BUILDING COST ESTIMATION MODEL BASED ON COST SIGNIFICANT ELEMENTS OF HIGH-RISE CONDOMINIUM PROJECTS IN KLANG VALLEY MALAYSIA

By

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ABSTRACT

BUILDING COST ESTIMATION MODEL BASED ON COST SIGNIFICANT ELEMENTS OF HIGH-RISE CONDOMINIUM PROJECTS IN KLANG VALLEY MALAYSIA

Lim Cheng Sim

In Malaysia, pricing each single item of bills of quantities to predict the cost of construction projects in the detailed design phase is still the most widely used traditional cost estimating technique. However, this technique has become ineffective in accuracy because of its dependency on the level of the project data source and is time-consuming due to the tediousness of pricing large numbers of small work items. Some overseas researchers have developed cost-significant estimation models but there is no such study in Malaysia, not even on construction industry stakeholders' awareness of this alternative cost estimating technique. Therefore, this research aimed to develop a building cost estimation model based on the cost-significant elements (CSEs) of high-rise condominium projects (HRCPs) to aid building contractors and consultant quantity surveyors (CQSs) to substantially reduce the time and effort spent on cost checking during the tendering period. Three research objectives were set: RO1 to determine the building contractor's and CQSs' levels of cost significance awareness of HRCPs in Klang Valley, RO2 to appraise the CSEs of HRCPs in Klang Valley; and RO3 to develop a building cost estimation model based on the CSEs of HRCPs in Klang Valley. In this study, a survey questionnaire was used to achieve RO1 and case studies were used to achieve

RO2 and RO3. The results showed that the levels of cost significance awareness of HRCPs were low for both building contractors and CQSs. The CSEs were appraised successfully, and the cost-significant model has been successfully developed using six historical projects. The model was tested using two similar projects and achieved an accuracy of 98% to 99%. Since the model has been proven to be accurate, it will be extremely beneficial for use by the local construction industry to vastly reduce the time spent on cost estimation processes during tendering.

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APPROVAL SHEET

This ~~dissertation~~/thesis entitled "**<u>BUILDING COST ESTIMATION MODEL BASED ON COST SIGNIFICANT ELEMENTS OF HIGH-RISE CONDOMINIUM PROJECTS IN KLANG VALLEY MALAYSIA</u>**" was prepared by LIM CHENG SIM and submitted as partial fulfillment of the requirements for the degree of Doctor of Philosophy in Science at Universiti Tunku Abdul Rahman.

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SUBMISSION OF ~~FINAL YEAR PROJECT /DISSERTATION~~/THESIS

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

Construction projects are complex and time-consuming tasks. Every construction project is distinctive in its own way. The construction process is depending on multiple highly variable factors which are unforeseeable. Parties involved in construction projects comprise different combinations of main contractors, employers, architects, engineers, consultant quantity surveyors (CQSs), subcontractors etc. Construction cost estimations are developed for different functions and construction firms' success and failure is very much dependent on the sharpness of the estimating staff's skill. More often, a contractor must submit a lower tender sum in order to get a good chance of being awarded a project. Nevertheless, the tender sum must not be under-priced that the contractor cannot gain any profit or encounter loss in the project undertaken. As such, a good estimation technique is the most important factor in the preparation of a realistic tender. The contractor normally will need to prepare a detailed project cost estimation for submission of the tender. Construction projects are generally tendered on not a lump sum basis but a series of unit rates (Clough et al., 2015).

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Holm et al. (2005) mentioned that cost estimation is the most important initial process in project construction because it is the process of predicting the costs required for the project. One of the results of an inaccurate cost estimation is that the contractor will go into an unprofitable project (Ashworth and Perera, 2015; Lowe et al., 2006). Inaccurate cost estimations cause many problems for example change of work order, delay in completion of projects or the worst is the bankruptcy of the company (Albogamy et al., 2013). In view of all the problems of traditional cost estimation models, researchers and contractors start to opt for intelligent solutions (Elfaki et al., 2014).

According to Ashworth and Perera (2015), cost model is the symbolic presentation of some measurable structure that exists as regards its significant cost, analysis, comparison or control. The calculation of the costs of construction projects has conventionally been done by applying the calculated unit rates to the quantities provided in the tender document's bills of quantities (BQs). Cost estimation models are categorized according to their attributes. The first category is the traditional cost estimation models which include conference method, financial method, unit method, superficial method, etc., and BQs. The second category is the statistical models which include regression analysis, causal models, risk models, knowledge-based, resources-based, and whole-life cost models.

Besides the traditional cost estimation models and statistical models, some overseas researchers have developed the use of cost estimation models based on the cost significance principle. Poh and Horner (1995) demonstrated how they used the cost significance theory to acquire a simplified method based on student hostels in Singapore which is highly accurate. Tas and Yaman (2005) constructed a building cost estimation model based on cost significant work packages of Turkish public residential buildings. Wang and Horner (2007) developed two cost models based on the cost-significance technique to measure the costs for premix road maintenance projects.

1.2 Problem Statement

Malaysia as one of the former British Protectorates, pricing every single item of BQs to predict the cost of projects in tendering is still the most widely used traditional cost estimating technique. However, this traditional cost estimating technique has become ineffective in accuracy as a result of its dependency on the level of the project data source and time consuming due to the tediousness in pricing large numbers of small items of work. Despite the fact that some international researchers have developed cost estimation models based on the cost significance principle, no study on their use or on the construction industry stakeholders' awareness of this alternative cost estimating technique has been conducted in Malaysia.

Apart from Poh and Horner (1995) and Tas and Yaman (2005), who used the cost significance principle to develop cost significant models for residential buildings, there hasn't been much research in this area. The models developed by Wang and Horner (2007) which were based on the cost significance method were on road maintenance projects. In the late 2010s there were cost significant models developed by many researchers in Indonesia, but they were also done only for infrastructure works. Both the models by Poh and Horner (1995) and Tas and Yaman (2005) were developed based on buildings of four to five storeys. The methods adopted to develop the models were very tedious as they had to firstly find the cost-significant work items in BQs and then similar work items were grouped together to select the work packages. The models developed were in trade form i.e., the works were grouped according to the trades of construction works and put into trade bills. However, for the current practice in the Malaysian construction industry, the majority of the BQs of tender documents are prepared in elemental form thus models based on trades form are no longer suitable to be used. Furthermore, due to the scarcity of land, low-rise residential buildings are not viable in urban areas. As such, the researcher has chosen to base on cost significant elements (CSEs) of high-rise condominium projects (HRCPs), create a building cost estimation model of which the method adopted is less tedious because the BQs used are readily in elemental form.

1.3 Research Questions

The purpose of this research is to answer the following research questions (RQ) based on the phenomena and issues being discussed in the problem statements in Section 1.2.

RQ1: Are the Malaysian building contractors and CQSs aware of the cost significance technique for estimating construction costs of HRCPs' in Klang Valley, Malaysia?

RQ2: What are the CSEs of HRCPs in Klang Valley, Malaysia?

RQ3: Is it possible to develop a building cost estimation model based on CSEs of HRCPs to accurately estimate the total building costs of HRCPs in Klang Valley, Malaysia?

1.4 Research Aim and Objectives

This research has aimed to develop a generic building cost estimation model based on CSEs of HRCPs in Klang Valley, Malaysia in order to aid building contractors and CQSs to substantially reduce the time and effort in cost checking during the tendering period. To achieve this aim, three (3) research objectives (RO) were set as below:

RO1: To determine the building contractors' and CQSs' levels of cost significance awareness of HRCPs in Klang Valley, Malaysia.

RO2: To appraise the CSEs of HRCPs in Klang Valley, Malaysia.

RO3: To develop a building cost estimation model based on CSEs of HRCPs in Klang Valley, Malaysia.

1.5 Scope of Study

Because the first objective of this research is to determine the building contractors' and CQSs' levels of cost significance awareness of HRCPs in Klang Valley, Malaysia, the targeted respondents were all the Malaysian CQSs and estimators working in quantity surveying consultant firms and building construction firms respectively who have experience in pricing tender or pre-tender estimates of HRCPs in Klang Valley, Malaysia.

On the other hand, as the main objective of this research is to develop a building cost estimation model based on CSEs of HRCPs in Klang Valley, Malaysia, the cost data must be extracted from the contract documents of completed HRCPs in Klang Valley, Malaysia.

1.6 Research Methodology

The researcher started this study by gathering preliminary ideas for the research area interested. This was accomplished by searching secondary data such as scholarly articles, published journals, books and other sources related to the topic. Issues arising from the interested research area were observed and the research topic was firmed up. After the preliminary study and selection of the topic in stage 1, the researcher moved on to stage 2 namely the research proposal. In this research, the literature on cost estimation methods and models was critically reviewed in order to set the research aim and objectives, as well as the scope of study. The research methods and data collection techniques were then selected from the options of published guidelines from past researchers. The final stage was then started with the data collection and analysis process. The process of searching for secondary data continued from stage 1. Meanwhile, the primary data were collected by questionnaire survey and case study cost data collection. In this research, the questionnaire survey was meant to collect quantitative data to achieve the RO1 which was to determine the building contractors' and CQSs' levels of cost significance awareness of HRCPs in Klang Valley, Malaysia. On the other hand, the case study data collection aimed at case study projects' historical cost data of HRCPs in Klang Valley, Malaysia. The purpose of the case study data collection was to identify the CSEs and further develop a generic cost estimation model based on CSEs of HRCPs in Klang Valley, Malaysia (RO2 and RO3). Finally, the writing up of the thesis which included the summary of the findings and recommendations for the future study took place.

The research methodology flow chart is displayed in Figure 1.1.

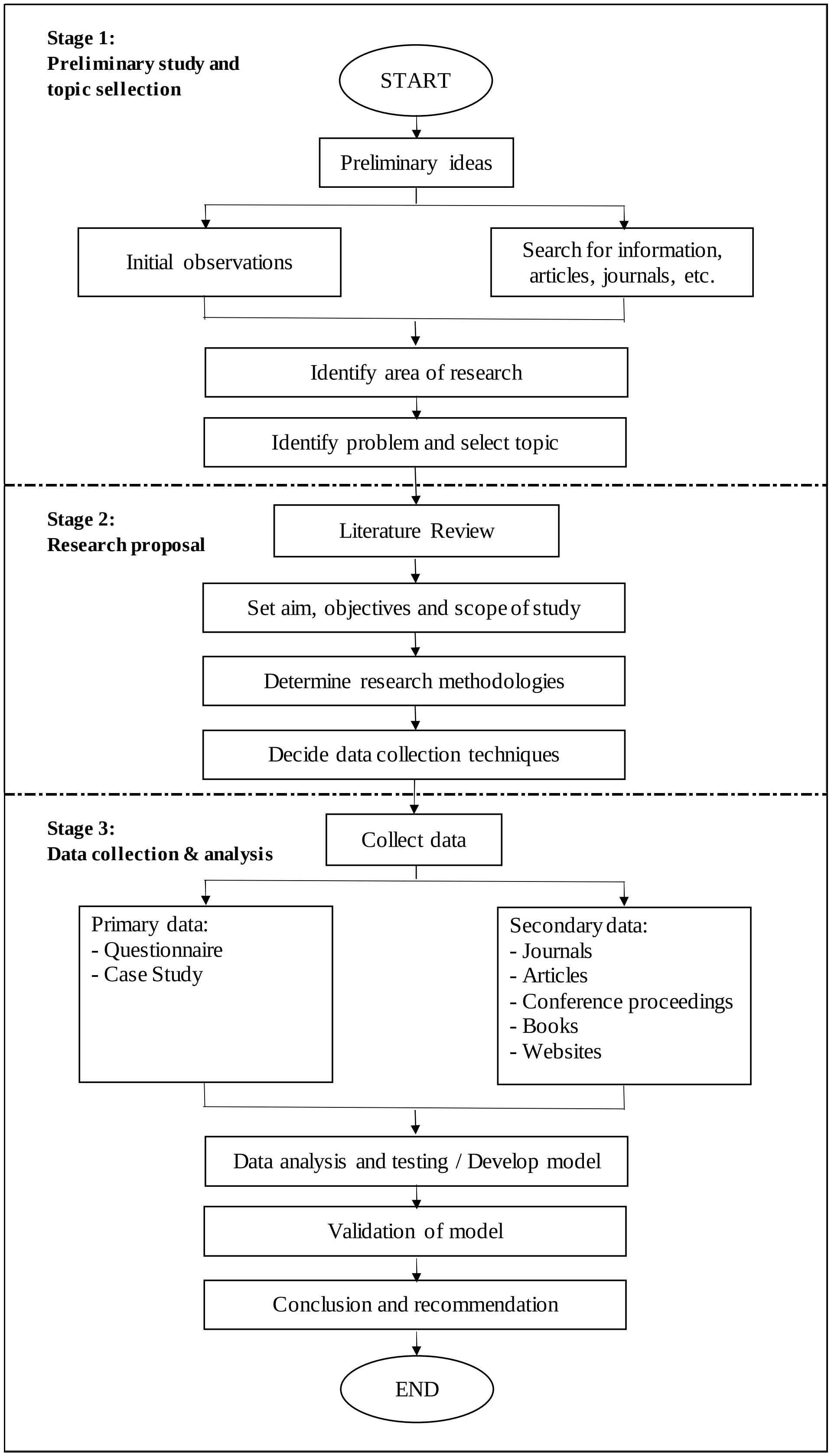


Figure 1.1: Research Methodology Flow Chart

1.7 Thesis Structure

This thesis comprises six main chapters which are Chapter 1 – Introduction, Chapter 2 – Literature Review, Chapter 3 – Research Methodology, Chapter 4 – Data Analyses and Findings, Chapter 5 – Discussions of the Results, and Chapter 6 – Conclusion.

Chapter 1 (Introduction) discusses the background of the study, problem statement, research questions, research aim and objectives, the scope of the study, research methodology, and thesis structure. In this chapter, the research issue to be addressed has been identified. The research questions were posed, and then the research aim and objectives were successfully developed. The last two subsections which are the research methodology and thesis structure are presented to enable comprehension of the flow of the study.

Chapter 2 (Literature Review) discusses and explains in detail the definitions of cost estimation, types of cost estimation, techniques of cost estimation, people involved in cost estimation, cost estimation exercises, construction project cost estimation, and cost estimation challenges. It is meant to give the readers an in-depth understanding of what cost estimation is. The basic knowledge of cost estimation is essential for the understanding of the entire part of the thesis. Furthermore, the cost significance techniques used by previous researchers were discussed. Lastly, the research gaps and the theoretical framework of this study are presented.

Chapter 3 (Research Methodology) displays the subsections on research methods that consist of quantitative research, qualitative research, and mixed methods research; research design; data collection methods that comprise of literature review, questionnaire, and case study; questionnaire data analysis methods that consist of descriptive analysis, Cronbach's alpha reliability test, mean analysis, Mann-Whitney U test, and Kendall's tau-b correlation analysis; and case study data analysis method.

Chapter 4 (Data Analyses and Findings) consists of two main sections, i.e., the questionnaire survey and the case study. The questionnaire survey section demonstrates the subsections on summary of questionnaire data analysis methods; the response rate; the descriptive analysis of the respondents' demographics consists of the nature of the business of the current company; experience in pricing HRCPs in Klang Valley, Malaysia, experience in pricing HRCPs in Klang Valley, Malaysia between different natures of business; and the local practice; the results of Cronbach's Alpha Reliability test; the results of mean ranking analysis; the results of the Mann-Whitney U test; and the results of the Kendall's tau-b correlation analysis. On the other hand, the case study section demonstrates the subsections on the development of the idea for case study; results for preliminary study 1; results for preliminary study 2; finalized criteria for case study which consists of case study revelations, case study corrective actions, and the final cost estimation model. The final cost estimation model's section has further discussed the brief specification of the case study projects, design/shape information of the case study projects, elemental cost contributions of the case study projects, the cost estimation model based on

CSEs of HRCPs in Klang Valley, Malaysia, and the validation of the cost estimation model developed.

Chapter 5 (Discussions of the Results) discusses the meanings of the results. This chapter helps others to understand about the study and the emphasis is on the study data.

Chapter 6 (Conclusion) wraps up the whole research process. It summarises how the research objectives were accomplished. Following that, the significance of the study, limitations, and recommendations for future research are all included.

1.8 Chapter Summary

This chapter gives the readers an overall view of the whole study flow, the background of study and the study processes. The researcher was able to reach at the aim and objectives after the background of study and the issues were identified. The chapter enables the readers to have a better perception on the research topic after reading this introduction of the whole study.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter explains in detailed the definitions of cost estimation, types of cost estimation, techniques of cost estimation, people involved in cost estimation, cost estimation exercise, construction project cost estimation and cost estimation challenges.

2.2 Definitions of Cost Estimation

In the context of cost management, costing is defined as the process to total up, to categorise, and to assign direct materials, costs of labour, and costs of factory operation on products, services or projects. A well-defined cost object relationship with its cost drivers is expected to be established through cost estimation. Cost estimation of various design solutions is able to present the best value to the client while the costs are kept at their minimum (Blocher et al., 2016).

Cost estimation is a subtopic of construction economics study which discusses about the use of finite resources in building and infrastructure construction. In short, cost estimation calculates the probable cost of a project and gives justification of expected cost prediction of items of resource that form the total construction tender price (Akintoye, 2000). The cost of labour, material, and facilities for multiple work elements shall be taken into account in the bill of quantities and specification of works like piling, groundwork, masonry, woodwork, structural steel work, roofing, surface finishes and landscaping; preliminaries; overheads and establishment charges; dayworks; provisional amounts; and prime cost sums when presenting the cost estimation of building and civil engineering projects (Geddes and Williams, 1996).

Cost estimation, hence, requires a series of systematic analysis of project and construction costs recommended (CIOB, 2009). In the process of determining the possible construction costs, the most economical construction methods that allows the specific construction works to be completed within the contract permitted time should also be considered (Knutson et al., 2009). The initial construction costs and costs-in-use essential throughout the building lifespan ought to be included in cost estimation (Ashworth, 2010). Unlike before, clients these days are no longer unfamiliar with the construction industry. They want to be advised on the final cost estimation as that is the actual figure that need to pay upon project completion (Kirkham, 2015).

All the above-mentioned definitions are general explanations of cost estimation. However, interpretations of cost estimations vary because it comes in different types. According to Doloi (2011), a construction team is formed by multiple parties that comes from different principles who are project managers, tendering team, business development team, land development team, project consultants and project financiers. Each of the parties possess respective responsibilities in the project life cycle. Thus, selection of suitable cost estimation shall be done after proper review and understanding of cost estimation types.

2.3 Types of Cost Estimation

Hinze (2012) stated that conceptual estimations and detailed estimations are among the construction cost estimations that are grouped according to their purpose of preparation. Before decision is made for construction, prospective project clients adopt conceptual estimations to obtain a rough figure of the cost of construction. The potential client had no choice but to depend on this conceptual estimation to understand the amount of capital required for that particular construction and its feasibility even though it is only an approximate calculation of the possible construction cost. Contrary to conceptual estimations, before entering the contract, the tenderers will prepare the detailed estimations through analysis of essential operations needed towards completion of project.

According to Kerzner (2013), there are four cost estimation types in project management. They are order-of-magnitude estimation, approximate kind of estimation, definitive kind of estimation, and estimation with the use of learning curves. When specified engineering information is not available, order-of-magnitude can be adopted by using information like experience, parametric curves, and estimated, capacity to prepare preliminary estimations. Similarly, approximate estimations are done without full design information. This type of cost estimation takes reference of similar design information from past projects and makes assumptions of the likely cost. Conversely, when detailed design data, plans and specification are available, definitive estimation of detailed estimation can be applied. While estimation using learning curves are usually used to calculate approximate time and cost required for operations of manufacture.

To summarise, it is critical to be informed on the cost estimation outcome, which includes rough quantities of materials, time, and cost required, before the client makes construction decisions such as contracting, pricing of works, establishing interim payment amounts, and project management team monitoring of actual quantity on site. Thus, it is vital to identify the type of cost estimation suitable for different project stages to cost the building design, to tender the works of construction, to control the actual costs on-site including estimation of order changes (Knutson et al., 2009). The cost estimation methods of pre-tender cost estimation are elaborated in the following section.

2.4 Techniques of Cost Estimation

Holm et al. (2005) stated that the categorisation of cost estimations by project degree would be consistent with the AACE International Philosophy of Total Cost Management, as this is a norm powered method implemented over the entire life cycle of a project. The distinct project description levels used to define cost estimation represent the usual phases and gates used by the stakeholders in project life cycle for assessment, authorisation, and execution (AACE, 1997). Table 2.1 shows the events that happened at different stages of the life cycle of the project, the plan of work, and the estimation kinds implemented at each cost planning processes. The purposes of pre-tender estimations are to fix the project forecast, to track the cost of project during the design process, also to contrast different design solutions' cost. To elaborate further, the key functions of cost estimations are: to prepare a preliminary project estimated cost for the client, to evaluate the feasibility of project, to design the project by not exceeding the cost limit, to analyse another design options and project elements, to prepare tenders, to prepare cost plans, to fix project budgets, to determine the expense impacts of order changes, to support claims while settling conflicts, to create schedule of values for demands of progress payments, and to form a background data on cost of building.

Table 2.1: Estimation Classifications

Stage	Event	Plan of Work	Estimation Types	Cost Planning Process
1	Project Identification	Consultation	Preliminary	Initial Estimate
2		Brief	Feasibility	Firm Estimate
3		Investigation	Viability	Preliminary Cost Plan
4	Project Definition	Constructional Details	Authorisation	Final Cost Plan
5		Working Drawings	Final Budget	Cost Check
6	Project Execution	Construction	Control	-

Source: Asworth and Perera (2015)

Isaac et al. (2010) defined financial approach as a methodology of development evaluation which is adapted by the land developers to assess the feasibility of the project primarily for housing schemes and construction of commercial buildings. The overall construction expense includes building costs, building costs' interest, professional fees, professional fees' interest, void time (letting time)'s interest, contingencies, charging expenses, advertisement, and land cost must be excluded from the overall production value when estimation the income of a project. This price of development performed can be determined by the way of multiplying net rental profit by year of acquisition or return on investment. The equation mentioned would also be used by simulations to measure the sum for permissible building costs and the sum for purchase of land.

