

APPLICATION OF BIM IN EARLY STAGE DESIGN COST ESTIMATION

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requirements for the award of the degree of
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To my mama, family and friends, thank you for the loves, supports, prayers,
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In the name of Allah, the most Gracious, the most Merciful

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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 menyusun strategi dan anggaran kos pembinaan pada peringkat awal rekabentuk dengan lebih mahir dan praktikal.

TABLE OF CONTENTS

CHAPTER	TITLE	PAGE
	DECLARATION	ii
	DEDICATION	iii
	ACKNOWLEDGMENT	iv
	ABSTRACT	v
	ABSTRAK	vi
	TABLE OF CONTENTS	vii
	LIST OF TABLES	xi
	LIST OF FIGURES	xvi
	LIST OF ABBREVIATION	xviii
1	INTRODUCTION	1
	1.1 Problem Statement	5
	1.2 Research Questions	6
	1.3 Objective of Study	6
	1.4 Scope of Study	6
	1.5 Significant of The Research	7
	1.6 Thesis Organization	8
2	LITERATURE REVIEW	10
	2.1 Early Design Phase and Its importance in Construction Cost	10
	2.1.1 Decision-making During Early Design Stage	12
	2.1.2 Architects Profession and Cost Management	14
	2.1.3 Elemental Cost Estimation	17
	2.2 Elements That Influence Construction Cost	21
	2.3 Building Information Modeling and Its Implication in Cost Estimation	29
	2.4 Summary	33
3	METHODOLOGY	35

3.1	Research Process	35
3.2	Statement of Problem	38
3.3	Hypothesis Establishment	38
3.4	Pilot Study	39
3.5	Design Elements Ascertainment	41
3.6	Experimentation Methodology	45
3.7	3.6.1 Instrumentation and BIM Simulation	47
	3.6.2 Economical Remodeling	50
	3.7.3 Statistical Analysis	51
4	EXPERIMENTED DESIGN ELEMENTS	55
4.1	The Experimental Model	55
	4.1.1 Door	56
	4.1.2 Window	58
	4.1.3 Wall	59
	4.1.4 Floor	60
	4.1.5 Roof	61
	4.1.6 Beam	62
	4.1.7 Column	63
4.2	Takeoff	64
4.3	The Experiments	68
	4.3.1 Element A; Door	68
	4.3.2 Element B; Window	84
	4.3.3 Element C; Wall	98
	4.3.4 Element D; Floor	106
	4.3.5 Element E; Roof	113
	4.3.6 Element F; Beam	117
	4.3.7 Element G; Column	120
4.4	Summary	124
5	RESULT AND DATA ANALYSIS	125
5.1	An Overview of The Research Process	125
5.2	Result	126
	5.2.1 Element A; Door	126
	5.2.2 Element B; Window	134
	5.2.3 Element C; Wall	142
	5.2.4 Element D; Floor	150
	5.2.5 Element E; Roof	158
	5.2.6 Element F; Beam	167
	5.2.7 Element G; Column	176
5.3	Summary	173

6	CONCLUSION AND RECOMMENDATION	186
6.1	Summary of Finding	186
6.2	Objective of The Study	188
6.2.1	Significant Relationship Between Construction Cost and Design Elements	188
6.2.2	The Impact of The Design Elements Towards Cost	194
6.2.3	Costing Consciousness	196
6.3	Recommendation for Further Study	198
6.4	Contribution and Final Remark	199
	REFERENCES	I
	APPENDIX	VII

