is a school project, school hall or any educational project classified under a medium quality and low complexity construction building based on its simple design and materials selected.

For this study, fluctuation index, location factor, labours and anything other than design category will be totally ignored. This study will only be focusing on the design elements, where architects can easily manipulate the elements to reduce cost during the design stage.

Design elements that have significant relation with construction cost during early design stage, focusing on single storey, medium quality low complexity project are identified from literature review. These elements then simulated using Building Information Modelling (BIM) to ascertain the position of each variable to get the best solution to reduce construction cost. The BIM software selected is Autodesk Revit as it is the most usable BIM software in Malaysia apparently, and it able to perform faster yet still maintains the equivalent accuracy than other software.

1.6 Significant of The Research

The findings from the research represented in this thesis are expected to be significant in further contribution to the construction industry especially for architects to manipulate the building elements to reduce construction cost during early design stage while remaining the gross area of the project. The study of the implication of BIM in building quantification will enrich the literature with a contemporary viewpoint on robust research. It is anticipated that the findings of this study could offer a sensible way for architects to strategize cost management during early design stage for their future project. A further benefit of the research is to offer the chance for a paradigm shift forward for architects to improve their cost analysis

for clients through their early involvement in the project using BIM, specifically in the Malaysian context.

1.7 Thesis Organization

This works has been logically structured to six (6) chapters and below is the summary of each chapter;

Chapter 1: Introduction is the background of the study and it comprises of introduction, background, statement of the problems, aims and objectives, research questions, scope of the study, significance of the study and the thesis organization.

Chapter 2: Literature Review presents the background of study in regards of construction cost and it dependencies as well as the implication of using BIM as an aid in construction industry.

Chapter 3: Research Methodology presents on how the study was conducted. The justification of the research, research design, and instrumentation are detailed presents in this chapter.

Chapter 4: Experimented Design Elements presents the table of inputs obtained from the experiments. It went through 95 experiments to show how the study was conducted and how the changes affect the construction cost. It introduces tables of

information on the selected design elements in detail on which components have been changed and how they reflected in the cost and design.

Chapter 5: Result and Analysis tackles on the results after the experiments have been conducted. The results are also illustrated in bar chart to show the comparison between the different elements, graphically. The analysis of the data also presented in this chapter in order to drive a statistical conclusion to the findings.

Chapter 6: Conclusion and Recommendation discusses on the findings based on the previous data analyses. The issue pertaining cost strategies during early design stage to promote a sensible way for architects to design is summarized in this chapter. To conclude the whole research, a review of the research objectives and a discussion on the implication of the study is also encapsulated. Followed by knowledge contribution, this chapter also promotes recommendations for future research.

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APPENDIX 1

PILOT SURVEY

1. Can you list down some of the computer software that you are familiar with? Preferably software to aid in architectural/engineering task such as drafting, documenting or simulating. (CAD, CAE and others)

2. How often do you use it?

3. Do you familiar with Building information modeling (BIM) software?
   If the answer is yes, list it

4. Have you try using it?

5. Do you find it very useful?

6. How do you budget the construction cost of one project in early design stage? Explain

7. How do you update yourself with the current rate of building construction?

8. Do you find any difficulties when dealing with other consultant in matter of project costing? Why? Explain it.