Secondly, the functional unit which is also known as unit of accommodation method applies unit cost of preceding projects. This unit of accommodation method divides the overall cost of construction by the quantity of functional units to determine the unit cost. For instance, it could be "cost per number of room" or "cost per number of bed" or "cost per number of parking space". This strategy is with the benefit of settling vast measures when determining the construction budget. However, it should be understood that this budget varies from the final cost of construction because the cost will be affected by factors like the site physical conditions, the client's brief or requirements, the existence of available services closed to the project, the building's specification and the project's business characteristics (CIOB, 2009).

Having said that, the previous method is not ideal for buildings like warehouses and open plan offices. For these kinds of buildings, a more accurate building cost estimation method could be adopted, which is the superficial floor area method. In short, this method calculates the cost by multiplying the building's gross floor area by an acceptable cost per square foot, as reference to a historical cost stored in database. Moreover, the superficial floor area method is also suitable in estimation the cost of external works' packages like concrete paving works and road surfacing works, with adjustment made based on its location, inflation and specification. Furthermore, physical characteristics of the building could bring out subjective judgements which is the reason why the assessment of external works shall be done separately. Due to the relevancy and simplicity of this cost estimation method, it is popular and commonly used by the profession (Brook, 2011).

Among the many methods, most cost estimators acknowledge the approximate quantities method as the most efficient operating method. Different from the methods before, approximate quantities method is also known as multiple rate approximate estimation method which could achieve accurate and reliable cost estimations because it needs a full set of building design and elaborated specification information. Hence, this method is only useful for when detailed design is available, or during final design stages, and tender production stages. Since uniform method to quantify estimated measurements for components is not available, measuring and costing of the builder's quantities for projects based on specifications and drawings is resorted to when predicting the cost of the project and when cost checks of individual items is conducted.

As a result, this approach allowed the estimators the versatility to quickly produce a reliable calculation within a limited timeframe (Smith et al., 2016).

Lastly, the elemental estimation method makes use of basic cost studies of prior related historical projects as the reference for a tentative cost model for the current project. Under this process, the cost of the sub-elements, the cost of group elements, and the overall cost of the project can be measured on a cost basis of per square foot. It offers flexibility in adjusting the cost due to design variations in the current scheme as opposed to previous venture. Additionally, elementary costs covered by element unit amounts and element unit prices may assist the cost manager to approximate current project costs if reviewed along with specification and design information, providing that the assessed costs are revised for cost adjustments after the previous project's tender date. Knowingly, the primary components of building design would have an effect on the overall cost of the project financially. (Seeley, 1996).

Kirkham (2015) claimed that since most of the contractors pay approximately the same rates on labour and supplies, their capacity to handle building projects will induce the disparities in their final costs. However, prior resource-based calculation is made, cost estimators need to utilise bar charts and network diagrams to refer to the full design plans when scheduling the building work. As a result, resource-based estimations are not appropriate to be included in the preparatory process of the project to determine the construction budget. Having said that though, in certain cases, predicting the cost of a proposed project on the basis of a resource-based calculation is faster and more efficient than calculating using past project costs.

The above methods of pre-tender cost calculation discussed up to now are conventional costing models which the building industry has been using for decades. The adaptation of cost analysis in handling construction costs has helped estimators in looking for an optimal way to incorporate a new proposed development project. Particularly, the cost model may be utilised to convey the system's information and concepts such as forecasting the likely future expense of a construction project to be constructed in a specific location and suggestions on room usage centred on the model's design analysis. Apart from this, the cost model built will also be able to determine how the system operates in other circumstances and include explanations for the system's conduct, i.e., changes in overall project expense as the consequence of various contracting processes, also how costs vary as the building height rises.

Typical cost model taxonomy has demonstrated that there are 4 types of cost models. In reference to regression analysis, one of the most commonly adapted mathematical methods, deductive cost models can analyse the associations between certain important variables of design, i.e., dimensions, form, building height, and overall building cost as the first type of cost model. Next, the following type of cost model, inductive cost models would yield results that are not correlations but causal like the unit rate in the BQs that will be considered as a cost model for the specific item of completed construction work as the contractor prices it.

The third category of cost model is optimization cost models that look for best solutions, taking into account the constraints, by exploring the practical solution space and looking for the part that suggest the best answer including energy estimation applications to improve sizes of pipes, sizes of windows, and the quality of insulation. Ultimately, the 4th category of cost model which is called stochastic cost models are developed through the introduction of risk management approaches to consider the economic risk. Relatively, the Monte Carlo simulation method that mimics operation over time and tests the system's life cycle will possibly be used to produce cost estimation ranges with predicted values. Noticeably, cost models are able to develop economically and effectively because of current computing technologies (Jaggar et al., 2002).

Nevertheless, many cost models made in the construction industry for the implementation have been quite positive. This is proven by the capability of such expense models to reliably estimation building costs at a high level. Definitely, today academics and professionals have learned a great deal from the information and communication technologies under which cost models are incorporated under computer systems, for instance, to simplify estimations and crunch numbers. In the early years of using computer science to calculate the project costs, knowledge-based systems (KBS) that use artificial intelligence technologies in the process of problem-solving were commonly used to deliver more reliable forecasts of construction costs within a shorter time span (Akerkar and Sajja, 2010).

In Turkey, Mohamed and Celik (1998) have built an automated knowledge-based method for alternative type of designs and materials selection and cost estimation to be used mainly for pre-design research, as it is important to provide a cost estimation tool that helps the planner to do a quick 'what if' research of design approaches and material selection during pre-design. In addition, the knowledge-based method often combines material collection and cost analysis for post-detailed construction by enabling input of building unit measurements from finished designs/drawings or by directly import the necessary data from the software like computer-aided design (CAD). In general, the device generates amounts of the operations, prices, and the chosen products complete with the corresponding amounts.

A generalized linear model-based expert way to predict the cost of the transport projects was developed by Chou (2009). A few parametric quantity estimation equations are included in the framework to be used by the Transportation Department of Texas (TxDOT) to estimation the early infrastructure quantities and to continually track and manage the project costs. The program would hire up-to - date unit rates for job products based on the current business conditions. Subsequently, these unit values are added to the expected quantities to identify the probable approximate overall cost of a project. This approach thus allows the planning of a more thorough cost estimation at the early phase of the project growth.

Through using case-based inference and the genetic algorithm, Kim and Kim (2010) presented a basic cost estimation model. They tested a mass generation genetic algorithm and used it on real project execution. In the early stages, producing a more functional cost estimation model for construction using a mass estimation methodology in the development of the software for building cost estimation. A notional cost estimation model that combines approximate series of theories, logic from case basis, and genetic algorithms to enhance cost forecasting in the stage of conceptual planning was introduced by Choi et al. (2014). Genetic algorithm was adapted to help in discovering suitable solutions through rough range and case-based reasoning models. The model being developed is considered to be more accurate and stable than the current model for cost estimation.

A cost estimation module that enables fast and accurate analysis of the original concept in a 3D modelling context was presented by Cheung et al. (2012). With this module, cost estimators can collect the information of quantities from 3D models, and calculations guided by the profile are immediately updated. This model of data uses a robust unit price method that is potential to be extended in incorporating some measures, like estimation emissions or estimation waste. Other than that, an ontological inference method was suggested by Lee et al. (2014) to digitalize the effort of looking for the most appropriate tiling job objects. The search method may therefore be performed entirely without being interfered by cost estimator. However, the standard of the outcome would subject to the ontology specified by the specialists. The suggested framework aims to develop and extend the adaptation of BIM (Building Information Modelling) technology.

A mathematical formula for the construction cost calculation of seismic retrofit net of an enclosed building in masonry was introduced by Jafarzadeh et al. (2015). The building cost has been better estimated by integrating four (4) elements: overall floor plan area, seismic weight's predictor, sizes of floor and roof diaphragm, and quality of mortar; Cost-area double-log model is proposed to generate an approximation at preliminary design stage of seismic retrofitting. An artificial neural network model for calculation of the conceptual design and building management costs of engineering resources for projects of public construction was provided by Hyari et al. (2016). This built model includes the expense of engineering resources, while in the available models, it merely emphasized the cost estimations of construction. It thereby enhances the planning of cost estimations for the early public building programs.

2.5 People Involved in Cost Estimation

Gould and Joyce (2014) contended that knowingly, role of the estimators is vital in building company because they have the obligation to obtain jobs that are required to keep their operation running. One of their jobs is to compile a full documentation of all costs of the project in reference to the design drawings they have been presented with. They also have comprehensive expertise on the material, labour, and service costs. Such expenses will be tied back to the construction processes. For that purpose, estimation involves detail-oriented and well-coordinated professionals. Therefore, estimators operate under pressure in most of the cases as they are responsible to tender on a project with limited time frame and all details in the project have to be covered by the tender.

Estimators can genuinely have different experiences and learn skills because a handful of them joined the industry as developers, contractors or consultants.

Peterson and Dagostino (2015) stressed that contractor's estimators need to hold ample building experience to gain a strong understanding of working environments that includes on-the-job material handling techniques, the most efficient construction methods, and labour efficiency. An estimator should be able to picture the building process from this knowledge and provide a reasonable estimation. Estimation is truly not an absolute science. Therefore, the precision of the final calculation would subject to the ability and judgement of the estimators. This ability and judgement do not form overnight, so they have to be developed over time. In short, this skill helps the estimators to adapt detailed calculation techniques while their judgement helps them to picture the project development process.

CQSs in Malaysia are qualified to be the professional in construction industry who could make recommendations on construction's costs, and financial plus contractual administration. The CQSs are also the specialists in the expense and operation of building projects, particularly in the housing, infrastructure or heavy engineering fields. The tasks that a CQS has to perform are to determine the expense of planning the site; the expense of design, labour, equipment and plant; consulting fees; taxes; the possible cost of running and maintaining new buildings; and propose alternate plans. They would also recommend the company regarding suitable contractual arrangements to be used for a project (RISM, 2016).

RISM (2016) illustrated fundamental and complementary services offered by the qualified CQSs. Many of a CQS's basic duties include, i.e. planning the construction project 's draft cost estimations and cost plans, preparing the quantity bills or specifications report for tendering, drafting and implementing the formal contracts, and producing the routine recurrent financial reports throughout the construction phase. Many more potential responsibilities of a CQSs are planning a project's feasibility reports, evaluating cost estimations on the project 's economy during the design process, pricing the quantity bills or discussing and approving pricing model, and auditing contracts and the corresponding budgets and expenditures.

Aside from the CQS, though, the cost estimators are recognised as specialists in estimation a project 's costs. The U.S. Department of Labor, Bureau of Labor Statistics (2011) indicated that approximately 59 percent of cost estimators are working in the building industry, while about 15 percent are working in the manufacturing field. Cost estimators who are practising in building industry usually went through certain college programs and earned a bachelor's degree in building, construction management, or construction science, or hold work experience for years in all phases of construction or in a specialist craft field. Furthermore, cost estimators are also experts in their particular fields as they are accredited by many related organizations such as the American Society of Professional Estimators (ASPE), the Association for the Advancement of Cost Engineering (AACE International), and the United States-based Society of Cost Estimation and Analysis (SCEA).

Likewise, cost estimators hold responsibilities in estimation the expense, scale and length of potential ventures correctly by determining the cost details that consumers and company owners require in order to tender on a contract or to assess the feasibility of a product or project recently proposed by defining the applicable activities. Also, in the building of the United Kingdom (UK), Hackett and Hicks (2007) elaborated on the role of CQSs and estimators in playing an important part in the viability of construction contracts. In this situation, all specialists in this sample have become study subjects.as cost specialists in building projects.

2.6 Cost Estimation Exercise

The cost estimation exercise is the relative exercises and actions in making an estimation of certain costs. Yet specific construction members in the same industry viewed the exercise differently. CQSs usually apply the term cost planning to pre-tender cost estimation in the surveying exercise. There are, specifically, three phases of construction cost preparation (Kirkham, 2015). Activities performed during the first level of cost accounting are presenting the customer summary, offering guidance on sourcing, and setting budgets. Just a very rough calculation is made of costing the report, as the lack of details has impeded other approaches to be used to measure the expense. One of the most common approaches for preliminary cost estimation are unit approach, cube approach, and superficial or floor area approach (Seeley, 1996).

The second stage is cost preparation and management of the construction exercise. During this process, the assessment of the design of the building is primarily conducted on the budget allocated for such design or feature. Then it is linked to the profit the customer will gain and in that situation a cost-benefit study will be done to determine the cost effectiveness of construction designs on this particular project. Subsequently, the comprehensive summary and a report of cost estimations are then to be planned. The conceptual cost plan is prepared to calculate a cost estimation for the project and the specific cost plan is the actual cost plan that lays out the cost depending on the construction item.

At last, cost control during procurement phase and construction phases is the third stage of the planning of building costs. According to Ashworth (2010) this is a post contract cost control because the function of cost planning is executed successfully when the design remained within the forecast amount as demonstrated by a reasonable tender sum. Therefore, it is expected that the actual construction cost should also come within the target figure. Figure 2.1 demonstrates the detailed calculation process that uses BQs to describe job definition and quantity construction. Thus, before attempting to enter a competitive tender, the tenderers have to calculate the unit rates of the items.

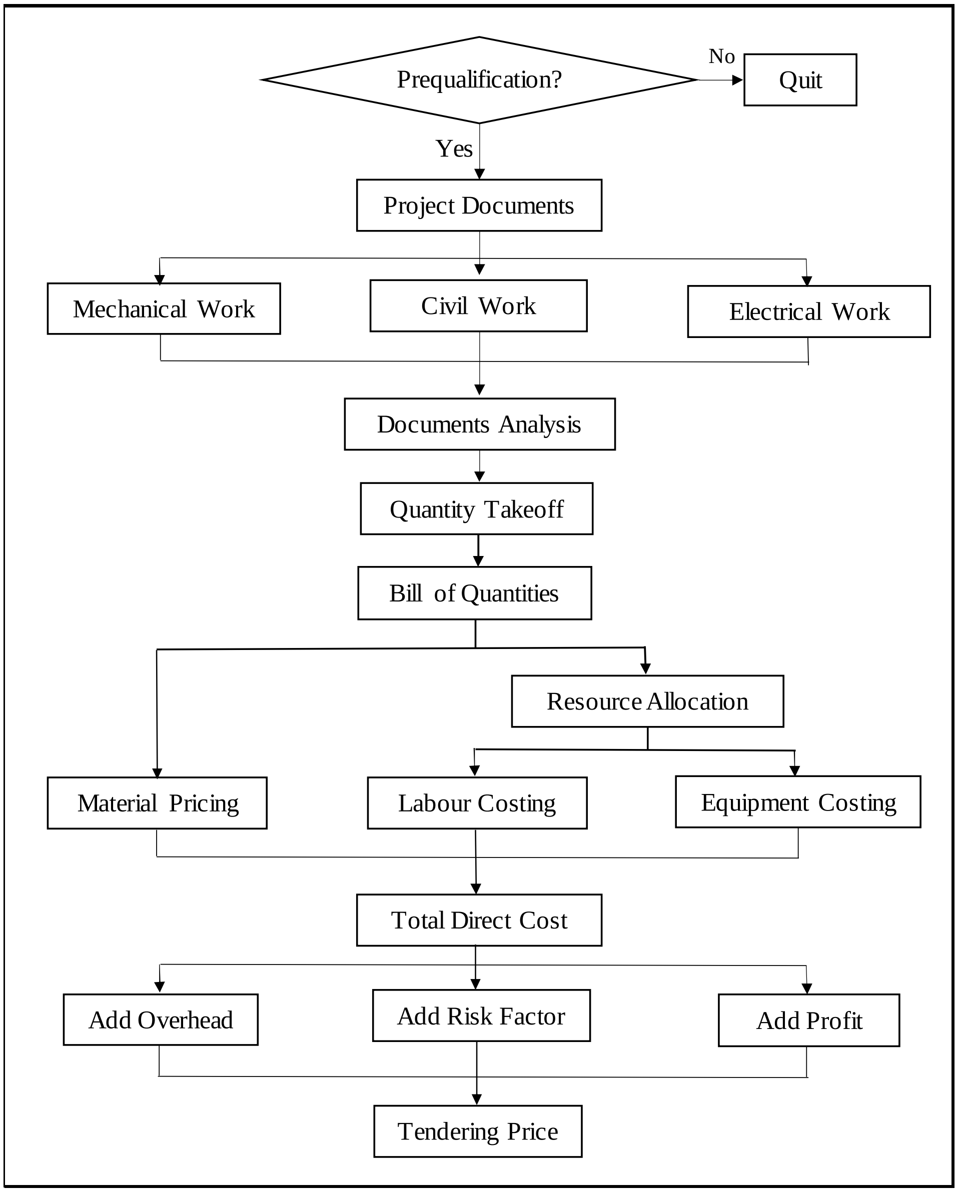


Figure 2.1: The Process of Detailed Estimating (Al-Harbi et al., 1994)

The bill of quantities is a cost model dependent on the product as it is structured on the basis of building components (Kirkham, 2015). Using prorated efficiency levels for costing all the work products, the procedure of unit cost build-up is subsequently carried out. As an outcome, this occurrence has resulted in the production of inaccurate unit price of products, because the real efficiency of work to complete the job is calculated from the real time taken for construction. In this way, pricing work products without establishing the construction work program is basically to overlook the impact of work sequences which will holds a significant effect on production levels and the duration of the work in whole.

Moreover, the presumption used in the estimation of a unit price of work is always inaccurate, as each building project is special, and the different work environment may have already put various challenges on the project. Therefore, it is ideal that consideration of labour constants, material constants and output of machinery from past project information are prioritised to establish the work program and can thus be used as a guideline of calculating the cost of each related operation. For regions that do not perform quantity surveys, construction cost estimators are qualified to produce cost estimations depending on the approach of construction management or project management.

Conversely, from the perspective of project management, it is noticeable that the work breakdown structure must be sorted out before estimation sensible costs for each element in addition to determining the full set of job demands and developing a reasoning network with checkpoints (Kerzner, 2013). To Verzuh, (2016), a work breakdown structure can be defined as the exercise needed in a project at this point. This makes it sound like estimation the cost of the project is very sensible and well-organized as the construction involves a range of processes or activities to know the ultimate outcome of the construction. Meanwhile, the use of estimations for cost planning of buildings is minimized by implementing this model and hence may lead in a more accurate estimation of costs.

In addition, the reason that the calculations themselves can only be planned to their standard of accuracy in keeping with the current stage of design development has not given attention to certain considerations in the following stages of a project that will specifically impact the actual cost of construction. Likewise, in the early stage of the project, the idea of planning a budget by considering a single price rate method and allocating the cost to other building elements in its subsequent stages by overlooking the construction activities is also a failure in understanding how construction process affect the final project value. Therefore, this practice needs to be improved by taking more factors into account throughout the entire cost estimation process in order to make more reality estimations of construction costs.

2.7 Construction Project Cost Estimation

The method of calculating building costs isn't as simple as costing the job for all construction type. CIOB (2009) has highlighted a few areas in its Code of Estimation Practice which should be properly considered when working out a cost estimation. They are strategy used for tendering, types of procurement system used, skill in pricing, settlements of tenders, and agreements and conditions of contracts. In other words, calculating building costs is in essence a whole set of work that will have to be done by professional CQSs before delivering the job to the chosen construction contractor.

Correspondingly, it can also be found that the estimation of project costs consists not just of the portion of estimation the price of the construction project but also of the proportion that is applicable to the management of the procurement for a building project.

Drew et al. (2001) commented that it is well known that contractual agreement has been proven to be one of the most important factors impacting overall cost of construction. According to Brook (2011), in deciding which type of procurement to use for the project, the needs of the customer, role of the contractor and risk management are also the project consultants' key concerns. In respect to all three main problems combined, it appears that the design and development agreement may be an appealing option for the client because it makes the negotiating relations between the two contractual parties i.e. the client and the contractor easy as the contractor is responsible for the project planning and construction.

Kerzner (2013) stated that apparently, the cost estimation process required both quantitative estimations and intuitive decisions in working with construction pricing; the process is thus viewed as an art. In addition, several research studies were carried out on the subject of estimating project costs, but with dissimilar goals and focus. Kaka and Price (1994) found that incorrect estimations would mainly impact the contracting organization and that if adequate loans were not obtained within the period given to deal with changes in working capital, the company might go into bankruptcy. Contractors however failed to adapt reliable and precise approaches for business and financial budgeting, and accurate prediction of pecuniary resources.

Furthermore, estimation the overall cost and the incapacity to correctly consider strategic and environmental factors are two primary reasons of incorrect estimations. Hence, it is mandatory to have an information network to obtain the cost data while assessing the performance of the contractor itself. A model that integrates the business practices of the contractor into the operating environment should be made available to the constructors to handle their works accordingly. In addition, Tah et al. (1994) considered approaches used to measure indirect construction costs to be arbitrary and dependent on practice. Therefore, it is rare to use probability and statistics for estimation costs. Hence, a user-friendly computerized estimation program has been proposed to be developed that respects the professional judgements of the estimator with the purpose to satisfy the requirements of the cost estimation process.

In addition, Mok et al. (1997) reported that the conventional probabilistic, or single figure, cost estimation approach was still used by most service engineers in the preparation of cost estimations, and the risk management process allows a systematic mechanism for the assessment of cost-influencing risk factors and the allocation of cost-est risk allowances. Another study carried out in Hong Kong in 1994 and 1999 on capital budget planning showed that most construction contractors did not carry out any form of investment financial management other than by targeting a minimum return rate. Nevertheless, the management of the capital budget is carried out by tracking the performance of the project (Lam et al., 2001).

Akintoye and Fitzgerald (2000), discovered that all scales of contractors prepare cost estimations primarily for construction planning, including preparation of tender, management of project cost during execution, and some degree of project assessment in studying the recent situation of project cost estimations in the UK. Nevertheless, contractors are not implementing updated cost estimation techniques which includes the risks and uncertainty of cost estimations, for example, the use of range estimation and parametric estimation process. During preparation of the BQs, unit prices are often calculated for all work products concerned on the basis of labor details and material constants.