LIST OF TABLE

TABLE NO.	TITLE	PAGE
Table 2.1	Differences Between Traditional 2D Construction Processes Versus Model Based Process	30
Table 3.1	Result Obtained from Pilot Survey	41
Table 3.2	Items Highlighted in BQ	43
Table 3.3	Item BQ category 1 Grouped Under Design Elements' Specification	44
Table 3.4	Tabular form A for Data Tabulation of The Experimental Subject	45
Table 3.5	Tabular Form B for Data Tabulation of The Experiments	46
Table 3.6	Tabular Form C for Data Tabulation of The Most Economical Design Elements	51
Table 4.1a	Door Element	57
Table 4.1b	Window Element	59
Table 4.1c	Wall Element	60
Table 4.1d	Floor Element	61
Table 4.1e	Roof Element	62
Table 4.1f	Beam Element	63
Table 4.1g	Column Element	64
Table 4.2	Table of Different of Both Quantity Takeoff Done in Revit by The Author and BQ by Quantity Surveyor.	65
Table 4.3	Paired Sample Rest for Revit Takeoff and BQ	67
Table 4.4	Element A Experiment A1 to A12	69
Table 4.5a	Experiment A1	70
Table 4.5b	Experiment A2	71

Table 4.5c	Experiment A3	72
Table 4.5d	Experiment A4	73
Table 4.5e	Experiment A5	74
Table 4.5f	Experiment A6	76
Table 4.5g	Experiment A7	77
Table 4.5h	Experiment A8	78
Table 4.5i	Experiment A9	79
Table 4.5j	Experiment A10	80
Table 4.5k	Experiment A11	81
Table 4.5l	Experiment A12	82
Table 4.6	Summary of Experiment Element A	83
Table 4.7	Element B experiment B1 to B12	85
Table 4.8	Façade Changes Based on Windows Designs and Sized Modification	86
Table 4.9a	Experiment B1	87
Table 4.9b	Experiment B2	88
Table 4.9c	Experiment B3	89
Table 4.9d	Experiment B4	89
Table 4.9e	Experiment B5	90
Table 4.9f	Experiment B6	91
Table 4.9g	Experiment B7	92
Table 4.9h	Experiment B8	93
Table 4.9i	Experiment B9	94
Table 4.9j	Experiment B10	95
Table 4.9k	Experiment B11	96
Table 4.9l	Experiment B12	97
Table 4.1	Summary of Experiment Element B	97
Table 4.11	Element C Experiment C1 to C12	98
Table 4.12a	Experiment C1	99

Table 4.12b	Experiment C2	100
Table 4.12c	Experiment C3	100
Table 4.12d	Experiment C4	101
Table 4.12e	Experiment C5	101
Table 4.12f	Experiment C6	102
Table 4.12g	Experiment C7	102
Table 4.12h	Experiment C8	103
Table 4.12i	Experiment C9	103
Table 4.12j	Experiment C10	104
Table 4.12k	Experiment C11	105
Table 4.12l	Experiment C12	105
Table 4.13	Summary of Experiment Element C	106
Table 4.14	Element D Experiment D1 to D10	107
Table 4.15a	Experiment D1	107
Table 4.15b	Experiment D2	108
Table 4.15c	Experiment D3	108
Table 4.15d	Experiment D4	109
Table 4.15e	Experiment D5	110
Table 4.15f	Experiment D6	110
Table 4.15g	Experiment D7	111
Table 4.15h	Experiment D8	111
Table 4.15i	Experiment D9	112
Table 4.15j	Experiment D10	112
Table 4.16	Summary of Experiment Element D	113
Table 4.17	Element E Experiment E1 to E19	113
Table 4.18a	Experiment E1 to E18	115
Table 4.18b	Experiment E19	116
Table 4.19	Summary of Experiment element E	117
Table 4.20	Element F Experiment F1 to F15	118