Moreover, it is also concluded that estimators' insufficient practical knowledge of construction, insufficient time to prepare cost estimations, weak tender documentation and the vast variation of quotations from subcontractors are the prime triggers for incorrect cost estimations. Likewise, Flyvbjerg et al. (2002) argued that taking advantage of an initial cost estimation to determine the feasibility of the project is highly deceptive and methodological. This has also been established that cost underestimation is not solely because of error, however, it is better defined as strategic misrepresentation or deception. This circumstance causes project stakeholders who wants to know actual figure to doubt the cost estimations and cost-benefit assesses compiled by the organization of the client.

Sturts and Griffis (2005) clarified that when costing engineering services, the job of estimation was evaluated on the basis of labour-hours in the past. Many who use computer-aided design and three-dimensional computer models, however, have claimed that their performance increased more than tenfold. Therefore, investing hours in pricing engineering services only in today's companies is far not sufficient as the current technologies can already enable workers to solve their problems. As a result, engineers and designers must update outdated costing approaches by creating new ones. Moreover, Günhan and Arditi (2007) mentioned that the assignment of 10% of the contract amount for every project as a fixed contingency sum for the client in which this standby money is not to be utilized for other activities is in actual fact more than sufficient for the client to encounter with unknowns in a project.

Consequently, it was proposed the contingency amount would be estimated in reference to details from previous project such as previously defined problem line items with respect to site conditions, time limits, design and building problems and project scale. Nevertheless, Laryea and Hughes (2008) found that the building industry does not employ systematic and predictive risk models developed from studies for estimation and costing project risk at the tendering phase. In fact, contractors don’t have a typical method for broadly and precisely pricing for risk, instead of researching how a collection of complicated microeconomic variables could influence the cost of the project. For this cause, it is important for this study to learn more about the factors that influence the calculation of the cost of the project.

In reviewing the latest state of the art for the UK, Soutos and Lowe (2011) found that CQSs in the UK prefer and are routinely performing basic cost planning during the project design phase using the approach suggested by the Building Cost Information Service (BCIS)'s Standard Form of Cost Analysis (SFCA); Laryea and Hughes (2011) explained that while risk management affects the pricing strategies of contractors, certain dynamic microeconomic considerations also impact prices. Risk is calculated and costed through contractual structures that represent market demands. In addition, there are various hypotheses behind theoretical models that are not realistic, and the actual scenario occurs in fact is important for modelling construction tender costing.

Yu et al. (2013) reported that operational cost estimation models are rarely eligible for best value tenders due to challenges in calculating demand disparities with respect to good or service efficiency variances. In terms of competition and productivity, they introduced a model named as price elasticity of quality (PEQ) for calculating PEQ of a good or service provided by tenderers, and a tender region is recommended for tenderer. Blomberg et al. (2014) found that inability to balance risk, unique conditions of the public sector, stifling or lack of creativity, collection of design parameters and parameterization of the implementation processes are five general cost premium considerations for military construction. Researchers found that, in addition to the well-recognized consideration of "federal laws and policies", "internal construction agent policies" have triggered cost premium rises.

Laryea and Lubbock (2014) claimed that quality of the documentation, period of the tender, competitiveness, input accuracy, and time to adjust and respond are some of the key obstacles to successful tender pricing by subcontractors. If eliminated, these obstacles will increase the quality and sustainability of contractors, and strengthen project supply-chain management. It will produce the desired project results. Udofia et al. (2015) uncovered important relationships between factors for motives of project termination and techniques for retendering. One of the key problems in the road construction industry is the improper procurement procedure which has triggered late delivery. Retendering strategies serve as a blueprint that can be followed when reforming a terminated project to reassure the project client’s needs about time, expense and efficiency.

2.8 Challenges of Cost Estimation

Research in the industry of estimation building costs continues to advance, though there are so numerous unanswered problems affecting the research sector. Difficulties such as estimation precision and estimation speed in any building cost work being carried out remain as the core concerns of their studies thus far. This can be easily proven by analyzing the features of the forms of projections used in the building industry. For the first estimation for a project, a tentative estimation using either a parametric cost estimation approach as suggested by Kerzner (2013) or a superficial area approach as mentioned by Ashworth (2010) is to be generated without complete construction design details as the project has not enter the comprehensive design stage at the point.

Fortune and Cox (2005) and Wang and Yang (2005) stated that intending to get a picture of the probable cost of a project, the potential client might only have some basic particulars, presumably the cost indicators that the client has already set, such as the scale of the building for example the building floor area, the building height, and number of storey of the building. While the use of one of the conventional cost estimation techniques which is the superficial area approach is still preferred, construction stakeholders appear to generate a primitive calculation solely based on the cost per square meter of gross floor space for the particular type of construction. Seeing that there are several factors impacting the overall expense of the project (Chan and Park, 2005); it is also problematic to quantify according to just one factor of gross floor area.

In fact, due to the intrinsic complexity of most building operations, along with the sometimes exceed limited time present for making an early cost estimation, mistakes have been caused to happen. These situations will impact the success of a project and potentially harm the profit margins of the contractors (Leung et al., 2005). Therefore, as the precision of the figures is directly associated with the magnitude of the information received during the planning period, generating a high-quality preliminary cost estimation is, predictably, a much more challenging task because of the lack of accurate information and the timeframes involved in the project's feasibility phase (Chou, 2009).

Knowingly, with greater precision, accurate cost assessments will deliver higher estimation efficiency. This could be done because the fully elaborated estimation can only be prepared upon completion of the detailed design stage. For regions that are influenced by the UK, QS practice is popular for their building industry. During this process, CQSs calculate the quantities of building or civil engineering projects by following the standard measurement method and summarizing them in BQs. Nonetheless, volumes of construction and structural engineering taking off need professional expertise. In addition, it is a very detailed task that needs attentive count on the type of materials adopted for an item and the building's operation arrangement on site.

Complete calculations will indeed take more time and therefore costly to produce. Nonetheless, the high accuracy of forecasts compensates for this. Therefore, a correlation may be drawn between the forecasting precision and the effort required to produce cost estimations. Thus, the more accurate the calculation, the greater the estimation 's level of accuracy. On the counter, the less accurate the calculation, the lower the estimation 's degree of accuracy. It has usually been linked in the conventional cost estimation to the initiative being placed forward when the calculation is done, as the more money are used to measure the project, the more reliable the result will be made afterwards. Nevertheless, new computer applications have reduced the difficulty of the cost calculation today (Jrade and Alkass, 2007).

Apart from estimation precision and speed of calculation, the management of cost information is also a taxing role in predicting the possible costs of building projects. Typically, this information explains the factors which influence the final cost of the project. Handling the construction cost information is therefore indeed a complicated job to be performed in the emergence of a dynamic and competitive construction market climate, particularly for organisations that manage a lot of projects at once. As a consequence, CQSs and estimators should have the ability to identify the right project information that ought to be registered and adequately managed as the excess of information will just screw up the whole cost calculation process. Thus, this work is undertaken to help practitioners in determining the major factors affecting cost estimation of a project.

2.9 Cost-significant Models for Multi-storey Residential Project

Poh and Horner (1995) developed a cost-significant model for student hostels in Singapore by using the historical BQs of six current projects and subsequently tested the model using another two current projects. They highlighted that cost-significant models rely on the well documented finding that 80% of a bill's value is contained within the 20% of the items which are the most expensive. Cost significant items have been identified simply as those items whose value is greater than the arithmetic mean value. Cost significant items can be grouped together, using a variety of techniques, into a smaller number of cost significant work packages, which within any given category of project consistently represent a fixed proportion of the total cost, usually close to 80%. The total value of the project can then be calculated simply by multiplying the total price of the cost-significant work packages by an appropriate factor, typically close to 1.25. The cost-significant model considerably reduces the time required to prepare a cost estimate compared with a traditional BQs, which may contain several thousand items. All the eight projects (Hall 4 to Hall 11) used were essentially similar: low-rise, four to five-storey, reinforced concrete frame buildings with plastered, non-load bearing internal and external brick walls. The bill values used exclude preliminaries, work for statutory bodies, provisional sums, prime cost items, dayworks and external works. The rationale for the exclusion of these items is because they are often highly cost variable and depend crucially on-site characteristics and client requirements. To include them might frustrate the development of an accurate model. The development of their model started with the identification of the cost-significant items as the first step. It was followed by grouping the cost-significant items into cost-significant primary and secondary trades. In the main, if the percentage contribution of a secondary trade was found to be significant, it was identified as a cost-significant work package. The final cost-significant model was then computed with eight primary trades and twenty-seven secondary trades (cost-significant work packages) is as shown in Table 2.2. The ratio of the sum of the cost-significant work packages in the model to the total bill value is the cost model factor (CMF). The factor was evaluated for each of the six project bills used to develop the model, and the average value adopted as the model CMF which was 0.793. The total cost of a future student hostel project could then be estimated by dividing the total price of the cost-significant work packages by the model CMF. The model developed was tested using the bills for the Hall 10 and Hall 11 and the achieved accuracy was about

3% excluding preliminaries and external works. Table 2.3 shows test results of the Poh and Horner's model.

Table 2.2: Cost-significant Model (Poh and Horner, 1995)

Cost Significant Work Packages (cswp)			Qty	Unit Rate	Amount
1 Earthwork	1.1	Excavation to reduced levels including substructure excavation (m3)			
	1.2	Anti-termite treatment (sum)			
	1.3	Earthfill and compaction (m3)			
2 Piling	2.1	Mobilisation (sum)			
	2.2	Load test (tonnes)			
	2.3	Piles (m)			
		(a) Driven timber piles			
		(b) Driven reinforced piles			
		(c) Driven steel piles			
		(d) Cast in situ bored piles			
3 Concrete	3.1	In situ concrete (m3)			
	3.2	Precast concrete (m3)			
	3.3	Bar and mesh reinforcement (tonnes)			
	3.4	Formwork (m2)			
4 Brickwork and blockwork	4.1	Any thickness brick/block wall (m3)			
	4.2	Glass block wall (m2)			
5 Finishes	5.1	Plastering for walls and ceilings (m2)			
	5.2	False ceiling (m2)			
	5.3	Tiling floors and walls (m2)			
		(a) ceramic tiles			
		(b) vinyl tiles			
		(c) brick tiles			
		(d) mosaic tiles			
		(e) glazed tiles			
		(f) carpet tiles			
	5.4	Screeding for floors (m2)			
	5.5	Waterproofing for floors and walls m2)			
6 Painting	6.1	In situ concrete (m3)			
	6.2	Precast concrete (m3)			
	6.3	Bar and mesh reinforcement (tonnes)			
	6.4	Formwork (m2)			
7 Roofing	7.1	Metal sheet roof (m2)			
		(a) Metal sheet and waterproofing (m2)			
		(b) Roof support (tonnes)			
		(i) Steel trusses (tonnes)			
		(ii) Timber trusess (tonnes)			
	7.2	Clay roof (m2)			
		(a) Tiles and insulation (m2)			
		(b) Roof support (tonnes)			
		(i) Steel trusses (tonnes)			
		(ii) Timber trusess (tonnes)			
	7.3	Flat concrete roof (m2)			
8 Carpentry	8.1	Wardrobes (m2)			
	8.2	Handrails (m)			
	8.3	Doors (nos)			
	8.4	Windows (m2)			
Total amount ($)					

(Cost model factor = 0.793)

Table 2.3: Test Results of Cost-significant Model (Poh and Horner, 1995)

		Hall 10	Hall 11
(A)	Sum of cswps	$8 074 481	$7 502 020
(B)	Estimated cost of project (excluding preliminaries and external works) [(A)/CMF]	$10 182 196	$9 460 304
(C)	Actual cost of project (excluding preliminaries and external works)	$10 254 978	$9 769 300
(D)	Accuracy of model (excluding preliminaries and external works) [{(B) - (C)}/(C)] x 100%	-0.71%	-3.16%

Cost Estimation Model Factor (CEMF = 0.730)

Using the similar approach as Poh and Horner (1995), Tas and Yaman (2005) used the cost significance principle to develop a cost significant model based on Turkish public residential buildings. Twenty-one (21) reinforced concrete-framed of four to five stories residential buildings were studied to determine the cost significant work items. It was observed that their classification of work items differed significantly from Poh and Horner (1995), and the cost significant work packages identified appear to be odd for the author. For instant there is a cost significant work package named ‘Scaffolding’; ‘Wall finishes’ and ‘Wall and ceiling plaster’ were separated into two different packages. This is very much different from the practice in Malaysia. Furthermore, they had not demonstrated any table or figure to show the cost significant model as Poh and Horner (1995) where the development and validation of the model were comprehensively presented.

2.10 Cost Significant Elements

Smith et al. (2016) by referring to the standard published pricing books in the UK and Australia, had studied and laid down their justifications on which are the cost significant elements for multi-storey apartment block project. They have stated the usual percentage of the elemental cost to the total building cost for some of the twelve elements listed. Table 2.4 tabulates their brief justifications against each element so that the CSEs can be easily identified.

Table 2.4: Cost-significant Elements of Multi-storey Apartment Block According to Smith et al. (2016)

No.	Elements	CSE/ NCSE	Smith et. al's Brief Justifications
1	Substructure	NCSE	On multi-storey projects, the foundation costs are spread over a relatively larger floor area and often only represent a small percentage of the total cost - in the region of 1-5%.
2	Frame (columns, upper floors)	CSE	These are relatively high-cost elements representing 10-20% of the total cost.
3	Stairs	NCSE	Stairs are not normally a cost-significant item. On most multi-storey projects the cost of stairs would only be a minimal 1-2% of the total cost.
4	Envelope (external walls and windows)	CSE	The envelope can represent 10-20% of the cost.
5	External doors	NCSE	This item is not usually cost significant.
6	Roof	NCSE	On a multi-storey project, roof costs are not usually notable. The roof has less significance as the number of storeys increases as the cost is distributed over higher gross floor area.
7	Internal subdivision (internal walls, screens, doors)	CSE	These can represent 5-10% of the total cost. In an open-plan office building this is not likely to be a significant cost item but for residential blocks is of critical importance.
8	Finishes (walls, ceilings and floors)	CSE	Wall finishes are related to the design decisions in internal subdivisions; ceiling and floor finishes are more closely related to quality selection.
9	Fittings	CSE	These are an important consideration, representing 5-10% of the total costs. In residential projects, wardrobes, bathroom, kitchen and built-in fittings when multiplied by the number of units can be a significant cost item.
10	Services	CSE	Consistently services rate between 30 and 40% of total costs and they are therefore a very important aspect to consider.
11	External works	NCSE	These are not usually a cost significant item, probably comprising less than 5% of the total costs. However, on a site with large area and extensive treatment the costs could be substantial.
12	Preliminaries	CSE	These are an impotant cost item, oftem representing 8-15% of the total.

According to Smith et al. (2016), there are seven (7) out of the total twelve (12) elements are CSEs while the balance are non-cost significant elements (NCSEs). The CSEs are (1) Frame, which includes columns and upper floors, (2) Envelope, which includes external walls and windows, (3) Internal sub-division, which includes internal walls, screens and doors, (4) Finishes, which includes walls, ceilings and floors, (5) Fittings, (6) Services, and (7) Preliminaries. The NCSEs are (1) Substructure, (2) Stairs, (3) External doors, (4) Roof, and (5) External Works.

2.11 The Effect of Different Groupings of Building Elements on CSEs

Lim et al. (2013) carried out a study on CSEs based on the cost data collected from the contract documents of a 5-storey medium cost walk-up apartments project in the outskirt area of Klang Valley, Malaysia. The elemental costs of one of the two blocks of the project were extracted and listed in two tables, one based on the original BQ format, and another based on RISM's ECA format for comparison of the cost significant elements in order to detect the differences in the cost distribution pattern. Table 2.5 displays the elemental costs of the building based on original BQ format and Table 2.6 displays the elemental costs of the building based on RISM's ECA format.

Table 2.5: Element Costs of A 5-Storey Walk-up Apartment Based on Original BQ Format

No.	Elements	Total Cost of Element (RM)
1	SUBSTRUCTURE	
1A	***Piling***	***370,145.40***
1B	Sub-structure Work	42,632.40
1C	Work Below Lowest Floor Finish	128,921.30
2	SUPERSTRUCTURE	
2A	***Frame***	***439,100.20***
2B	***Upper Floor***	***326,696.10***
2C	***Roof***	***247,231.70***
2D	Staircase & Handrailing	25,638.10
2E	***External Walls***	***211,436.20***
2F	***Windows***	***230,600.00***
2G	Internal Walls & Partitions	121,881.70
2H	Doors & Ironmongery	162,660.00
3	FINISHES	
3A	***Internal Wall Finishes***	***357,333.25***
3B	***Internal Floor Finishes***	***264,113.85***
3C	Internal Ceiling Finishes	53,424.30
3D	External Finishes	177,170.30
3E	Staircase Finishes	5,256.80
3F	Painting Works	147,652.20
4	FITTINGS AND FURNISHINGS	0
5	SERVICES	
5A	Sanitary Appliances	62,568.00
5B	***Plumbing Installation***	***497,741.60***
5C	Refuse Disposal	0
5D	Air-Conditioning & Ventilation System	0
5E	***Electrical & Telephone Services (including Air-Conditioning, Ventilation & Communication Installation)***	***435,873.00***
5F	Fire Protection Installation	0
5G	Lift and Conveyor Installation	0
5H	Communication Installation	0
5J	Special Installation	0
5K	Builder’s Profit & Attendance on Services	1,920.00
5L	Builder’s Work in Connection with Services	17,700.00
	Actual Total Bill Value:	4,327,696.40
	Mean Bill Value:	196,713.47
	Total Bill Value of CSEs:	3,380,271.30
	No. of Total Elements:	22
	No. of CSE in Total:	10
	CSE/TE (per cent):	**45.45%**
	Total Bill Value of CSEs/Actual Total Bill Value:	**78.11%**

Table 2.6: Element Costs of A 5-Storey Walk-up Apartment Based on RISM's ECA Format

No.	Elements	Total Cost of Element (RM)
1	SUBSTRUCTURE	
1A	***Piling***	***370,145.40***
1B	Work Below Lowest Floor Finish	171,553.70
2	SUPERSTRUCTURE	
2A	***Frame***	***439,100.20***
2B	***Upper Floor***	***326,696.10***
2C	***Roof***	***249,103.70***
2D	Stairs	32,370.70
2E	***External Walls***	***211,436.20***
2F	***Windows & External Doors***	***317,422.00***
2G	Internal Walls & Partitions	121,881.70
2H	Internal Doors	93,616.00
3	FINISHES	
3A	***Internal Wall Finishes***	***407,949.25***
3B	***Internal Floor Finishes***	***264,113.85***
3C	Internal Ceiling Finishes	71,246.30
3D	***External Finishes***	***235,258.70***
4	FITTINGS AND FURNISHINGS	0
5	SERVICES	
5A	Sanitary Appliances	62,568.00
5B	***Plumbing Installation***	***497,741.60***
5C	Refuse Disposal	0
5D	Air-Conditioning & Ventilation System	26160
5E	***Electrical & Telephone Services (including Air-Conditioning, Ventilation & Communication Installation)***	***306,498.00***
5F	Fire Protection Installation	3300
5G	Lift and Conveyor Installation	0
5H	Communication Installation	103215
5J	Special Installation	0
5K	Builder's Profit & Attendance on Services	1,920.00
5L	Builder's Work in Connection with Services	14,400.00
	Actual Total Bill Value:	4,327,696.40
	Mean Bill Value:	196,713.47
	Total Bill Value of CSEs:	3,625,465.00
	No. of Total Elements:	22
	No. of CSE in Total:	11
	CSE/TE (per cent):	**50.00%**
	Total Bill Value of CSEs/Actual Total Bill Value:	**83.77%**

From the tabulations of the 2 tables, it is seen that both the formats have a total of 22 elements, however the there are some differences in the breakdown methods. For example, the original BQ format divides the substructure into 3 bills i.e., piling, substructure work, and works below lowest floor level; whereas the RISM's ECA format divides the substructure into only 3 bills i.e., piling and work below lowest floor finish where sub-structure work is included in work below lowest floor finish. Another significant difference between the two formats is for stair. For the original BQ format, the works for stair are divided into 2 bills i.e., Element 2D Staircase & Handrailing and Element 3E Staircase Finishes whereas for the RISM's ECA format the works for stair are all included in one single bill i.e., Element 2D Stairs where it includes stair structure, stair finishes, and stair balustrades and handrails. Other than that, it is observed that the original format separated Windows and Doors & Ironmongery in 2 different bills whereas the RISM's ECA format includes Windows and External Doors in one bill and Internal Doors in another.

The main finding for this study was that different ways of grouping the elements have a very great effect on the cost significant elements of the same type of building. It was also finalized that 78.11 percent of the total building cost is contributed by 45.45 percent of the total number of elements based on original BQ format; whereas 83.77 percent of the total building cost is contributed by 50.00 percent of the total number of elements based on RISM's ECA format.

2.12 Research Gap

As mentioned in the problem statement in Chapter 1, there is hardly any study done on cost significant model for residential buildings after the models developed by Poh and Horner (1995) and Tas and Yaman (2005). The discovery on the use of cost significant models in the overseas countries had initiated the author's interest in this area of study. However, due to the scarcity of land, to develop cost significant model for low-rise residential is no longer beneficial. As such, the author has aimed to develop a generic building cost estimation model based on CSEs of HRCPs in Klang Valley, Malaysia by adopting the similar method used by Poh and Horner (1995).

Other than Smith et al. (2016) who had studied and laid down their justifications on which are the cost significant elements for multi-storey apartment block project, there has not been any similar study on this area. As such, to find out the local construction industry stakeholders' awareness on cost significance elements is crucial before the move to develop the cost significant model. This is simply because it will be wasteful of time and effort for the researcher to proceed with the development of the cost model if the local construction industry stakeholders have high awareness on cost significance theory and the cost significance model has already been widely used.

2.13 Theoretical Framework

Based closely on the methods adopted by Poh and Horner (1995) in developing the cost significant model, two theoretical frameworks for this research is created to reflect how the research objectives would be achieved. However, the methods were further improved in order to suit the practice in the local construction industry. For example, instead of the identification of the cost significant items and further grouping into cost significant work packages used by the former researchers, the grouping method of building elements by the Royal Institution of Surveyor Malaysia (RISM)'s elemental cost analysis (ECA) is used. Figure 2.2 shows the schematic diagram of the theoretical framework for RO1 and Figure 2.3 shows the schematic diagram of the theoretical framework for RO2 and RO3.