Table 4.21a	Experiment F1 to F5	118
Table 4.21b	Experiment F6 to F10	119
Table 4.21c	Experiment F11 to F15	120
Table 4.22	Summary of Experiment Element F	120
Table 4.23	Element G Experiment G1 to G15	121
Table 4.24a	Experiment G1 to G5	122
Table 4.24b	Experiment G6 to G10	122
Table 4.24c	Experiment G11 to G15	123
Table 4.25	Summary of Experiment Element G	123
Table 5.1	Result of Experiment A1 to A12	127
Table 5.2	Correlation; Door Element	131
Table 5.3a	Model Summary; Door Element	133
Table 5.3b	Coefficient	133
Table 5.4	Result of Experiment B1 to B12	135
Table 5.5	Correlations; Window Element	140
Table 5.6a	Model Summary; Window Element	141
Table 5.6b	Coefficient	142
Table 5.7	Result of Experiment C1 to C12	143
Table 5.8	Correlation; Wall Element	147
Table 5.9a	Model Summary; Wall Element	149
Table 5.9b	Coefficient	149
Table 5.10	Result of Experiment D1 to D10	151
Table 5.11	Correlations; Floor Element	155
Table 5.12a	Model Summary; Floor Element	157
Table 5.12b	Coefficient	157
Table 5.13	Result Experiment E1 to E19	159
Table 5.14	Correlations; Roof Element	165
Table 5.15a	Model Summary; Roof Element	166
Table 5.15b	Coefficient	167

Table 5.16	Result of Experiment F1 to F15	168
Table 5.17	Correlations; Beam Element	173
Table 5.18a	Model Summary; Beam Element	174
Table 5.18b	Coefficient	175
Table 5.19	Result of Experiment G1 to G15	177
Table 5.20	Correlations; Column Element	181
Table 5.21a	Model Summary; Column Element	183
Table 5.21b	Coefficient	183
Table 5.22	Cost Summary Before and After Undergone The Experiment.	185
Table 6.1a	Paired Samples Statistics	187
Table 6.1b	Paired Sample Correlations	187
Table 6.1c	Paired Sample Test	187
Table 6.2	Relationship Distribution of Design Elements Toward the Construction Cost	188
Table 6.3	Model Summary of Design Elements	190
Table 6.4	Model Summary of Design Elements' Characteristic	191
Table 6.5	Relationship Between Design Elements, Elements' Characteristic Toward The Construction Cost.	192
Table 6.3	Level of Construction Cost Dependency on Design Elements in Descending Order	194
Table 6.4	Fractionation of The Design Elements.	195

LIST OF FIGURE

FIGURE NO	TITLE	PAGE
Figure 1.1	Building Cost Influential Factors	3
Figure 2.1	Architectural consultancy; architects' scope of works	16
Figure 2.2	Cost estimation starts after the schematic phase in the basic architectural service	18
Figure 2.3	Project and cost estimating process	20
Figure 2.4	Construction Cost Organization diagram	25
Figure 2.5	Construction Cost Organization diagram	26
Figure 2.6	Construction Cost Organization diagram	27
Figure 2.7	Construction Cost Organization diagram	28
Figure 2.8	BIM integrated Model	32
Figure 2.9	Summary of Construction Cost Dependency	34
Figure 3.1	Research Process	36
Figure 3.2	Prototype of The Multipurpose Hall Produced in Autodesk Revit	46
Figure 3.3	Window Component Produced in Revit Attached With Its Property and Type Property	48
Figure 3.4	Example of Window Schedule Applied in One of The Simulated Model	49
Figure 3.5	BIM Simulation Operation	49
Figure 3.6	The Statistical Analyses Involved in This Study	52
Figure 4.1	The 3D view of The Multipurpose Hall	55
Figure 4.2	The Elevation Views of The Multipurpose Hall Highlighted on The Roof Skyline	61
	Figure 4.2a Side Elevation	61
	Figure 4.2b Front Elevation	62
Figure 4.3	Construction Cost Based on Takeoff	66
Figure 4.4	Cost Based on Its Elements	67

Figure 5.1	Line Graph of Result Experiment A1 to A12	128
Figure 5.2	Impact of Door Cost to The Construction Cost	129
Figure 5.3	Scatterplot of Door Operation to Construction cost	130
Figure 5.4	Scatterplot of Door Panel Material to Construction cost	130
Figure 5.5	Line Graph of Result Experiment B1 to B12	136
Figure 5.6	Impact of Windows Cost to The Construction Cost	137
Figure 5.7	Scatterplot of Window Type to Construction Cost	138
Figure 5.8	Scatterplot of Window Size to Construction Cost	138
Figure 5.9	Scatterplot Wall Cost to Window Cost	139
Figure 5.10	Line Graph of Result Experiment C1 to C10	144
Figure 5.11	Impact of Wall Cost to The Construction Cost	145
Figure 5.12	Scatterplot of Wall Material to Construction Cost	146
Figure 5.13	Scatterplot of Wall Finish to Construction Cost	146
Figure 5.14	Line Graph of Result Experiment D1 to D10	152
Figure 5.15	Impact of Floor Cost to The Construction Cost	152
Figure 5.16	Scatterplot of Floor Type to Construction Cost	154
Figure 5.17	Scatterplot of Floor Material to Construction Cost	154
Figure 5.18	Line Graph of Result Experiment E1 to E19	158
Figure 5.19	Impact of Roof Cost to The Construction Cost	161
Figure 5.2	Scatterplot of Roof Profile to Construction Cost	163
Figure 5.21	Scatterplot of Roof Material to Construction Cost	163
Figure 5.22	Scatterplot of Roof Frame to Construction Cost	163
Figure 5.23	Scatterplot of Wall Cost to Construction Cost	163
Figure 5.24	Line Graph of Result Experiment F1 to F15	170
Figure 5.25	Impact of Beam Cost to The Construction Cost	171
Figure 5.26	Scatterplot of Beam Type to Construction Cost	172
Figure 5.27	Scatterplot of Beam Size to Construction Cost	172
Figure 5.28	Line Graph of Result Experiment G1 to G15	176

Figure 5.29	Impact of Column Cost to The Construction Cost	179
Figure 5.3	Scatterplot of Column Type to Construction Cost	180
Figure 5.31	Scatterplot of Column Size to Construction Cost	180
Figure 6.1	Relationship Distribution of Design Elements Toward the Construction Cost	189
Figure 6.2	The strength of Elements' Characteristic to The Construction Cost.	193
Figure 6.3	Percentage of Design Elements' Contribution to The Construction Cost Defined by Their Characters	195

TABLE OF ABBREVIATION

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.

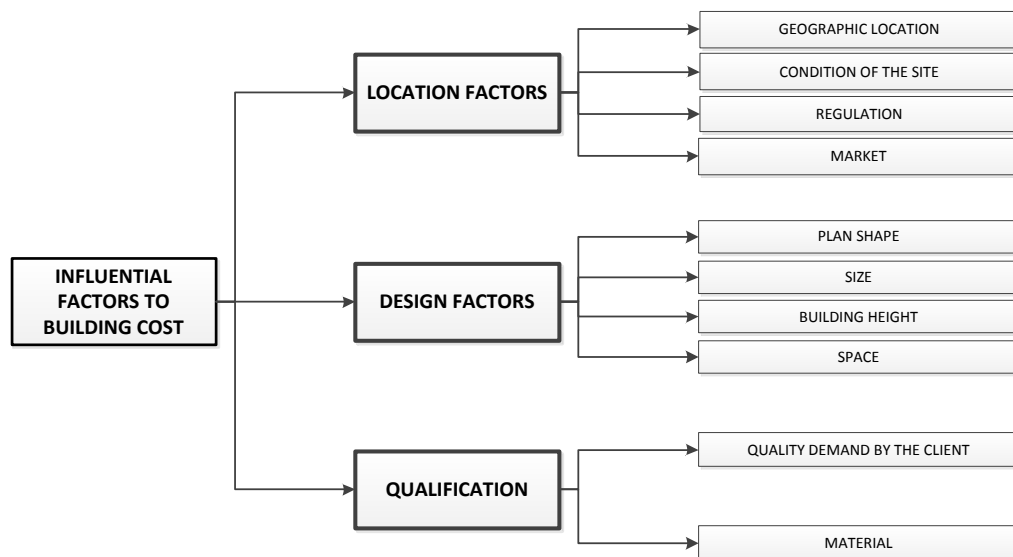


Figure 1.1: Building Cost Influential Factors (Bowen, 2001b)

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 work 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 its 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.