Figure 2.2: Schematic Diagram of the Theoretical Framework for RO1

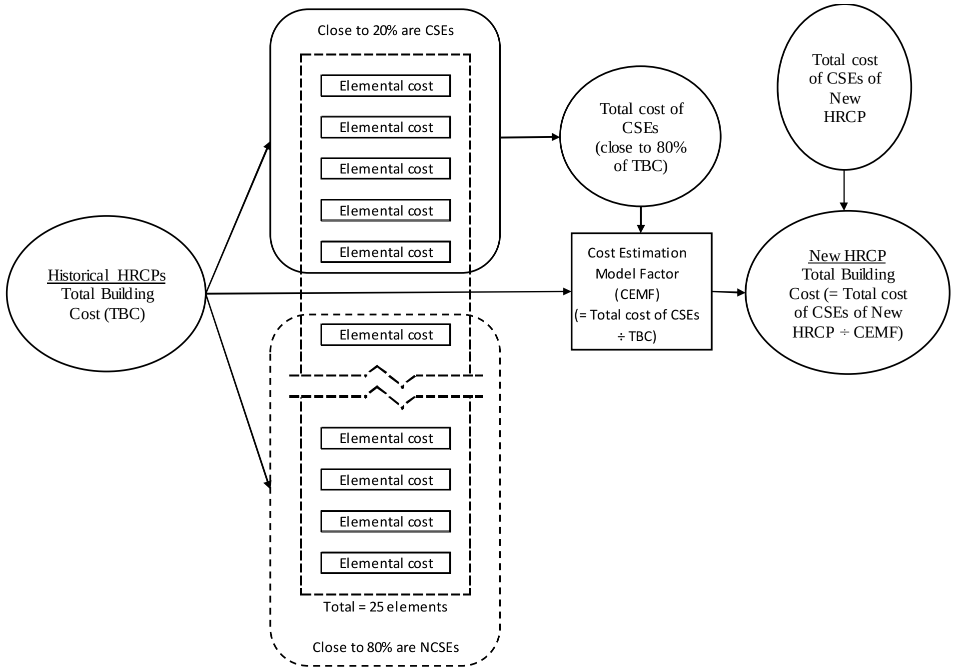


Figure 2.3: Schematic Diagram of the Theoretical Framework for RO2 and RO3

2.14 Chapter Summary

This chapter gives the readers to have an in-depth understanding of what is cost estimation. The chapter discusses in detailed the types of cost estimation models used worldwide. The techniques used when preparing cost estimation are demonstrated. People involved in building up the cost estimation model are also shown so that the selection of the questionnaire's respondent can be reasoned. Cost estimation exercise, construction project cost estimation, and cost estimation challenges also have been explained clearly. The basic knowledge on cost estimation is essential for the understanding of the whole part of the thesis. Furthermore, ways of how the past researchers developed the cost significant models and identified cost significant elements have also been discussed. The theoretical frameworks are presented to give the readers a clear idea on how the research objectives is to be achieved.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

This chapter displays the subsections on research methods that consist of quantitative research, qualitative research, and mixed methods research; research design; data collection methods which comprise of literature review, questionnaire, and case study; questionnaire data analysis methods that consist of descriptive analysis, Cronbach's alpha reliability test, mean ranking, Mann-Whitney U test, and Kendall's tau-b correlation analysis; and case study data analysis method.

3.2 Selection of Research Method

Research definitions abound, especially in textbooks; those used consistently emphasize that they have a clear purpose (Bezzina and Sunders, 2013). Kothari (2009) defined research as "a scientific and systematic search for pertinent information on a specific topic"; and further concluded that research refers to a systematic approach consisting of presenting the problem, formulating a hypothesis, gathering facts or evidence, evaluating facts and drawing certain conclusions in the form of a solution(s) to the problem or generalizing certain theoretical formulations. Saunders ed al. (2016) defined research as “something that people undertake in order to find out things in a systematic way, thereby increasing their knowledge” and emphasized that the two important phrases are ‘systematic way’ and ‘to find out things’. On the other hand, the term methodology refers to the techniques used by researchers in the search for answers to several research problems (Taylor et al., 2016). As such, it can be said that research methodology sets out particular systematic techniques or methods that are typically used to classify, collect and interpret the information and data obtained for the research subject.

According to Creswell and Creswell (2018), the research methods can be divided into 3 types: quantitative, qualitative and mixed. They also noted that one of the key elements of the research framework is the different research methods involving the ways of data collection, analysis and interpretation suggested by researchers for their studies. A comprehensive demonstration as shown in Table 3.1 has been developed by them for useful reference to consider the full range of data collection options and to organize these methods, for instant, by the degree of predetermined nature, the use of closed-ended/open-ended questioning, and the focus on statistical versus non-statistical data analysis.

Table 3.1: Quantitative, Mixed, and Qualitative Methods

Quantitative Methods	Mixed Methods	Qualitative Methods
Pre-determined	Both pre-determined and emerging methods	Emerging methods
Instrument based questions	Both open- and closed-ended questions	Open-ended questions
Performance data, attitude data, observational data, and census data	Multiple forms of data drawing on all possibilities	Interview data, observation data, document data, and audiovisual data
Statistical analysis	Statistical and text analysis	Text and image analysis
Statistical interpretation	Across databases interpretation	Themes, patterns interpretation

Source: Creswell and Creswell (2018)

3.2.1 Quantitative Research

Fain (2017) stated that quantitative research aims at discovering relationships, causes, and effects as it relates to calculating and evaluating the relationships between and among variables at a specific point of time. Whilst according to Fellows and Liu (2015), The positivity inquiry research method underpins quantitative research, which is concerned with numerical data and statistics. The Positivity method is a method for collecting observed data by experimental study. Close-ended questions are used to collect data. The information gathered will then be analysed statistically. For Yap and Chua (2018), on the other hand, this research method collects data that can be analyzed numerically and represented in tables, graphs, or statistics. It is frequently used to handle large amounts of data, which are critical for achieving high reliability results. In order to generate new insights into the research field, the data collected by this method must be justifiable and dependable for data analysis purposes.

Saunders et al. (2016) said that quantitative research concentrates on the statistical analysis of collected survey data. As a deductive method it can be claimed that statistical data are used to test the theory. Meanwhile, Creswell (2018) explained that quantitative approach involves extensive experiments with numerous variables and distinguish the relationship between or among the variables. The data obtained is analyzed using a wide variety of statistical methods. The validity of the data must be assured and verified. It is important to make sure that all the respondents have a clear understanding of the questions as a result of the data to be gathered in a typical manner.

Quantitative study in simple terms is therefore a method for collecting a large volume of high-reliability data that can be numerically analyzed to check the hypothesis and gain new insights into the research field.

3.2.2 Qualitative Research

Similar to quantitative research, discussions on qualitative research have not been lesser as compared. The followings are some of the quotes observed.

According to Fain (2017), qualitative work seeks to identify meanings rather than cause and effect, as it focuses on processes and meanings where the main emphasis is on the generation of social knowledge and emergent meanings.

Meanwhile, Kumar et al. (2013) and Mills and Gay (2018) had the similar opinions that qualitative research is investigative as the approach examines and explains human behavior.

Pajo (2018) stated that qualitative research is used to examine and obtain answers from the beliefs, behaviors, expectations, feelings and experiences of people through interviews or group discussions. It focuses on gaining insight and knowledge on research and produces non-numeric data in the form of texts, terms, illustrations and videos; and Fellows and Liu (2015) explained that qualitative research is always adopted when numerical data collected from quantitative research cannot demonstrate the problem where the beliefs, behaviors, expectations, feelings and experiences of an individual are being investigated.

Cresswell (2018) believe that qualitative research is an interpretive research approach which exploring and understanding the perspective and opinions of each individual to the phenomenon while Saunders et al. (2016) mentioned that qualitative research needs the researchers to have the sense of instinctive during the data collection process.

Bashir et al. (2008) explained that qualitative research includes the studied use and compilation of a variety of analytical materials (case study, personal experience, introspective, life story, interview, observational, historical, interactional and visual texts) that define problematic moments, routine and meanings in the life of individuals. Bhat (2020) defined qualitative research as a market research method focusing on data acquisition through open-ended and conversational communication and had developed a figure showing six frequently used qualitative research methods as shown in Figure 3.1.

Figure 3.1: Types of Qualitative Research Methods

In general, qualitative research concepts are not as simple as quantitative research concepts. It can be any kind of methods that produces findings not arrived at by statistical procedures or any means of quantification. It is less structured than quantitative research and it mainly aims at defining a phenomenon or subject rather than testing it.

3.2.3 Mixed Methods Research

Mixed methods research is the combination of both quantitative and qualitative research methods. The idea of mixed methods research was long originated in 1959. The research approach of mixed methods includes gathering, combining, evaluating and incorporating both quantitative and qualitative data and offering a greater and more detailed understanding of research problems than the quantitative and qualitative approach alone (Creswell and Creswell, 2018). Mixed methods research has become an increasingly used and accepted approach to conducting social research since 2001 (Bryman, 2012).

Bryman (2012) developed a classification for mixed methods research he derived from conducting a content analysis of empirical articles in refereed journals in the social sciences. Two criteria were based on i.e., the priority decision and the sequence decision. The priority decision was focused on how far is a qualitative or a quantitative method the principal data-gathering tool or are they of equal weight? The sequence decision was based on ‘which method precedes which?’, or put it another way, does the qualitative method precede the quantitative one or vice versa or is the data collection associated with each method concurrently? The criteria yield nine possible types of classifications as shown in Figure 3.2.

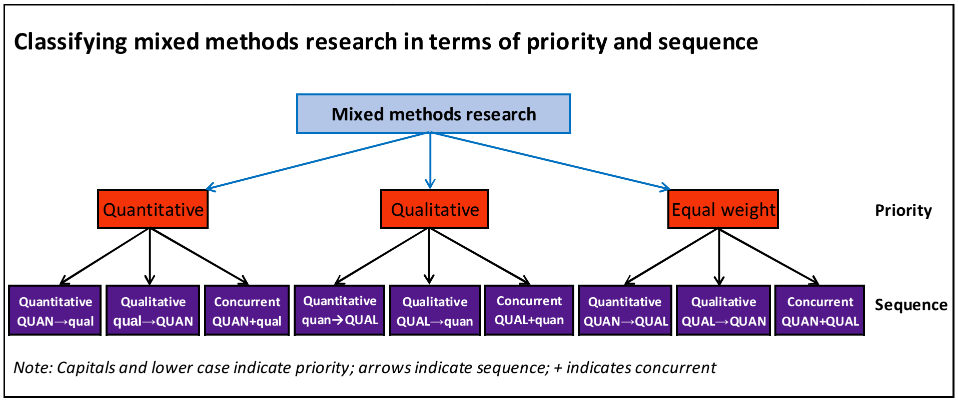


Figure 3.2: Classifying mixed methods research in terms of priority and sequence (Bryman, 2012)

In this classification as shown in Figure 3.2, upper case shows priority: for instant, QUAL shows that the qualitative component was the main data-collection method; lower case shows a more subsidiary role: for instant, qual. Arrows refer to the sequence: for instant, QUAN→qual means that the collection of quantitative data was the main method of data collection, and the collection of such quantitative data was carried out before the qualitative data which had a subsidiary function. The + basically means that the quantitative and qualitative data is more or less collected simultaneously. One problem with this and similar classifications that embellish it is that when reading a study report, it is not always easy to decide issues of priority and sequences. It is, however, useful as a way of thinking about fundamental aspects of developing mixed methods studies.

3.3 Research Design

Research design is a framework or structure describing data collection and interpretation which is essential in providing the basis for the whole research work (Bryman, 2012; Creswell, 2018). The research design shall be properly planned before a study begins. According to Kothari (2009), Research design is important to the research study as it facilitates the smooth running of research operations that produce maximum knowledge and reliable findings with minimal cost and time. Research design is an advance preparation of strategies for gathering relevant data and methods for analyzing and interpreting data to achieve research objectives.

Research should be conducted if a issue, dispute, event or situation requires a decision. The research objectives are defined to determine the details needed to decide the matter. Data collection approach is designed to help solve the problem. Data are collected, stored, analyzed and interpreted to find their significance. All these separate but interconnected parts are included in this research study, which may help solve the problem. According to Kumar et al. (2013), selection of qualitative or quantitative research depends on the purpose of the study, the information needed for the analysis, and the availability of resources such as time, costs and people. It is common for both approaches to be used in a single study known as mixed methods. Table 3.2 shows the differences in characteristics between qualitative and quantitative research.

Table 3.2: Qualitative Research versus Quantitative Research

Characteristic	**Qualitative Research**	**Quantitative Research**
Data collection method	Focus groups, in-depth interviews and review of documents for types of themes	Surveys, structured interviews and observations, and reviews of records or documents for numeric information
Approach	**Inductive** process to formulate theory or hypotheses	**Deductive** process to test pre-specified concepts, constructs and hypotheses that make up a theory
Nature	**Subjective**. Describes a problem/condition from the point of view of those experiencing it	**Objective**. Provides observed effects (interpreted by researchers) of a programme on a problem/condition
Type of information	**Text** based	**Number** based
Sample size	More in-depth information on **a few** cases/observations	Less in-depth but more breadth of information across **a large number** of cases
Statistical Tests	Does **not involve** statistical test	**Uses statistical tests** to test the hypotheses
Validity and reliability	Depends largely on **skill and rigour of the researcher**	Depends largely on **the measurement instruments used** for the study
Time spent and expenditure incurred	**Lighter** in the planning phrase and **heavier** during the analysis phase	**Heavier** in the planning phrase and **lighter** during the analysis phase
Results	**Less generalizable** (because of lack of statistical analysis and limited sample size)	**More generalizable**

Source: Kumar et al. (2013)

In this research, mixed methods which combine the application of questionnaire survey and review of documents were employed in the data collection. Questionnaire survey was employed to achieve the first research objective which was RO1, to determine the building contractors' and CQSs' levels of cost significance awareness of HRCPs in Klang Valley, Malaysia. Thereafter, historical cost data of HRCPs were obtained from contract documents to appraise the CSEs and further generate a cost estimation model based on CSEs of HRCPs in order to fulfil the second and third research objectives i.e., ROs and RO3. The quantitative approach was selected because a big numerical data is required to be collected to determine the level of cost significance awareness among the building contractors and CQSs. By using the questionnaire surveys, the questionnaire could be distributed to the respondents with a short period and a huge amount of quantitative data could be gathered. After the data were obtained, the numerical data could be analyzed in effective ways by using the Statistical Package for the Social Sciences (SPSS). However, to develop the cost estimation model mentioned, it involves interpretive approach to find out the phenomenon of which are the CSEs of HRCP where in-depth scrutiny into the projects' details is required. As such, quantitative approach is not suitable for this purpose of the research as one of the main characteristics of quantitative approach is that it requires less in-depth but more breath of information across a large number of cases. In view of that the qualitative approach with inductive process to formulate theory or hypotheses is more appropriate to be used for this purpose.

The research process in this study was generated in the form of a flowchart as in Figure 3.3 through modification of the research design according to McNabb (2013).

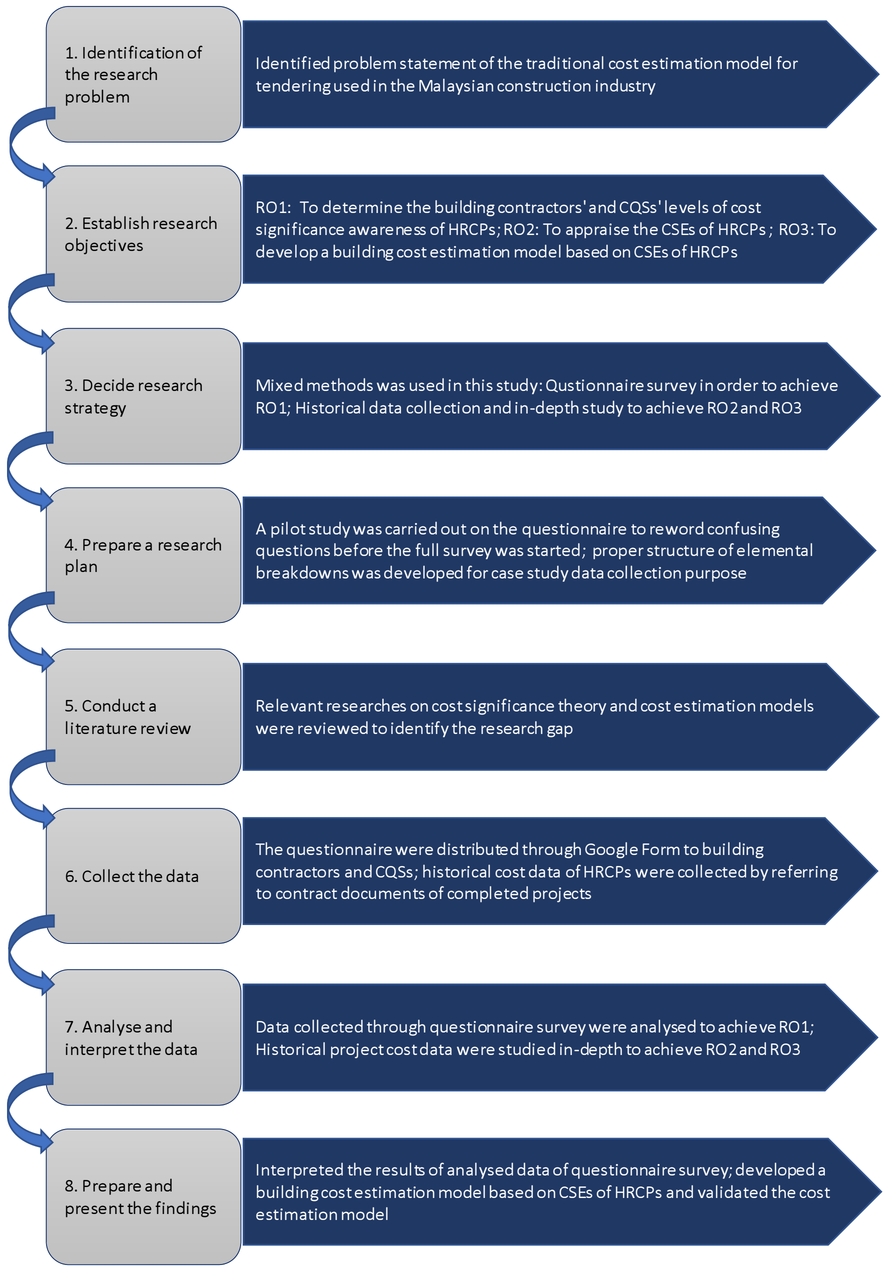


Figure 3.3: Flowchart of Research Process

Figure 3.4 exhibits the study flow and detail steps to bridge the current knowledge gap. It is divided into 3 major sections each to achieve one research objective. RO1 which is to determine the building contractors' and CQSs' levels of cost significance awareness of HRCPs in Klang Valley, Malaysia, is to be achieved by questionnaire survey. RO2, which is to appraise the CSEs of HRCPs in Klang Valley, Malaysia, is to be achieved by case study analysis of historical project data. The detail steps of how to identify the CSEs are clearly displayed in the diagram. RO3, to develop a building cost estimation model based on CSEs of HRCPs in Klang Valley, Malaysia, is to be achieved also by case study analysis for RO2. The detail methods of how to construct the model and steps to validate the model are clearly shown.

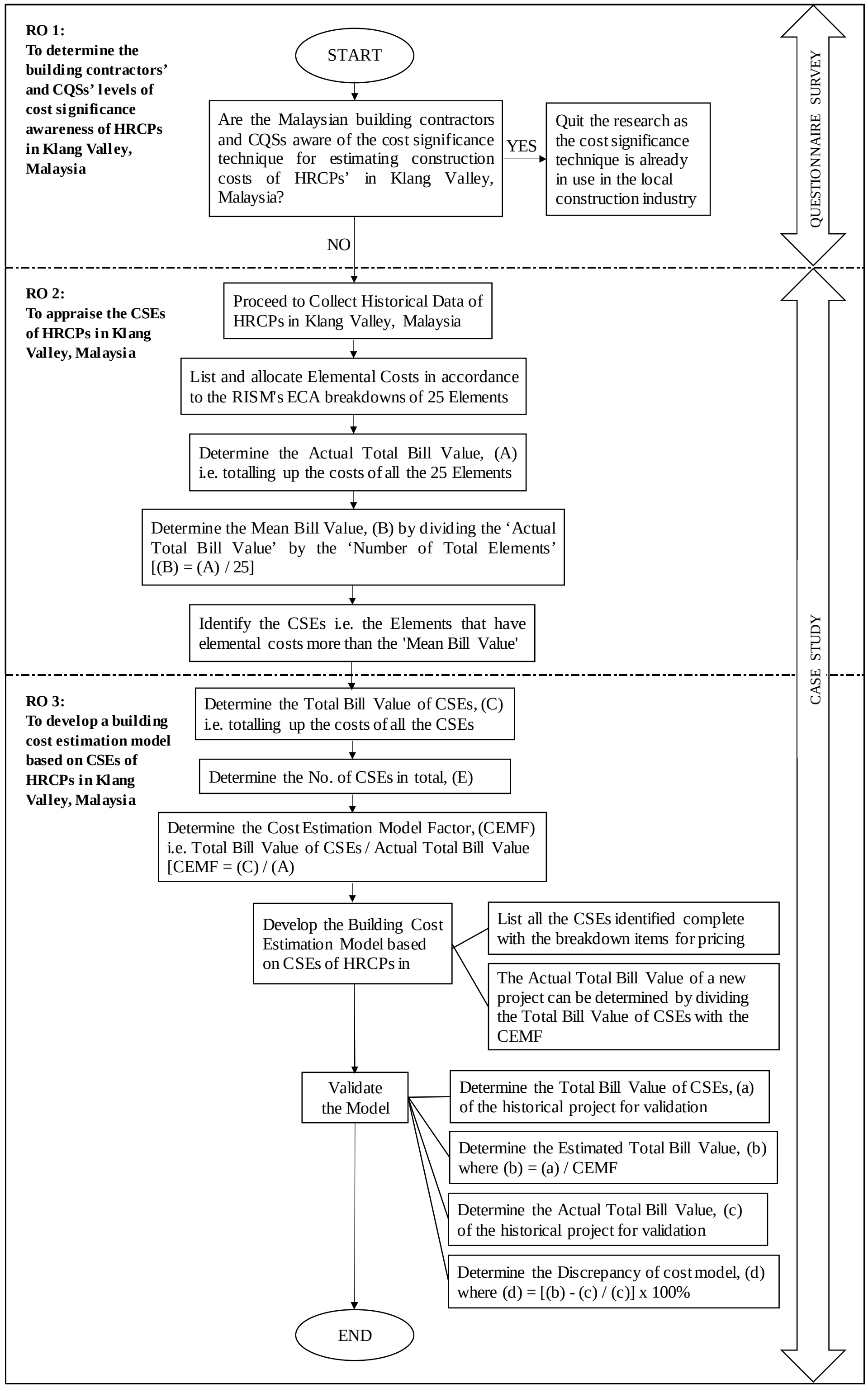


Figure 3.4: Study Flow and Detail Steps

3.4 Data Collection Methods

The data collection is a pivotal phase of a research study therefore researchers must take due care in order to get accurate data from the respondents to attain the research aim and objectives accurately. The process of data collection shall start after the research problems and objectives have been established as well as the research design has been specified (Kothari, 2009). There are generally two types of research data which are primary and secondary data. Primary data are collected initially, directly and freshly from respondents for the first time, while secondary data are data that have been obtained, analyzed, and passed through statistical methods by previous researches (Kothari, 2009).

There have been many statements by researchers on primary data and secondary data. The basic principle is that primary data are directly collected from original sources. According to Hox and Boeije (2005), primary data are defined as new information directly collected by researchers and investigators through surveys, interviews and focus groups. One of the key benefits of primary data is that data are unique to the study objectives. Also, additional data can be obtained from respondents during the study period. For Scherbaum and Shockley (2015), primary data are considered to be the original data source that has not been interpreted and also has not used different methods to ensure the data reliability. Walliman (2011) stated that primary data is the easiest way to record the information and can be conducted through observed, experienced or recorded from actual sources. Kumar et al. (2013) claimed that there are four basic types of primary data: observations, experiments, surveys and in-depth interviews.

On the contrary, secondary data are data already obtained from primary sources and readily accessible to researchers for their own study. This is a kind of data already obtained in the past. Kumar et al. (2013) mentioned that secondary data are data from written sources including journals, books, magazines, internet or internal records. These are the information that other researchers have gathered, interpreted and documented. Researchers can easily access the information and access it through the Internet or information published. Cheng et al. (2014) explained that secondary data are knowledge already available and public data gathered by other researchers. Because of its efficiency and availability, it is a strong source of data for researchers. Furthermore, secondary data is important to enhance researchers' basic knowledge of the research subject. Popular secondary data sources include newspapers, journal articles, government articles, journals, books, magazines, and internet searches. Nonetheless, the use of secondary data is restricted by the fact that the selection of respondents and data collection methods are not under the researchers' control.

First step taken in this research study was to collect the secondary data in order to have a broad perspective and understanding on the cost estimation techniques used in the local construction industry, identify the shortcomings of the practice and to explore new solution to the current situation. The secondary data were collected for the written materials for literature review as reported previously in Chapter 2 of this study. Thereafter, the primary data for this research were collected through questionnaire survey and collection of historical of cost data by referring to the contract documents of HRCPs to achieve the objectives set.

3.4.1 Literature Review

According to Hart (2018), there are two phases of literature review. In his definition, phase one of literature review is a systematic search of the recognized sources and resources. This involves finding paper and electronic sources related to the subject and method(s) of the researcher by creating a straightforward search strategy that includes a justifiable vocabulary specifying what will and won't be included in the search. The search will include setting up a comprehensive scheme for the handling of what will be a large amount of information and papers. Phase two is the study, critical evaluation, and synthesis of existing information on the research topic, the thesis or issue that the researcher seeks to tackle. The researcher selects various texts, ideas, hypotheses, arguments, and interpretations that appear important to the creation of the specific theoretical frame of reference and/or the use of a particular methodology. This includes classifying these pieces into systems for objective examination of these definitions, claims and various interpretations. The researcher interrogates others' work in critical evaluation. The researcher scrutinizes another chain of reasoning and the proof they gave to support their claim. The study aims to observe the use of a seminal work by successive authors; analyze their interpretation and use of that work and analyze the synthesis established. The reason for this is to recognize errors in claims, scientific assumptions and hypotheses demonstrating how an issue and problem might gain from applying an existing theory and/or technique and/or practice. This 'finds the gap' for the study or finds in the literature what might be suggested as best practices.

The research topic must be established before reviewing the literature. Reviewing literature enables researchers to have deeper understanding of the subject. The fixed subject will become the central idea of the researchers for exploring further on the relevant areas of literature. This means that literature review shall be performed after the study topic is decided. Literature review will increase the understanding and enable researchers to be confident in their ability (Neuman, 2014).

The literature review should be comprehensive and summarize the main literature material of research questions. According to Creswell (2018), there is no clear, standardized way to perform a literature review, but it is up to researchers to determine how to do it. Creswell (2018) recommended a comprehensive way with seven steps in conducting a literature review. They begin with Step 1 which is identifying key words, where it is useful for finding materials in a university library or college library. Such key words may emerge in identification of a topic or may result from preliminary readings. Step 2: with the key words identified, computer can be used to begin searching the databases for journals and books related to the topic. Step 3: locate about 50 reports of research in journal articles or books related to the research topic. Step 4: skim these papers and chapters of books, pick those that are central to the topic. Step 5: while identifying useful literature materials, begin designing a literature map which is in a form of a visual picture or figure of groupings of the literature on the topic. The literature map is useful to illustrate how the study will add to the existing body of knowledge. Step 6: draft summaries of the most relevant articles. The summaries can then be combined into the final literature review in the research report. Include clear references to the literature follow the guidelines of the thesis writing. Step 7: assemble the literature review, thematically structuring or arranging it according by important concepts. End the literature review with a rundown of the key topics and explain how the specific study contributes to the literature and solves a theme gap. The review will also refer to the data collection and data analysis approaches to add to the literature. At this point, a critique of the past literature can be advanced and the flaws in it or problems in its methods can be pointed out.

Figure 3.5 shows the simplified diagram of the literature review process conducted in this research.

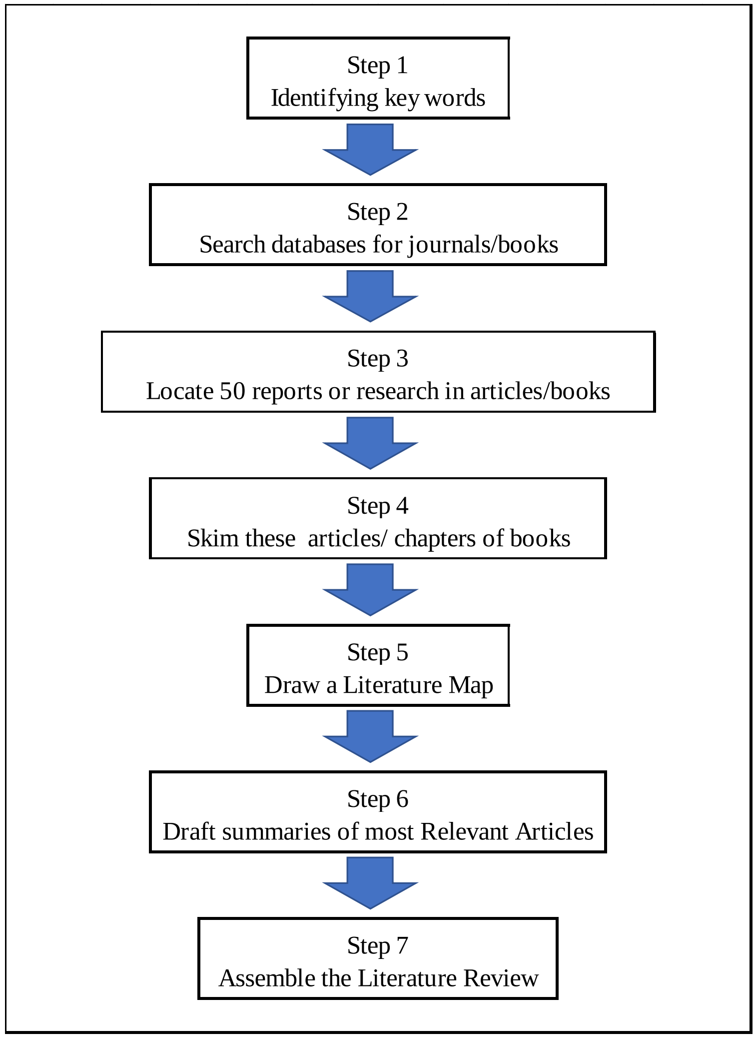


Figure 3.5: Literature Review Process

This present study adopted the seven steps in conducting a literature review recommended by Cresswell (2018). The study begins in the first step by identifying key words relevant to the cost estimation model based on cost significant elements which include: "cost estimation model", "construction projects", "cost estimate", "cost significance", "cost significant model", "cost control", "pre-tender cost estimates", "tendering" and other related keywords. These key words which were resulted from preliminary readings are very useful when finding materials in the university's academic library. In the second step, key words are searched in the online databases subscribed to the university library to find the relevant journal articles on the cost estimation model based on cost significant elements. Such electronic databases which can be accessed by using the university library's website include ASCE Library, Emerald, Google Scholar, IEEE Xplore, ProQuest, ScienceDirect, Scopus, Taylor & Francis Electronic, Wiley Digital Library and Web of Science. In the third step, around fifty research papers in articles and books related to cost estimation model based on cost significant elements were found during the initial phase of the study. Those research reports in journal articles or books were then ranked by their relevance to the current study. In the fourth step, this initial group of research reports is skimmed to see if they contribute to literature understanding to the study on cost estimation model based on cost significant elements. In the fifth step, after the useful literature was collected, a literature map was drawn to show literature groupings related to cost estimation model based on cost significant elements. This helps demonstrate how the current study relates to the literature by placing the current study within the broader research body. In the sixth step, the summaries of the most important research reports are presented in the final literature review of this research report. Literature references are used in this analysis by referring to the Universiti Tunku Abdul Rahman (UTAR) Thesis Manual (January 2020), so that a full list of references may be included at the end of this report. In the final i.e., the seventh step, the literature review is structured thematically based on the important concepts. It ends with a review of the key topics and recommendations for how the new research contributes to the literature.

3.4.2 Questionnaire

The quantitative methods used in research can be developed by focusing on either experimental or non-experimental design. The experimental research design aims to assess the effect of the theory or treatment intervention on an outcome. The experimental design is less appropriate for this research study as the laboratory performs experimental research is only appropriate for scientific testing. (Surbhi, 2016). Therefore, the non-experimental research design was used in this research study to represent the survey design. A survey design is common because it has many advantages, one of them being able to allow the researcher to easily and quickly collect and analyse the data (Chua, 2012). The sampling of the survey design is wider than the experimental design. The survey design is ideal for field testing to evaluate program effectiveness (Surbhi, 2016).

The use a questionnaire is popular for social science studies to address the questions researchers want to ask their respondents. This research method can easily reach all possible respondents, as the questionnaire is printed on papers distributed either by hand or by email. Additionally, web-based survey systems can also be used to submit questionnaires to prospective respondents through electronic means. For this reason, a researcher has the choice of submitting his questionnaires on papers or in electronic form. Typically, a questionnaire is used to gain the respondents' opinions of those subjects they are acquainted with. This process will usually be completed within a very short time, as potential respondents already have the answers in their minds and just need to reply accordingly.

3.4.2.1 Purpose of Questionnaire

The questionnaire developed in this study was used to measure the levels of cost significance awareness of HRCPs in Klang Valley, Malaysia among building contractors and CQSs. In this case, each of the targeted respondents was asked to demonstrate his/her level of agreement on each of the twenty-five cost elements shown that the element is a cost significant element based on a five-point Likert scale. Besides showing the level of agreement on whether an element is a cost significant element, the respondent was also asked to provide his/her demographic details to allow comparisons of similarities and differences between responses. In addition, the questionnaire also aimed to find out the most common type of method used in estimating construction costs of HRCPs in Klang Valley during tendering by building contractors and pre-tender estimates by CQSs. Other than that, the questionnaire was used to determine whether the cost significance technique to estimate construction costs of HRCPs in Klang Valley is being adopted by building contractors and CQSs during tendering and pre-tender estimates respectively.

According to Kothari (2009), a questionnaire is a list of questions relating to the study objectives and questions are organized in a structured and systematic manner. However, the questionnaire is expected to be understandable and answerable, and all questions must be answered independently by the respondents. A well-designed questionnaire is extremely important in order to attract the attention of the respondents and to obtain their interest in responding passionately and sincerely to the questionnaire. It is therefore necessary to identify the appropriate steps to be taken when constructing a questionnaire in order to achieve its purpose. The appropriate steps in determining the questionnaire sample size, strategies used in the questionnaire development and questionnaire distributing techniques are discussed in the following sessions.

3.4.2.2 Questionnaire Respondents and Sample Size

According to Sekaran and Bougie (2016), target population is defined as a group of phenomena, objects or persons researchers want to study. A sample is taken from a population and analyzed. The research findings and outcomes are deduced to the real population. Kumar et al. (2013) explained that the population is too big and costly to research the whole population. Sampling is therefore necessary to classify the respondents to be investigated. Sample size is very significant in research, if it is too small, the outcome can later be inaccurate. At the other hand, if the sample size number is too large, it will cost a lot of money and time to perform the research.

The sample design is usually determined before data collection process. It is known as a planning method, technique and procedure that allows researchers to select the study sample from a large population. It is important in determining the sample size and context for the research study (Kothari, 2009) while according to Chua (2012) and Pajo (2018), it is the method of choosing a part of a large population known as a sample that actually represents the entire population. Chua (2016) mentioned that sampling selection is extremely significant, because it affects the reliability and validity of the research study. The study sampling design involves identification of the survey frame or target population, sampling procedures and sample size.

The sampling frame is one of the key areas to remember when the sampling is planned. It is to set a boundary to the size of the sample from a large population group. Nevertheless, a research analysis may have more than one sampling frame (Turner, 2003) as each sampling frame provides the research subject with various types of information and perspectives. In this research study, there were two group of sampling frames which consisting of building contractors and CQSs in the construction field within Klang Valley area. A total of two groups of sampling were adopted to obtain the information to determine the levels of cost significance awareness of HRCPs in Klang Valley, Malaysia and the popularity of the use of cost estimation model based on cost significant elements in the local construction industry. CQSs and estimators working in quantity surveying consultant firms and building construction firms who had experience in pricing tender or pre-tender estimates of HRCPs in Klang Valley, Malaysia are targeted as the potential respondents since they were responsible for estimating the project costs in their organisations. In the cases where there was no CQS or estimator being hired in the firm, other personnel involved in doing cost estimates for their companies were also targeted as the potential respondents as long as they had experience in pricing tender or pre-tender estimates of HRCPs in Klang Valley, Malaysia. This could happen in many small and medium sized quantity surveying consultant firms and building construction firms for the reason that the business owners are normally the ones who prepare the project cost estimates.

Methods of sampling are divided into probability and non-probability sampling. According to Zikmund et al. (2013), if all elements in a population have a known, non-zero probability of being picked, it is called 'probability sampling'. Every participant of the probability sample population has an equal opportunity to be selected. Differ from probability sampling, the survey method is known as 'non-probability sampling' when the likelihood of any particular selected population member is uncertain. (Zikmund et al., 2013). The selection of participants is based solely on the researcher's personal opinion. Kumar (2011) had quite similar explanation on methods of sampling too. According to him, probability sampling techniques suggested equal and independent probability of sampling from a large population. It means the collection of elements in the sample does not influence certain factors, such as personal preference. Non-probability sampling approaches were used where the population is unknown or cannot be determined. The selection of non-probability samples is based on non-random filtering and subject to researchers' judgment.

As before mentioned, the targeted respondents in this research study were CQSs and estimators working in quantity surveying consultant firms and building construction firms who had experience in pricing tender or pre-tender estimates of HRCPs in Klang Valley, Malaysia. Even though there are records from the official website of Board of Quantity Surveyors Malaysia (BQSM, 2020) showing the number of CQSs including registered consultant QS, registered professional QS and registered provisional QS in Malaysia, there is no indication whether they are working with quantity surveying consultant firms or building construction firms. There is also no statistical record of how many personnel are working in the capacity of a CQS or an estimator in the Malaysian construction industry. Moreover, personnel who has experience in pricing tender or pre-tender estimates of HRCPs in Klang Valley, Malaysia may not be necessary a registered member of the board. Another scenario would be that an estimator who had experience in pricing HRCPs in Klang Valley while working in a CIDB Grade G7 building contractor's company in the past few years but currently is working with a Grade G1 contractor in Kedah. This is not an odd case as according to Jayaram (2015), Malaysia scored third highest voluntary turnover rate at 9.5% in Southeast Asia in 2015. The sample size for this study was determined by the equation by Krejcie and Morgan (1970) as shown below:

$$Ss = \frac{Z^2 \text{ x } p \text{ x } (1 - p)}{e^2}$$

where,
Ss = the sample size
Z = z-value which represents the confidence level in the data
p = the variability of responses
e = the sample error

According to Krejcie and Morgan (1970), the equation is suitable when the targeted population is greater than 100,000. In this study, the targeted population are quantity surveying consultant firms and building construction firms. There are 391 quantity surveying consultant firms registered with BQSM and about 130,905 building contractors for all the grades from G1 to G7 are presently registered with CIDB Malaysia. As such, this equation was deemed to be suitable for this research to select a representative sample size.

Consistent with past studies, a confidence interval of 95%, which represents 1.96 under the normal curve (z), and a sample error of 10% were used to calculate the sample size. According to Nnaji et al. (2019), sample errors of 5 to 20% have often been utilized in construction management studies especially exploratory studies. With the variability of responses of 50:50, the sample size for this study was determined at 97. Therefore, the researcher had aimed at collecting a sample size of a minimum of 100 respondents with even distribution of such personnel from quantity surveying consultant firms and building construction firms.

3.4.2.3 Questionnaire Design

A questionnaire should be user-friendly, look competent, true, attractive and motivational in nature and enable respondents to respond correctly and accurately. Most importantly, to all respondents it must be clearly understandable because they are likely to complete easy-to-understand questionnaires. The questionnaires must be clean, typed, and carefully designed. Questions in the questionnaire must be reliable and measure what is intended to be measured to achieve the research objective(s). The subject should be interesting or fascinating for the questionnaire to be completed by the respondents. Respondents are motivated to complete a questionnaire if a summary of the results is to be provided. Confidentiality must be maintained and thus the answers can only be used as part of the results of the analysis but not for any other reason (Shao, 2002).

The research guidelines from Kothari (2009) and Fink (2017) identifies several questionnaire preparation's rules that are essential for a good questionnaire. The questionnaire shall be systematically organized in the series as essential questions first followed by general knowledge questions. This is to prevent fatigue in answering the questionnaire, and the interest in answering the questionnaire is assumed to be diminished after a period of time. Moreover, some respondents might put in answer randomly and insincerely in later part of the questionnaire due to lack of time. In these situations, the data collected would be inaccurate and unreliable, particularly when the important questions are at the end of the questionnaire. In addition, the wording used in the questionnaire shall be short, simple, understandable, and straightforward. The questionnaire shall provide ample space if there are subjective questions to ensure that respondents' ideas are not limited. Chua (2012) highlighted that the questionnaire shall include specific directions for respondents to answer questions. It shall also provide the intention of the questionnaire and the definition of unfamiliar terms in the questionnaire to avoid misunderstanding by the respondents.

When designing a questionnaire, the steps to construct a questionnaire need to be identified. There are three steps to take when developing the questionnaire. Firstly, the preliminary questions from the literary review are listed. Secondly, the preliminary questions should be divided into a few main sections which refer to the research objective(s) (Naoum, 2007). Finally, the questions included in the questionnaire are decided on. There are two forms of questions included in the questionnaires, open-ended questions, and closed-ended questions. Open-ended questions require the respondent to offer full and thorough answers. Nonetheless, most respondents cannot give completed answers and therefore increase the data analysis difficulty. On the other hand, the closed-ended questions provide ease to respondents to answer questions as there are restricted numbers of answers to be set by researcher in the close-ended questions (Fellow and Liu, 2015). Both the open-ended questions and closed-ended questions have been adopted in this research.

Ordinary scales are used to provide details on the human identification, classification category of entries and their ranking order on some underlying properties (Ingule and Gatumu, 1996). In other words, the ordinal scale is used to measure variables that may be ranked. Likert scale is a commonly used ordinal scale form which was developed in 1932 by the psychologist Rensis Likert to measure attitude. This is typically a 5-point, or 7-point ordinal scale respondents make use of to show the extent to which they agree or do not agree with a statement (Sulivan and Artinao, 2013). Likert scale assumes that respondents are of a linear intensity of feelings and experience. According to

Revilla et al. (2014), the consistency coefficient of the data collected increases with the number of categories.

The questionnaire of this research consists of a total of 6 sections: Section 1 - Prequalification Exercise, Section 2 - Survey consent, Section 3 - Respondent's contact, Section 4 - Respondent's demographic profile, Section 5 - Cost significant elements and Section 6 - Local Practice. Prequalification exercise was set at the very beginning of the questionnaire in order to sieve away unsuitable respondents from participating the questionnaire survey as the targeted respondents were personnel who were working in the capacity of CQS related job especially with the experience in pricing for tendering/pre-tender estimates for HRCPs in Klang Valley, Malaysia. This was also to avoid the unnecessary wasting of the respondents' time and effort who were actually not the targeted personnel for the survey. Survey consent which was included in Section 2 of the questionnaire was for the purpose of fulfilling the requirement of the university that it is a must to get the written consent of the respondent for the survey. This section started with introduction to the respondents the aim of the survey. It further gave the respondents the estimation of the time duration needed to answer the survey so that they might decide earlier whether to continue with it at that point of time. In this section, affirmation on keeping the information given by the respondents confidential was emphasized so that the respondents were feeling safe and comfortable to participate the survey exercise. Meanwhile, the researcher's email address and mobile contact number were provided to enable the respondents to reach the researcher in case the respondents had in doubt or unclear of the questions asked and thus able to answer accurately. Lastly, this section ended with the researcher's appreciation to the respondents' assistance in participating the survey before the respondents ticked on one of the choices given to agree to proceed unless otherwise. In Section 3 - Respondent's contact, the respondents were asked to give their names and email addresses. The purpose of this was to allow the researcher to keep track on who were the invitees that had actually responded for the monitoring the responses and also enabled the researcher to communicate or talk to the respondents to make sure they understood the questions well. Section 4 of the questionnaire was to find out the respondents' demographic profiles. Two closed-ended questions were included. First was the nature of the respondents' current companies with only two choices either CQS or main contractor. Second was how long were the experience of the respondents in pricing construction costs of HRCPs in Klang Valley, Malaysia with five ranges of the years from '5 years and below' to 'more than 20 years'. In Section 5, the respondents were requested to show their level of agreement on how much they agreed to each of the 25 elements listed is a cost significant element of HRCPs in Klang Valley, Malaysia. A five-point Likert scale where 1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree and 5 = strongly agree had been used to evaluate the awareness of the respondents on cost significant elements of HRCPs in Klang Valley, Malaysia. Highlights were given on the exclusions of the scope of study which are earthworks, piling, external works, preliminaries and contingency sums so that the respondents could make their judgement more accurately. At the same time, the definition on HRCPs was given for the same intention. Meanwhile explanation on definition of cost significant element was given with the demonstration of an example of building project with 4 elemental bills to aid the respondents to have a clearer idea of what a cost significant element is. Section 6 being the last section of the questionnaire aimed to determine the current practice in the local construction industry of the methods used in estimating construction costs of HRCPs in Klang Valley, Malaysia during tendering/pre-tender estimates and the respondent's knowledge on the use of cost significance technique to estimate construction cost of HRCPs in Klang Valley, Malaysia.

3.4.2.4 Pilot Test

A pilot study is described as a small-scale test for the evaluation of questionnaire validity, efficiency and data measurement (Ballan, 2012; Chua, 2016). It is a pre-testing procedure before the actual sampling process is to be carried out. In addition, Connelly (2008) states that pilot study is necessary to establish and check the adequacy of research tools and the feasibility of full study. Based on a study by Johanson and Brooks (2010), 30 sets of data from the population of interest are a fair minimum requirement for a preliminary survey. Respondents' feedback is gathered and used to enhance the questionnaire to make it more accurate and to increase the comprehension of questions (Teijlingen and Hundley, 2001).

In view of the importance of the pilot studies, a pilot test is necessary in this research in order to avoid obtaining incorrect and inconsistent data from the respondents. As a result, 30 sets of questionnaires were distributed earlier and returned in order to undergo a pilot test to check the validity, reliability and appropriateness of the questions. This pilot group was excluded from the final study sample as the respondents had commented the questionnaire. This determined whether the survey could be completed by the respondents in the sample and whether they could understand the questions. Feedback from the pilot test was taken into account and some of the instructions were reworded so that they could be easily understood. The reliability of the survey was presented in the data analysis section. Finally, the finalized questionnaire was used for a full-scale study.

3.4.2.5 Questionnaire Distribution

As said in the sub-section 3.4.2.2, probability technique is not suitable for this study as the targeted population of respondents is unknown thus non-probability sampling technique is therefore used for this study. There are many examples of non-probability sampling technique for instant judgement sampling, convenience sampling and snowball sampling. Snowball sampling, as the name suggests, begins small, but sampling increases as the process continues. This is also known as 'chain-referral sampling,' since in the early stages, some respondents that match the study characteristics are found. Then they serve as informants to identify those who apply and match the sample characteristics (Bailey, 1994). The process repeats and the sample size increases. Furthermore, Noy (2008) defined snowball sampling as a technique whereby the researcher accesses potential respondents through contact information given by other respondents or informants. This is a repetitive method and the central concept is focused on the gathering of information between informants, this is why the 'snowball' metaphor is used in the name.

Snowball sampling method is the most suitable sampling technique for this study as the targeted respondents were specifically required to have experience in pricing tender or pre-tender estimates of HRCPs in Klang Valley, Malaysia. As such, the boundary of the targeted companies was narrowed down to only consultant quantity surveying firms and building construction firms as these are the organization where CQSs and estimators are attached to. With Snowball sampling method, it was faster to achieve the aimed number of targeted respondents to participate in the questionnaire survey.

In the very beginning, the researcher started with contacting some acquaintances such as former college and university course mates, friends and the researcher's former students from quantity surveying courses who were currently working in the construction industry. They were then invited to participate in the questionnaire survey if found that they were the suitable respondents for this research study. In the cases where any of the researcher's acquaintances was not a qualified respondent to take part in this survey, he/she was asked to recommend other colleagues or friends who were eligible and might be interested in responding to the questionnaire survey. This helped to ensure that there was a response from the sample selected. The process repeated until the aimed number of respondents were obtained.

Throughout questionnaire collection, the various modes of questionnaire management can carry major variations in the quality of the data collected (Bowling, 2005). First, it is necessary to obtain the consent of the respondents before the questionnaire is distributed. It is therefore important to contact the respondents and the methods of contact, such as letter, face-to-face contact, email and telephone communication. Next, the strategies used to administer the questionnaire affect significantly the quantity and quality of the data collected and the response rates of the respondents. The questionnaire may be delivered by hand, by phone, by post or by electronic mail to the respondents. Finally, there were two approaches to administering the questionnaire of this survey. The first was the mode of interview through verbal communication, where survey questions were asked to the respondents through face-to-face contact or by telephone. The second was mode of self-administration where the respondents needed to answer and fill out the questions themselves and there was no verbal communication between the two parties. After designing the questionnaire and determining the sampling size, the questionnaires for this study were sent to the targeted respondents by e-mail. The questionnaires were created using the Google Form form. The surveys were enclosed as hyperlinks and included in the email with a formal cover letter highlighting the research objectives. The questionnaires were distributed to the respondents who were working in the QS consulting firms and building construction firms in Klang Valley, Malaysia. Respondents were given approximately 2 weeks to answer the questionnaire. After 2 weeks a gentle reminder was sent if there was no response from any of the respondents. Online email surveys tend to have higher response rates than paper surveys, as respondents require little effort to respond.

Respondents are free to fill out questionnaires in various forms and at any time, including mobile phones and handheld devices like laptops and tablets (Kierczak, 2018). The questionnaire data collection for this study took around two and a half months' time. That was because most of the respondents were very busy with their work.

3.4.3 Case Study

The qualitative approach allows researchers to look at a specific topic in detail and in depth. Researchers are not constrained by the current list of analyses while approaching fieldwork, which contributes to the openness, depth and detail of qualitative research. It is therefore possible to obtain useful detailed information on a smaller sample of people as well as on cases (Patton, 2014). According to Maxwell (2012), qualitative research is flexible, as the research design can be constructed and reconstructed to a more noteworthy degree. Whilst Saunders et al. (2016) claimed that a lot of researchers formulate their theories using an inductive approach and the natural perspective will develop a new theory instead of the current theory. Conversely, some researchers are also pursuing a deductive approach that scrutinize existing theory using the qualitative method. The method of data collection for the qualitative method may vary depending on the research needs. All data collection methods must take into account the naturalistic and interactive nature of the data. A single data collection method may be used for the relevant research, such as semi-structured interviews or other analytical methods. This can be referred to as a single-method qualitative method. A multi-method qualitative study will involve more than one data collection technique. Qualitative study is a useful tool for exploratory studies, which can lead to a hypothesis and one of the advantages of this method is that the data collected is natural.

According to Patton (2014), there are three kinds of qualitative data. They can be obtained through (1) interview, (2) observations and fieldwork and (3) documents. Table 3.3 shows the three kinds of qualitative data with their definitions.

Table 3.3: Kinds of Qualitative Data

Methods of Collection	Definitions of Qualitative Data
Interview	Open-ended questions and probes yield in-depth responses about people's experiences, perceptions, opinions, feelings, and knowledge. Data consist of verbatim quotations with sufficient context to be interpretable.
Observations and fieldwork	Fieldwork descriptions of activities, behaviors, actions, conversations, interpersonal interactions, organizational or community processes, or any other aspect of observable human experience are documented. Data consist of field notes: rich, detailed descriptions, including the context within which the observations were made.
Documents	Written materials and documents from organizational, clinical, or program records; social media postings of all kinds; memoranda and correspondence; official publications and reports; personal diaries, letters, artistic works, photographs, and memorabilia; and written responses to open-ended surveys are collected. Data consist of excerpts from documents captured in a way that records and preserves the context.

Source: Patton, J., 2014. Qualitative Research & Evaluation Methods, 4th ed. Lonson: Sage Publications.

In this research, qualitative research method where case study of historical cost data of HRCPs in Klang Valley, Malaysia was utilized to develop a building cost estimation model based on cost significant elements. The historical cost data was collected by referring to contract documents from construction organizational companies. The qualitative method used in this research closely follows the methodology adopted by Poh and Horner (1995) to develop a cost-significant model based on historical cost data of student hostels in Singapore.

3.4.3.1 Case Study Sample Size

The sample size in qualitative analysis clearly describes the potential number of analytical materials and sources. The word 'sample size' derives from quantitative, precise sciences and refers to the precision of identifying the source and materials of data collection prior to collection. Defining the sample size of qualitative research equal to x number is contrary to the qualitative research logic. Therefore, the word 'sample size' is not used frequently in qualitative analysis, and when used, it is with a general understanding of its nature. The much-used word 'saturation' refers to the form close to the 'sample size'. The factual orientation is the starting point in qualitative research, and the researcher desires to discover about facts. For such an approach it makes sense to use the word 'saturation’. Saturation is used when a qualitative study has a factual purpose. The saturation point for the data, however, is difficult to define (Eriksson and Kovalainen, 2016).

The concept of data saturation, which is the stage where no new details or patterns are found in the data after more interviews or cases have been completed (Guest et al., 2006) is useful when considering about sample size in qualitative research. This approach means that a single case study or interview never is sufficient, as data saturation can only be seen after analyzing at least two (or usually more) cases. This concept of sampling until data saturation can be used to justify the use of a certain sample size in any qualitative research that is guided by this concept (Boddy, 2016).

According to Marshall (2013), apart from choosing a research subject and suitable research design, no other research activity is more fundamental to producing reliable research than sufficient sampling. Ensuring adequate data is a prerequisite to reliable research. Most qualitative methodologists openly recognize the lack of sample size standards. At the same time, some qualitative methodologists are not bothered by the lack of guidance, even if the ambiguous existence of sample size guidance represents the qualitative orientation of study. Some qualitative methodologists present general guidelines for sample size for phenomenological studies. Denzin and Lincoln (1994) proposed approximately 6, Kuzel (1999) suggested 6 to 8, and according to Morse (2000) it should be in between 6 to 10. Case studies are among the toughest types of qualitative study to classify. Yin (2009) recommended at least 6 sources of evidence while Creswell (2007) recommended no more than 4 or 5 cases.

In view of the general recommendation by the qualitative methodologists and reference made to Poh and Horner (1995), the researcher decided to collect historical cost data from minimum 4 to 6 case studies of HRCPs in Klang Valley, Malaysia for the purpose of developing a cost estimation model based on cost significant elements.

3.4.3.2 Case Study Selection Criterion

The case study selection criteria is important and shall be determined before data collection stage as the design of high-rise buildings in the Kuala Lumpur City Area is built in a variety of shapes and forms. (Ghazali et al., 2016). It is observed that majority of the HRCPs in Klang Valley are taller than 20 storey high due to the scarcity of land in this area, except those located at more outskirt of Kuala Lumpur. The selection of HRCPs for case study for this research is based on the criterion of project location, height of the condominium projects, provision of facilities and designed with carpark podium.

The first criteria: project location. The selected condominium projects for case study shall be located in the Kuala Lumpur and its conurbation (KLC) as it is one large urban entity which incorporates the complete range of urban functions. The KLC refers to the entire Klang Valley Region as originally defined by the Klang Valley Study (1972) together with much of the Kuala Langat district and the remaining part of the Sepang district where the KLIA is located. It covers a total area of approximately 4,000 square kilometres, which is about 40 percent larger than the size of the Klang Valley Region of 2,843 square kilometres. Since the Kuala Lumpur Structure Plan (KLSP) of 1984, the other urban centres in the Klang Valley Region, notably Petaling Jaya, Shah Alam and Subang Jaya, have grown at a rate that far outstrips that of the city. There has been strong in-migration to the KLC outside Kuala Lumpur from all over the country and net out-migration from Kuala Lumpur into residential areas located outside the city. As such, KLC has become the place where the high-rise condominium projects have increased exponentially.

The second criteria: height of the condominium projects. The selected condominium projects for case study shall be high-rise residential buildings ten (10) storeys and above in height. Definitions of high-rise buildings differ from country to country. Parasonis and Gautudis (2009) compared the different definition of a high-rise building of the United States of America (USA) and some European countries. A high-rise building is defined as a structure, the height of which from the ground to the highest point. In the USA it is 23 metres; Germany, France and the UK 22 metres; Lithuania 30 metres, Ukraine 73.5 metres and Russia 75 metres. There is no national building code or guidelines defining the minimum height or number of floors of high-rise buildings in Malaysia as mentioned by Lau et al. (2016). Therefore, the definition of high-rise building in this study is based on International Building Code IBC 2009 as well as National Fire Protection Association NFPA code. Both codes define high-rise buildings as buildings with a minimum height of 75 feet (22.9 m) above ground level. Referring to typical condominium buildings' floor height of approximately 3.3 m in Malaysia, 22.9 m is the height of a seven-floor building. However, condominiums less than 10 storey high is categorized as medium-rise (Seo and Omar 2011). As such, the minimum number of storeys acceptable as high-rise in this study is ten.

The third criteria: provision of facilities. The selected condominium projects for case study shall be with common facilities such as swimming pool, gymnasium, landscape, 24 hours security system, sports court and so on. According to Seo and Omar (2011), The Condominium is basically a “gated and guarded” mass housing typology and very popular among higher income urban dwellers who demanded better living condition, more privacy, security and crime prevention features with high quality finished. From the viewpoint of housing typology, a condominium is similar to an apartment. But the prevalent meaning in general is a higher cost urban mass housing with shared facilities and amenities provided by the private developer.

The fourth criteria: designed with carpark podium. The selected condominium projects for case study shall be with carpark podium instead of open carparks outside the building. A common strategy of podium and towers, a model adopted throughout Asia for nearly all new public housing developments. Putting housing on top of the podium provides residents with not only shopping, sports, community facilities. It is a successful way of dealing with high-density development, and maximizing the site intensity (Jenks and Dempsey, 2005).

3.4.3.3 Case Study Collection Process

Using the approach similar to questionnaire data collection, the first step was to contact some acquaintances for example former college and university course mates, friends and the former students from quantity surveying courses who are currently working in the construction industry to check if contract documents of completed HRCPs in Klang Valley were available in their companies. The selection criterion of the HRCPs were clearly briefed to them so that the suitable projects may be obtained. Secondly was to obtain the company's permission to allow the access to the cost data from the documents. In case any of them was not able to help, he/she was asked to check with friends who can offer the assistance.

The main problem encountered during the case study data collection was that the contract documents contain private and confidential contents especially the cost data. According to the Oxford Advanced Learner's Dictionary of Current English, "confidential" means "meant to be kept secret" or "not told or shared with other people" (Faruqi, 2011). Quite frequently there is a confidentiality provision in the employment contract that aims to prohibit employees from sharing sensitive details to anyone and failure to meet the commitments would amount to a breach of contract. Therefore, most of the people approached for the case study data refused the request especially building contractors to whom the cost data is the utmost secret for the companies as disclosure of cost data to other people outside the organization may lead to the leakage of their pricing strategies to their competitors.

Fortunately, there were still some friends and former colleagues who were willing to lend their helping hands to the researcher. They are the directors of QS consultant firms who can make important decisions in their organizations. However, as the service providers to their clients, they must seek for the clients' permissions before letting the researcher to have access to the contract documents. As such, a cover letter from the university of the researcher was required to assure that the data collected will be solely used for the purpose of the research and be kept confidential and will not be disclosed to any other party.

During the data collection, the researcher had to go the QS consultant firms to physically refer to the contract documents of HRCPs in Klang Valley to capture the information needed for the study. The contract documents are in bulk volume consist of hardbound copies of books including contract drawings. There is normally one hardbound copy of book for documents consist of letter of award, relevant correspondences of contractor, declaration of non-collusion, form of tender, instructions to tenderers, agreement and conditions of contract, preambles, specification, BQs and appendices. This book is normally named as Volume I of the contract documents. The subsequent volumes of the contract documents are generally contract drawings which consists of architectural drawings and structural drawings. The number and the thickness of the books for these drawings depend very much on the value of the total construction cost and project design. There are usually 5 to 6 numbers of hardbound books for a project of HRCPs in Klang Valley. The researcher had to take a very close scrutiny at the contract documents in order to summarize the essential data needed for the study. These data were captured into the computer worksheets on the spot when collecting the project data. The most tedious part of the process was to regroup the different groupings of building elements following the standard list of building elements suggested in the manual for the preparation of elemental cost analysis (ECA) from BCIC RISM. Thus, the time taken for the case study data collection took around a year as it has been found that different QS consultant companies have different ways of grouping the building elements in the BQ even though there is a list of standard building elements published by RISM.

3.5 Questionnaire Data Analysis Methods

A few analytical software packages can be used for quantitative data analysis, such as Microsoft Excel and the Social Sciences Statistical Package (SPSS) (Research Methodology, 2018). There are different numbers of statistical tests that can be performed using SPSS. The statistical tests are divided into two main groups, parametric tests and non-parametric tests. Parametric tests are the tests that assumed that the data would be normally distributed, it is often used when there are no skewed or outliner data. In addition, parametric tests are suitable for larger sample sizes of more than 30 samples ($n \geq 30$) (Marshall and Boggis, 2016). Since there is a larger sample size, it is easier to detect differences and relationships between the independent groups. Examples of parametric tests include t-tests, variance analysis (ANOVA) and regression tests. On the other hand, non-parametric tests do not make any assumption about data distribution. Non-parametric tests are encouraged to be used when the sample size is smaller because it is difficult to detect differences and normality. Examples of non-parametric tests include the Mann-Whitney and Kruskal-Wallis tests (Marshall and Boggis, 2016).

The data analysis process will be carried out after the data collection process to analyse all data collected from the respondents. Such findings will be presented in accordance with the research objectives. The key aim of data analysis is to ensure that data obtained from the respondents are correctly interpreted to produce reliable study results. During the data analysis process, the data collected will be processed, rearranged and tabulated for the interpretation of results.

SPSS tools were used in this study to analyse the quantitative data. Table 3.4 illustrates the statistical analysis conducted with SPSS.

Table 3.4: SPSS Data Analysis Framework

Level	Type of Analysis	Purpose
1	Descriptive Analysis	Demographic characteristics of respondents
2	Cronbach's Alpha Reliability Test	To check the reliability or internal consistency among responses
3	Mean Analysis	Pattern of rankings and mean scores
4	Mann-Whitney U Test	To identify specific methods/factors with significant disagreement between any two groups
5	Kendall’s tau-b Correlation Analysis	To measure association between two ordinal variables

3.5.1 Descriptive Analysis

Descriptive analysis is one of the simpler analytical approaches used to define a study's basic feature. The survey data will be tabulated and presented in graph form to enable a meaningful presentation. Tables and charts compared to raw data allow researchers to comprehend the information with one glance. The aspects analyzed under descriptive analysis are the participating respondents ' demographic profile for instant job titles, gender, work experience, etc. The information is helpful in recognizing the respondents' appropriateness and eligibility.

Two generic questions were raised in this research, which included the nature of the organization and years of experience in pricing the construction costs of HRCPs in Klang Valley, Malaysia. This was intended to determine

whether these aspects would affect their perception on the CSEs of the HRCPs in Klang Valley, Malaysia.

3.5.2 Cronbach's Alpha Reliability Test

Reliability test is widely used in questionnaire surveys based on Likert scale to assess the reliability of the samples. Cronbach's Alpha is used to test data reliability or internal consistency. Cronbach's coefficient alpha was the most widely used internal consistency index for estimating the reliability of measurement instruments such as questionnaires, scales, and inventories when it was developed in 1951. (Raykov, 1997). It's used in a variety of disciplines, including sociology (Cortina, 1993). According to Joppe (2000), A reliable research is a study with an accurate population representation, and the result can be interpreted in a similar study. Sekaran and Bouegie (2016) stated that the reliability of a measurement means that it has no bias and ensures accurate measurement over time. The formula of Cronbach's Alpha is as shown below:

$$\alpha = \frac{N \times \bar{c}}{\bar{v} + (N-1) \times \bar{c}}$$

Where,

N = number of scale items

$\bar{c}$ = average of all covariances between items

$\bar{v}$ = average variance of each item

When value of alpha is high, it indicates that the test is highly correlated. The alpha value is influenced by the number of items in a test which may result in a greater alpha value being measured by a greater number of items. Different researchers interpret the alpha scores differently. For example, Perry et al. (2014) stated that an alpha score above .75 is taken to mean a high reliability scale, .5 to .75 is widely accepted as indicating a moderately reliable scale, while a value below this usually indicates a low reliability scale. In general, an alpha score of more than .7 is usually acceptable. Table 3.5 shows the interpretation of Cronbach's Alpha by Sekaran and Bougie (2016).

Table 3.5: Interpretation of Cronbach's Alpha

Cronbach's Alpha Range	Level of Reliability
$\alpha < .6$	Poor Reliability
$.6 < \alpha < .7$	Fair Reliability
$.7 < \alpha < .8$	Good Reliability
$.8 < \alpha < .95$	Very Good Reliability

Source: Sekaran, U. and Bougie, R., 2016 Research Methods for Business: A Skill Building Approach. John Wiley & Sons.

In this research, the reliability of multiple questions from the Likert scale surveys was tested by Cronbach’s alpha reliability test. The main purpose of this test is to examine the reliability of the perception on the CSEs of the HRCPs in Klang Valley, Malaysia.

3.5.3 Mean Analysis

According Manikandan (2011), the arithmetic means is the easiest and most commonly used method of measuring the central tendency. The central tendency is the statistical test that figures out the means of the entire distribution. It is suitable for both discrete as well as continuous data. Whilst in the explanation by Rajasekar et al. (2013), measures of central tendency are to describe the position of the distribution of data collected in the research study. Mean is usually used to examine the relationships of different variables in the research analysis and investigate whether there is a significant difference between the samples. Once the mean for each variable is determined, the variables can be listed by the determined mean. The formula given for arithmetic mean is:

$$\bar{x} = \frac{\sum x}{n}$$

Where,

$\bar{x}$ = Mean of an item

$\sum x$ = Sum of an item

n = Total numbers of observations

In this research, the mean is calculated in order to represent the overall average response regarding the respondents' level of agreement on the elements that they are CSEs of HRCPs in Klang Valley, Malaysia. The mean specifies the highest and lowest agreement mentioned. The variable with the highest score indicated the agreement is the highest and vice versa. A comparison can be observed on the ranking of the level of agreement on the elements that they are CSEs of HRCPs in Klang Valley between building contractors and CQSs.

3.5.4 Mann-Whitney U Test

The Mann-Whitney U test is used to determine whether two independent variables differ statistically from each other (Weaver, et al., 2018). It is suitable for the comparison of differences in the same population. This test ranks all scores in both groups. (Carver and Nash, 2009). The Mann-Whitney U test would test the null hypothesis (H0) and the alternative hypothesis (H1). H0 indicates that there are no significant differences between two separate samples, while H1 indicates that there are significant differences between two separate samples.

In this research, the Mann-Whitney U test is used to test whether there are significant differences between building contractors and CQSs of their level of agreement on the elements that they are CSEs of HRCPs in Klang Valley, Malaysia. The hypothesis statements were formed as following:

H0: There are no significant differences between building contractors and CQSs of their level of agreement on the elements that they are CSEs of HRCPs in Klang Valley, Malaysia.

H1: There are significant differences between building contractors and CQSs of their level of agreement on the elements that they are CSEs of HRCPs in Klang Valley, Malaysia

3.5.5 Kendall's Tau-b Correlation Analysis

Kendall's tau-b correlation is a nonparametric correlation coefficient that can be used instead of the Spearman correlation. According to Perry et al. (2016), it is to measure association between two ordinal variables and takes into account tied ranks, as to enable the use for small size data sets with a lot of tied ranks. Kendall's tau-b is a nonparametric measure of the strength and direction of association between two variables measured on a scale of at least one ordinal scale. Kendall's tau-b, for instant, could be applied to see if there is a link between examination's grade and time spent doing revision (i.e., where there were 5 possible examination's grades 1, 2, 3, 4, and 5; and time for revising split into 5 categories: less than 10 hours, 11-19 hours, 20-29 hours, 30-39 hours, and 40 hours or more). Kendall's tau-b can be used to figure out if there's a link between customer satisfaction and time of delivery (i.e., where time of delivery has 4 categories: less than 2 days, 2 to 3 days, 3 to 5 days, and more than 5 days; and measure customer satisfaction in respect of the level of agreement of customers with the statements, "the time it took to deliver my parcel that I am satisfied with ", where the level of agreement had five categories: strongly disagree, disagree, neither disagree nor agree, agree and strongly agree) (Laerd Statistics, 2022).

In this research study, Kendall's tau-b is adopted to test whether there are strong correlations between the respondents' years of experience in pricing HRCPs in Klang Valley, Malaysia and their level of agreement on the elements that they are CSEs of HRCPs in Klang Valley, Malaysia. If the value is equal to or less than 0.05 (≤ 0.05), it suggests that the correlation is significant.

3.6 Case Study Data Analysis Method

Elemental costs appeared on the summary page of the BQ for a building project can be analysed by following the similar method introduced by the former researchers so as to determine the CSE and their cost contribution in percentages to the TBC. The theory underpinning this work is the Pareto's principle which state that 80 per cent of the effect is caused by 20 per cent of the causes. As such, we may hypothesize that 80 per cent of the TBC is caused by 20 per cent of the number of elements.

Case study is carried out on six (6) numbers of HRCPs in Klang Valley, Malaysia to develop a building cost estimation model based on CSEs of the HRCPs. Tabulations are done based on the Royal Institution of Surveyors Malaysia's (RISM) elemental cost breakdown of twenty-five (25) elements. Total cost of each element is captured from the contract documents of a project. Firstly, the 'Actual Total Bill Value' is obtained by totalling up the elemental costs of the total of twenty-five building elements. Secondly, the 'Mean Bill Value' is found by dividing the 'Actual Total Bill Value' by the 'Number of TE'. Then the CSEs and NCSEs can be determined by checking if the total cost of each element is greater than or smaller than the 'Mean Bill Value'. A building cost model is then developed where only the total cost of the CSEs need to be calculated and thereafter by multiplying it with a cost model factor developed based on the projects analysed, the total building cost can be determined.

With the same approach, study is carried out on two (2) numbers of recently completed HRCPs in Klang Valley, Malaysia in order to validate the cost model developed.

3.7 Chapter Summary

This chapter has explained in detail the research method used in this study which is the mixed methods research. The eight steps employed in the research process are as shown in Figure 3.3. The secondary data was obtained through review of apposite literature which has prompted out the idea for the research design of this study. On the other hand, the primary data were collected through questionnaire and case study. The aimed respondents for the questionnaire data were CQSs and estimators working in quantity surveying consultant firms and building construction firms who have experience in pricing tender or pre-tender estimates of HRCPs in Klang Valley, Malaysia so that reliable results can be obtained to achieve the research objectives 1 and 2. As for the data analysis and testing, the SPSS statistical software was used. The case study data collection method was adopted to obtain cost data and other information from historical projects provided by QS consultant firms and analysed following the similar way adopted by the previous researcher dominating this area of research for the ultimate purpose of developing a cost estimation model based on cost significant elements of HRCPs in Klang Valley, Malaysia. Chapter 4 presents the results of questionnaire survey and case study.

CHAPTER 4

DATA ANALYSES AND FINDINGS

4.1 Introduction

This chapter discusses the data analyses and findings of the mixed methods i.e., both the questionnaire survey and the case study.

4.2 Questionnaire Survey

The data analyses and findings of the questionnaire survey are demonstrated in the subsections on summary of questionnaire data analysis methods; the response rate; the descriptive analysis of the respondents' demographic which consists the nature of business of the current company, experience in pricing HRCPs in Klang Valley, Malaysia, experience in pricing HRCPs in Klang Valley, Malaysia between different nature of business, and the local practice; the results of Cronbach's Alpha Reliability test; the results of mean ranking analysis; the results of Mann-Whitney U test; and the results of Kendall's tau-b Correlation analysis.

4.2.1 Summary of Questionnaire Data Analysis Methods

Three out of the six sections where the essential data were collected for analysis to find out the results in order to achieve the first two research objectives are Section 4: Respondent's demographic profile, Section 5: Cost significant elements, and Section 6: Local Practice. Table 4.1 shows the summary of questionnaire data and their analysis methods/tests.

Table 4.1: Summary of Questionnaire Data and Analysis Methods

Section	Purpose	Nature of Question	Type of Analysis Method/Test
1	Prequalification Exercise	1. Is respondent with experience of pricing tender/PTE? 2. Is respondent with experience of pricing HRCPs in Klang Valley?	Descriptive Analysis
2	Survey consent	1. Respondent understands the survey consent and agrees to proceed with the survey?	Not Applicable
3	Respondent's contact	1. Respondent's name. 2. Respondent's email address	Not Applicable
4	Respondent's demographic profile	1. Nature of business of respondent's current company. 2. Respondent's years of experience in pricing HRCP's in Klang Valley.	Descriptive Analysis
5	Awareness of Cost significant elements	1. Respondent's agreement that each of the 25 elements is a CSE of HRCPs in Klang Valley based on the 1 to 5 point scales *(1=strongly disagree →5=strongly agree)*	Cronbach's Alpha Reliability Test; Mean Ranking; Mann-Whitney U Test; Kendall's tau-b Correlation Analysis
6	Local Practice	1. Has respondent been using traditional method/other method(s) in pricing HRCP in Klang Valley? *(choose traditional or other method(s))* 2. If other method(s) being used, respondent to specify. *(open-ended question)* 3. Has respondent heard of Cost Significance Technique to estimate HRCPs in Klang Valley? *(choose yes or no)* 4. Has respondent used Cost Significance Technique (CST) to estimate HRCPs in Klang Valley? *(choose yes or no)* 5. Respondent's choice of how accurate the CST is based on the 1 to 5 point scales *(1=not accurate→5=very accurate)*	Descriptive Analysis

The purpose of Section 1 of the questionnaire is for prequalification exercise to make sure only qualified respondents are participating the survey. Initially, the survey questionnaire was distributed to 200 potential respondents through emails where the email addresses were obtained through snowball sampling method as discussed in the previous chapter. Finally, there are only 158 responses received. However, 39 out of the 158 responses were unqualified respondents where 4 respondents are not with the experience of pricing tender/PTE while 35 respondents are with the experience of pricing tender/PTE but not with experience of pricing HRCPs in Klang Valley. Therefore, it was left with 119 survey questionnaires for analysis purpose. Due to 5 cases of straight liners (Hair et al., 2017) and 2 cases of outliers (Kumar et al., 2013) detected, 7 survey questionnaires are excluded from the data set after screening and cleaning data (Pallant, 2016). 112 eligible questionnaire data are then left for data analysis. Figure 4.1 shows the computation of the survey questionnaire in a pie chart showing both the numbers and percentages.

In Figure 4.1, the whole pie chart represents 100% of the total number of questionnaires distributed, i.e., 200 numbers. The 42 unresponded questionnaire is equivalent to 21% of the total number of questionnaires distributed. Following the same principle, 4 respondents without experience in pricing tender/PTE 2%; 35 respondents with experience in pricing tender/PTE but not for HRCPs in Klang Valley, Malaysia 17%; 5 straight lining 3%; 2 outliers 1%; and 112 eligible questionnaire data for analysis 56%.

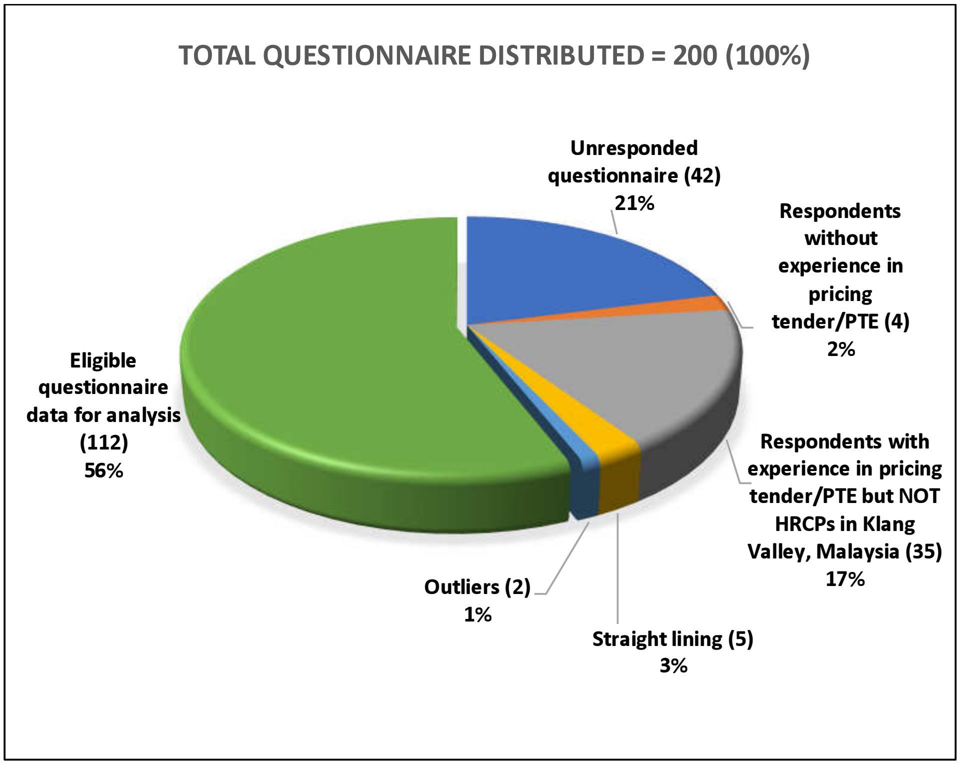


Figure 4.1: Computation of Survey Questionnaire

The final 112 eligible questionnaire data were statistically analyzed using Microsoft Excel and SPSS. Microsoft Excel was used to do the descriptive analysis for Section 4 and Section 6 of the questionnaire i.e., respondent's demographic profile and local practice respectively. On the other hand, SPSS was used to carry out Cronbach's alpha reliability test, mean ranking analysis, Mann-Whitney U test and Kendall's tau-b correlation analysis for Section 6: awareness of cost significant elements. The findings are seen and discussed in the following sessions to provide a deeper understanding and insight into the analysis.

4.2.2 Response Rate

There were 158 respondents participated out of the 200 set of questionnaire survey distributed. However, after the dropping out of a total of 39 respondents after the prequalification exercise, there remained only 119 survey questionnaires. As such, the response rate for the participation of overall respondents was 79% whilst the response rate for the participation of qualified respondents was reduced to 59.5% only. Nevertheless, the response rates are considered high as Baruch and Holton (2008) in their study pertaining survey response rate levels had concluded that the average response rates for studies which collected data from individuals and studies which collected data from organizations were 52.7% and 35.7% respectively. Most importantly, the researcher's aim of collecting a sample size of a minimum of 100 has been exceeded and to have even distribution of such personnel from quantity surveying consultant firms and building construction firms has also been achieved.

4.2.3 Descriptive Analysis: Respondents' Demographic

This sub-topic describes the survey respondents' demographic information. The respondents' demographic backgrounds are extremely significant in examining how respondents of different backgrounds show their degree of agreement on how much they agree to each of the 25 elements listed is a cost significant element of HRCPs in Klang Valley.

4.2.3.1 Respondent Demographic: Nature of Business of Current Company

Figure 4.2 shows the total number of respondents categorised by the nature of business of their current companies. The questionnaire has fixed the respondents to be from only two types of companies i.e., building contractor company and QS consultant company. Out of the total of 112 respondents, 55 are working at building contractor companies and 57 are working at QS consultant companies. In terms of percentage, the respondents from main contractor firms are 49% and the respondents from QS consultant firms are around 51%.

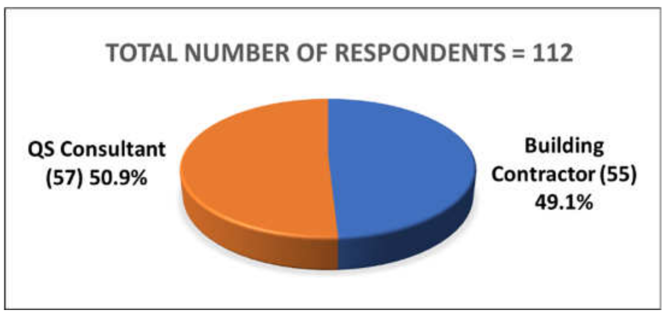


Figure 4.2: Nature of Business of Respondent's Current Company

4.2.3.2 Respondent Demographic Profile: Experience in Pricing HRCPs in Klang Valley

Figure 4.3 shows the total number of 112 respondents categorised by experience in pricing HRCPs in Klang Valley, Malaysia comparing the 5 experience categories as shown in the questionnaire. Out of the total of 112 respondents, 29 (25.9%) have experience of 5 years and below, 35 (31.3%) have experience of 6 to 10 years, 14 (12.5%) have experience of 11 to 15 years, 18 (16.1%) have experience of 16 to 20 years and 16 (14.3%) have experience of more than 20 years. Thus overall, there are 48 (42.9%) respondents with experience of more than 10 years and 64 (57.1%) respondents with experience of 10 years and below in pricing HRCPs of Klang Valley, Malaysia.

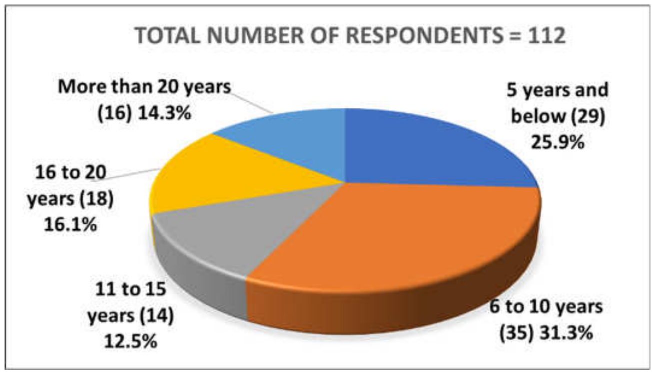


Figure 4.3: Experience in Pricing HRCPs in Klang Valley (5 experience categories)

4.2.3.3 Respondent Demographic Profile: Experience in Pricing HRCPs in Klang Valley between Different Nature of Business

Figure 4.4 shows the comparison of the 55 building contractors and the 57 QS consultants categorized by the experience in pricing HRCPs in Klang Valley, Malaysia comparing the 5 experience categories as shown in the questionnaire. There were 13 (23.6%) building contractors compared with 15 (26.3%) QS consultants for the experience category of 5 years and below of experience in pricing HRCPs in Klang Valley, Malaysia. 19 (34.5%) building contractors compared with 16 (28.1%) CQSs for the experience category of 6 to 10 years; 9 (16.4%) building contractors compared with 6 (10.5%) CQSs for the experience category of 11 to 15 years; 5 (9.1%) building contractors compared with 13 (22.8%) QS consultants for the experience category of 16 to 20 years; and 9 (16.4%) building contractors compared with 7 (12.3%) QS consultants for the experience category of more than 20 years of experience in pricing HRCPs in Klang Valley, Malaysia. Therefore, there are overall 32 (58.2%) building contractors compared with 31 (54.4%) QS consultants for the experience category of 10 years and below while there are 23 (41.8%) building contractors compared with 26 (45.6%) CQSs for the experience category of more than 10 years of experience in pricing HRCPs in Klang Valley, Malaysia.

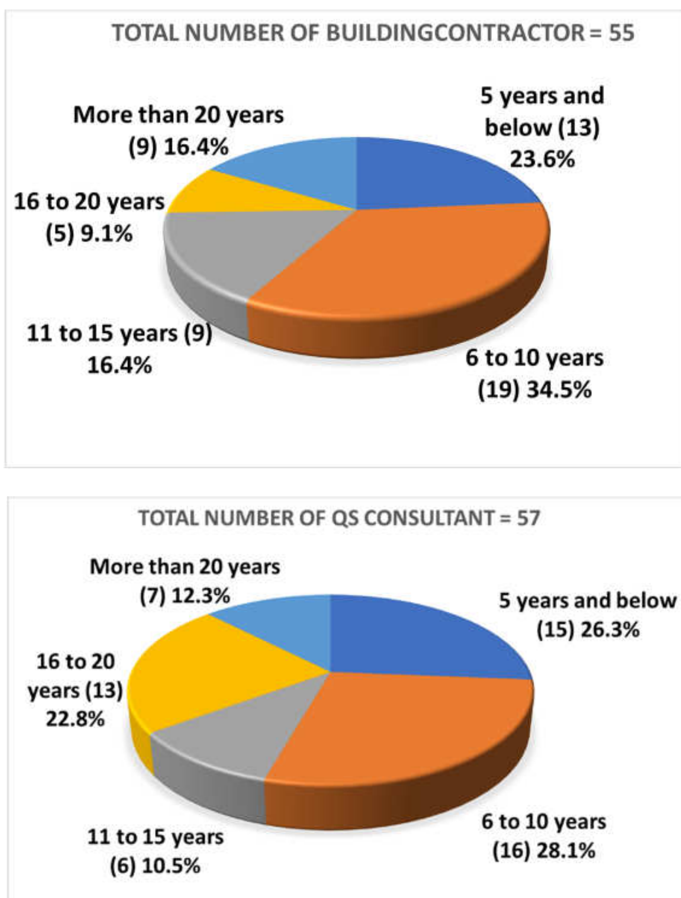


Figure 4.4: Experience in Pricing HRCPs in Klang Valley between Building Contractors and QS Consultant (5 experience categories)

4.2.3.4 The Local Practice

Table 4.2 shows the results of Questionnaire Section 6 which aimed at determining what is the common method used in the local construction industry to estimate construction costs of high-rise condominium projects in Klang Valley during tendering/pre-tender estimate. The results show that the common method used in the local construction industry to estimate construction costs of high-rise condominium projects in Klang Valley during tendering/pre-tender estimate is the traditional method i.e., pricing every single item of each element of BQs. There is no answer from the respondents on any other method used to estimate construction costs of high-rise condominium projects in Klang Valley during tendering/pre-tender estimate. The results also show that there are only 23 (20.5%) respondents who have heard of the cost significance technique, an alternative method to traditional method of estimating construction cost of a project. 15 of these 23 respondents are working with building contractors where 4 of them have 5 years and below experience in pricing HRCPs in Klang Valley, Malaysia. Others are 6 to 10 years - 5 respondents; 11 to 15 years - 2 respondents; 16 to 20 years - 1 respondent; and more than 20 years - 3 respondents. On the other hand, 8 of these 23 respondents are from QS consultants where 3 of them have 5 years and below experience in pricing HRCPs in Klang Valley, Malaysia. Others are 6 to 10 years - 3 respondents; 11 to 15 years - none; 16 to 20 years - 1 respondent; and more than 20 years - 1 respondent.

Table 4.2: Results of Questionnaire Section 6 (Local Practice)

Question	Type of Answering Method	Result
What method have you been using in estimating construction costs of high-rise condominium projects in Klang Valley during tendering/pre-tender estimate?	Choose either one: 1. Traditional method i.e., price every single item of each element of bills of quantities. 2. Other method(s)... to specify	- All the 112 respondents answered that they have been using traditional method i.e., price every single item of each element of bills of quantities and there is no other method used.
Have you heard of Cost Significance Technique an alternative method to traditional method of estimating construction cost of a project?	Choose either one: 1. Yes 2. No	- Answered 'Yes' - 23 respondents - Answered 'No' - 89 respondents <u>Answered 'Yes':</u> - 15 building contractors (5 years and below - 4; 6 to 10 years - 5; 11 to 15 years - 2; 16 to 20 years - 1; more than 20 years - 3) - 8 QS consultants (5 years and below - 3; 6 to 10 years - 3; 11 to 15 years - none; 16 to 20 years - 1; more than 20 years - 1)
Have you ever used the Cost Significance Technique to estimate construction costs of high-rise condominium projects in Klang Valley during tendering/pretender estimate?	Choose either one: 1. Yes 2. No	All the 23 respondents who answered 'Yes' in the previous question have answered 'No' for this question.

In general, it is concluded that the common method used in estimating construction costs of high-rise condominium projects in Klang Valley during tendering/pre-tender estimate without any other alternative. The awareness on the availability of alternative methods example method based on Cost Significance Technique is very low. Only a small population of QS consultants and building contractor have heard of this technique but no one has ever used the method. As such they couldn't give their comment on how accurate the Cost Significance Technique is.

4.2.4 Results of Cronbach's Alpha Reliability Test

The results of Cronbach’s Alpha reliability test show the value of .881 for the pilot test data set of 30 respondents with 25 number of items/variables, whilst for the final data set of 112 respondents the value of .866 with 25 number of items/variables is shown. Table 4.3 shows the level of reliability of the data for this study based on Cronbach’s Alpha value with reference to the interpretations by Perry et al. (2014), and Sekaran and Bougie (2016). It can be thus concluded that the levels of reliability for both the pilot test data set and final data set are within the range of high reliability scale according to interpretation by Perry et al. (2014) or considered as having very good reliability according to interpretation by Sekaran and Bougie (2016).

Table 4.3: Level of Reliability of The Data for This Study Based on Cronbach's Alpha Value

Researcher	Interpretation on Level of Reliability	Level of Reliability of The Data for This Study
Perry et al. (2014)	Score above .75 = high reliability scale; .5 to .75 = moderately reliable scale; Below .5 = low reliability scale	High reliability scale
Sekaran and Bougie (2016)	$\alpha < .6$ = Poor Reliability $.6 < \alpha < .7$ = Fair Reliability $.7 < \alpha < .8$ = Good Reliability $.8 < \alpha < .95$ = Very Good Reliability	Very good reliability

4.2.5 Results of Mean Analysis

Table 4.4 shows the respondents' levels of agreement on the statement that each of the 25 elements listed is a CSE of HRCPs in Klang Valley, Malaysia based on a five-point Likert scale where 1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree and 5 = strongly agree. The results were derived at by using mean analysis method. The five elements with the highest mean values are 'Frame', 'Upper Floors', 'Internal Floor Finishes', 'Electrical Installation' and 'Internal Floor Finishes'. 'Frame' which reaches a mean of 4.35 is the highest; 'Upper Floors' which reaches a mean of 4.17 is the second. This means that they are very cost significant to the respondents. 'Internal Floor Finishes' which reaches a mean of 3.96 is the third; 'Electrical Installation' which reaches a mean 3.94 is the fourth; and 'Internal Wall Finishes' which reaches a mean of 3.85 is the fifth. All the elements with the means above 3.00 but below 4.00 are considered cost significant to the respondents. The lowest five elements are 'Builder's Work in Connection with Services', 'Builder's Profit & Attendance on Services', 'Stairs', 'Refuse Disposal' and 'Internal Doors'. 'Builder's Work in Connection with Services' which reaches a mean of 2.37 is the lowest; 'Builder's Profit & Attendance on Services' which reaches a mean of 2.45 is the second lowest; 'Stairs' which reaches a mean of 2.60 is the third lowest; 'Refuse Disposal' which reaches a mean of 2.64 is the fourth lowest; and 'Internal Doors' which reaches a mean of 3.02 is the fifth lowest.

Table 4.4: The Respondents' Levels of Agreement on The Statement That Each of the 25 Elements Listed Is A CSE of HRCPs in Klang Valley, Malaysia

Statements	Mean	Standard Deviation	Cost Significance Level
2A) Frame	4.35	.596	Very significant
2B) Upper Floors	4.17	.815	Very significant
3B) Internal Floor Finishes	3.96	.67	Significant
5E) Electrical Installation	3.94	.809	Significant
3A) Internal Wall Finishes	3.85	.785	Significant
1A) Works Below Lowest Floor Finish	3.77	1.04	Significant
5G) Lift and Conveyor Installation	3.77	.771	Significant
5D) Air-Conditioning & Ventilation System	3.71	.81	Significant
2E) External Walls	3.66	.982	Significant
3D) External Finishes	3.60	.885	Significant
5B) Plumbing Installation	3.59	.823	Significant
2F) Windows & External Doors	3.52	.93	Significant
5F) Fire Protection Installation	3.45	.948	Significant
3C) Internal Ceiling Finishes	3.34	.896	Significant
4) Fittings and Furnishing	3.28	.979	Significant
2G) Internal Walls & Partitions	3.22	.956	Significant
5A) Sanitary Appliances	3.16	.991	Significant
2C) Roof	3.11	1.017	Significant
5H) Communication Installation	3.07	.887	Significant
5J) Special Installation	3.05	.909	Significant
2H) Internal Doors	3.02	.986	Significant
5C) Refuse Disposal	2.64	.957	Not significant
2D) Stairs	2.60	1.078	Not significant
5K) Builder's Profit & Attendance on Services	2.45	1.089	Not significant
5L) Builder's Work in Connection with Services	2.37	1.057	Not significant

As 3 = neither agree nor disagree which serves as a neutral point, it implies that any mean value greater than 3 is considered as 'agree that such element is a cost significant element' and any mean value smaller than 3 is considered as 'disagree that such element is a cost significant element'. From Table 4.4, it is observed that there are only 4 elements with the mean values smaller than 3, all other 21 elements are with the mean values greater than 3.

This generally means that the respondents thought that 21 elements out of the 25 elements are cost significant elements. At this point of finding, it was still too early to achieve the research objective RO1 which aimed to determine the building contractors' and CQSs' levels of cost significance awareness of HRCPs in Klang Valley, Malaysia. To measure such level of cost significance awareness, the phenomenon of which are the CSEs of the HRCPs in Klang Valley, Malaysia must be determined by the qualitative method where historical cost data were to be obtained by referring to the contract documents of completed HRCPs in Klang Valley, Malaysia.

4.2.6 Results of Mann-Whitney U Test

Table 4.5 shows the results of the Mann-Whitney U test comparing the QS consultant and the building contractor respondents' levels of agreement on the statement that each of the 25 elements listed is a CSE of HRCPs in Klang Valley, Malaysia. The probability values for all of the statements, except 3D) External Finishes, 5D) Air-Conditioning & Ventilation System, and 5F) Fire Protection Installation, are more than 0.05. This means that the results are not significant. For statements 3D) External Finishes, 5D) Air-Conditioning & Ventilation System, and 5F) Fire Protection Installation, the probability values are less than 0.05, which means that the results are significant. Thus, except the above three statements, the null hypothesis is accepted. It may therefore be concluded that the levels of agreement on the statement that each of the 25 elements listed is a CSE of HRCPs in Klang Valley, Malaysia between the QS consultant respondents and building contractor respondents are quite similar.

Table 4.5: Result of The Mann-Whitney U Test Comparing the QS Consultant and Building Contractor Respondents' Levels of Agreement on The Statement That Each of The 25 elements Listed Is A CSE of HRCPs in Klang Valley, Malaysia

Statement	Mann-Whitney U	Wilcoxon W	Z	Asymptotic Significance (2-tailed)
1A) Works Below Lowest Floor Finish	1451.000	3104.000	-.725	.469
2A) Frame	1364.500	2904.500	-1.350	.177
2B) Upper Floors	1502.000	3042.000	-.420	.675
2C) Roof	1448.500	3101.500	-.721	.471
2D) Stairs	1492.500	3145.500	-.459	.646
2E) External Walls	1456.500	2996.500	-.698	.485
2F) Windows & External Doors	1278.500	2818.500	-1.822	.069
2G) Internal Walls & Partitions	1292.500	2945.500	-1.683	.092
2H) Internal Doors	1558.500	3098.500	-.055	.956
3A) Internal Wall Finishes	1306.000	2846.000	-1.685	.092
3B) Internal Floor Finishes	1313.000	2853.000	-1.727	.084
3C) Internal Ceiling Finishes	1336.500	2876.500	-1.423	.155
3D) External Finishes	1219.000	2759.000	-2.216	.027*
4) Fittings and Furnishing	1369.000	2909.000	-1.212	.225
5A) Sanitary Appliances	1312.500	2852.500	-1.557	.120
5B) Plumbing Installation	1429.500	2969.500	-.868	.385
5C) Refuse Disposal	1539.500	3079.500	-.171	.864
5D) Air-Conditioning & Ventilation System	1178.000	2718.000	-2.465	.014*
5E) Electrical Installation	1383.000	2923.000	-1.167	.243
5F) Fire Protection Installation	1202.000	2742.000	-2.242	.025*
5G) Lift and Conveyor Installation	1281.500	2821.500	-1.839	.066
5H) Communication Installation	1443.000	2983.000	-.764	.445
5J) Special Installation	1480.500	3020.500	-.533	.594
5K) Builder's Profit & Attendance on Services	1516.500	3169.800	-.307	.759
5L) Builder's Work in Connection with Services	1424.500	2964.500	-.866	.387

Grouping variable: nature of business of respondent's current company.
*Significant as *p*-value < 0.05

4.2.7 Results of Kendall's Tau-b Correlation Analysis

Table 4.6 shows the results of the Kendall's tau-b correlation analysis comparing the overall 112 respondents' levels of agreement on the statement that each of the 25 elements listed is a CSE of HRCPs in Klang Valley, Malaysia based on the 5 categories of years of experience (5 years and below, 6 to 10 years, 11 to 15 years, 16 to 20 years, and more than 20 years) in pricing HRCPs in Klang Valley, Malaysia. It is observed that other than the statements 2A) Frame, 5C) Refuse Disposal, 5K) Builder's Profit & Attendance on Services, and 5L) Builder's Work in Connection with Services, the probability values (p-value) are more than 0.05 indicating that correlations are not significant. Among the statements with significant correlations, only 2A) Frame shows a positive correlation coefficient. This means that the more experienced respondents have higher awareness that frame is a cost significant element. For Statements 5C) Refuse Disposal, 5K) Builder's Profit & Attendance on Services, and 5L) Builder's Work in Connection with Services, the correlations coefficients are negative. This means that the more experienced respondents have higher awareness that these elements are not cost significant. As such, it may be concluded that the correlations between the respondents' years of experience in pricing HRCPs in Klang Valley, Malaysia and their level of agreement on the elements that they are CSEs of HRCPs in Klang Valley, Malaysia are generally not statistically significant.

Table 4.6: Correlation Between Years of Experience in Pricing HRCPs in Klang Valley, Malaysia, And Levels of Agreement on The Statement That Each of the 25 Elements Listed Is A CSE of HRCPs (N=112)

Statement	Correlation Coefficient	p-value
1A) Works Below Lowest Floor Finish	-0.017	0.827
2A) Frame	0.197 *	0.019
2B) Upper Floors	0.154	0.058
2C) Roof	-0.033	0.674
2D) Stairs	-0.060	0.445
2E) External Walls	0.091	0.249
2F) Windows & External Doors	0.058	0.469
2G) Internal Walls & Partitions	0.037	0.639
2H) Internal Doors	-0.013	0.869
3A) Internal Wall Finishes	0.149	0.064
3B) Internal Floor Finishes	0.126	0.122
3C) Internal Ceiling Finishes	0.046	0.564
3D) External Finishes	0.085	0.286
4) Fittings and Furnishing	-0.010	0.894
5A) Sanitary Appliances	-0.025	0.746
5B) Plumbing Installation	0.039	0.628
5C) Refuse Disposal	-0.182 *	0.021
5D) Air-Conditioning & Ventilation System	0.074	0.355
5E) Electrical Installation	0.124	0.123
5F) Fire Protection Installation	-0.091	0.248
5G) Lift and Conveyor Installation	0.018	0.823
5H) Communication Installation	-0.054	0.501
5J) Special Installation	-0.021	0.787
5K) Builder's Profit & Attendance on Services	-0.171 *	0.028
5L) Builder's Work in Connection with Services	-0.170 *	0.030

* Correlation is significant at the 0.05 level (2-tailed).

4.3 Case Study

The data analyses and findings of the case study are demonstrated in the subsections on development of the idea for case study; results for preliminary study 1; results for preliminary study 2; finalized criteria for case study which consists of case study revelations, case study corrective actions, and the final cost estimation model. The final cost estimation model's section has further discussed about brief specification of the case study projects, design/shape information of the case study projects, elemental cost contributions of the case study projects, the cost estimation model based on CSEs of HRCPs in Klang Valley, Malaysia, and the validation of the cost estimation model developed.

4.3.1 Development of the Idea for Case Study

At the outset of this research study, the researcher had initially planned to study in the area of cost estimation of construction projects. After reviewing on some literature pertaining to construction cost estimating, the researcher had come across the topic called cost significant modelling which has attracted the researcher's interest in it and thus the researcher decided to further explore into this area of study in order to produce something new based on the similar ways adopted by those researchers expertise on the topic of cost significance theory, which is expected to be of a significant contribution to the body of knowledge.

The research had started with 2 numbers of preliminary studies on different types of projects before embarking on the detailed scrutiny in constructing the final model for this research study. In the first preliminary study, a pilot analysis was carried out using cost data from a medium-cost apartment block to test the CSEs and their cost contributions comparing the two grouping methods i.e., the original BQs' format and the RISM's ECA format. The second preliminary study was a study aimed at determining the main contractors' awareness levels of the on CSEs of HRCPs in Klang Valley, Malaysia.

4.3.2 Results for Preliminary Study 1

The researcher had carried out the preliminary study 1 (Lim et al., 2.13). The details of the study were discussed in Section 2.11. The main finding for this pilot study is that different ways of grouping of the elements have very great effect on the cost significant elements of the same type of building. It was also finalized that 78.11 percent of the total building cost was contributed by 45.45 percent of the total number of elements based on original BQ format; whereas 83.77 percent of the total building cost was contributed by 50.00 percent of the total number of elements based on RISM's ECA format. As the main intention of the researcher was to develop a cost estimation model which if proved accurate and useful then may be significant helpful for the use of the local construction industry in order to vastly minimize the time spent for the cost estimation process, the results shown is less convincing for the type of building projects to be used. In addition, the comparison of the study gives an indication that in developing a cost model based on cost significant elements, a standard method of grouping the elements must be used. As such, the researcher decided to opt the study to other type of building project i.e., HRCPs. Another reason for the change of mind was also due to scarcity of the land area in Klang Valley, Malaysia, housing developers are moving towards constructing high-rise rather than low-rise residential buildings.

4.3.3 Results for Preliminary Study 2

The preliminary study 2 (Lim et al., 2018) carried out was a statistical analysis of main contractors' awareness on CSEs of HRCPs. The research was carried out using Questionnaire method where 232 survey questionnaire collected personal interviews were analyzed using various quantitative methods to test the level of awareness. The results of this preliminary study show that in general, the main contractors' awareness on CSEs is quite low. Moreover, both the building contractors' staff in managerial levels and executive levels are almost having the same awareness levels on CSEs of HRCPs in Klang Valley, Malaysia. Meanwhile, in the study on a Malaysia's private university quantity surveying undergraduates' awareness on CSEs of HRCPs by Lee et al. (2016) where the researcher was involved in, the results of the study revealed that the undergraduates' knowledge on CSE s is rather weak. These studies indicate the awareness levels on CSEs of HRCPs in Klang Valley, Malaysia are quite low both for the working adult contractors and QS undergraduates.

However, the questionnaires for the above studies are both based on the 12 elements grouping method developed by Smith et al. (2016). The 12 elements are: substructure (consists of foundation including piles), frame (consists of columns, upper floors), envelop (consists of external walls plus windows), roof, external doors, internal subdivision (consists of internal walls, screens, doors), finishes (consists of wall, ceiling, floor finishes), fittings, services, external works, and preliminaries. In view of this method of elemental grouping is very much different as compared to the way of grouping used by the Malaysian construction industry, it might lead to the confusion of the respondents in answering the questions set in the survey questionnaires. In view of this, the researcher decided to recollect the quantitative data through questionnaire using the method of elemental grouping shown in the manual of ECA by BQSM so that more reliable result could be obtained. The results of the questionnaire survey have been critically discussed in the former chapter.

4.3.4 Finalized Criteria for Case Study

After the makeup of mind of the researcher on the type of building to be studied to develop a cost estimation model based on CSEs which is HRCPs in Klang Valley, Malaysia, the researcher had started with the collection of the case study projects of HRCPs in Klang Valley, Malaysia with different designs. There were generally 2 stages of the case study data collections, the first stage was the collection of case study data for analysis based on the breakdown comparison of 12 elements grouping method developed by Smith et al. (2016) and the second stage was the collection of case study data for analysis based on the 25 elements grouping method in accordance with the RISM's Manual for the preparation of ECA.

During the case study data analysis, the researcher has come to some revelations during both stages of the case study collections. During the first stage of the case study collections, the researcher have come to the revelation that for building project without carpark podium i.e. with open carpark outside the building(s), the element of external works becomes a CSE whereas for building projects with carpark podium, the elements of external works become non CSEs. As such, the researcher has opted to select building projects with carpark podium during the second stage of the case study collection. On the other hand, during the second stage of the case study data collection, the researcher has come to the revelation that HRCPs which are below 20 storey high are not having the same CSEs with the HRCPs which are 20 storey high and above, therefore HRCPs which are below 20 storey high are excluded from the final case study data for analysis.

4.3.4.1 Case Study Revelations

The researcher has collected and analyzed case study data from 6 HRCPs with various differences in designs for instants height of building, number of tower blocks, number of storey for carpark podium, and provision of carparks in open external area or carpark podium; during the first stage of the case study collections. The dates of completion of these six projects were ranging from September 1996 to September 2009. The elemental costs are tabulated based on the breakdown comparison of 12 elements grouping method developed by Smith et al. (2016) as shown in Table 4.7.

Table 4.7: Element Costs of HRCPs in Klang Valley, Malaysia Based on Grouping Method Developed by Smith et. al.

No	Elements	Smith el al.'s Theory	Total Cost of Element																	
			Project 1: 2 block 15&16s (open carpark)			**Project 2:** 3 block 16-22s on 10s podium carpark			**Project 3:** 1 block 21s on 6s podium carpark with facilities floor			**Project 4:** 2 block 22s + 1 block 20s on 5s podium carpark			**Project 5:** 1 block 23s on 8s podium carpark + shops & office			**Project 6:** 1 block 33s on 5s podium carpark + 1 block 7-9s on 2s podium carpark		
1	**SUBSTRUCTURE**	NCSE	1,683,370.01	6%	NCSE	11,447,529.63	13%	CSE*	791,614.18	4%	NCSE	10,276,731.58	12%	CSE*	5,611,459.70	8%	NCSE	4,657,221.21	8%	NCSE
2	**FRAME (COLUMNS, UPPER FLOORS)**	CSE	5,236,890.61	19%	CSE	22,640,948.19	26%	CSE	5,923,094.16	30%	CSE	25,420,455.56	29%	CSE	11,683,986.55	17%	CSE	9,546,916.23	17%	CSE
3	**STAIRS**	NCSE	368,307.80	1%	NCSE	314,765.29	0%	NCSE	169,467.55	1%	NCSE	856,988.46	1%	NCSE	394,538.38	1%	NCSE	658,593.78	1%	NCSE
4	**ENVELOPE (EXTERNAL WALLS AND WINDOWS)**	CSE	1,450,180.75	5%	NCSE*	5,568,974.08	6%	NCSE*	1,441,018.25	7%	NCSE*	4,960,574.92	6%	NCSE*	5,329,024.54	8%	NCSE*	3,884,668.53	7%	NCSE*
5	**EXTERNAL DOORS**	NCSE	799,680.56	3%	NCSE	988,367.90	1%	NCSE	233,191.52	1%	NCSE	1,613,449.83	2%	NCSE	1,548,117.64	2%	NCSE	1,555,179.04	3%	NCSE
6	**ROOF**	NCSE	685,796.30	2%	NCSE	3,703,344.04	4%	NCSE	177,505.60	1%	NCSE	901,993.21	1%	NCSE	1,754,063.30	2%	NCSE	1,604,995.35	3%	NCSE
7	**INTERNAL SUBDIVISION (INTERNAL WALLS, SCREENS AND DOORS)**	CSE	1,883,737.11	7%	NCSE*	4,167,133.75	5%	NCSE*	1,032,363.29	5%	NCSE*	2,019,903.31	2%	NCSE*	6,176,486.48	9%	CSE	4,175,573.22	7%	NCSE*
8	**FINISHES (WALL, CEILING AND FLOOR)**	CSE	5,729,700.62	21%	CSE	9,420,490.39	11%	CSE	3,600,263.39	18%	CSE	11,532,537.34	13%	CSE	13,401,264.78	19%	CSE	10,374,146.87	18%	CSE
9	**FITTINGS AND FURNISHINGS**	CSE	884,800.00	3%	NCSE*	1,348,060.00	2%	NCSE*	108,478.60	1%	NCSE*	1,173,730.00	1%	NCSE*	482,690.00	1%	NCSE*	1,294,046.96	2%	NCSE*
10	**SERVICES**	CSE	4,899,293.00	18%	CSE	15,936,593.60	18%	CSE	3,915,096.46	20%	CSE	21,925,972.49	25%	CSE	16,345,247.15	23%	CSE	13,550,602.64	24%	CSE
11	**EXTERNAL WORKS**	NCSE	2,875,241.60	10%	CSE*	4,643,390.82	5%	NCSE	656,099.38	3%	NCSE	2,865,738.21	3%	NCSE	1,059,541.42	2%	NCSE	2,356,948.81	4%	NCSE
12	**PRELIMINARIES**	CSE	1,008,000.00	4%	NCSE*	6,798,919.36	8%	NCSE*	1,745,500.00	9%	CSE	3,699,836.08	4%	NCSE*	6,603,509.76	9%	CSE	3,981,501.26	7%	NCSE*
	Actual Total Bill Value:		27,504,998.36	100%		86,978,517.05	100%		19,793,692.38	100%		87,247,910.99	100%		70,389,929.70	100%		57,640,393.90	100%	
	Mean Bill Value:		2,292,083.20			7,248,209.75			1,649,474.37			7,270,659.25			5,865,827.48			4,803,366.16		
	Total Bill Value of CSEs:		18,741,125.83			59,445,561.81			15,183,954.01			69,155,696.97			54,210,494.72			33,471,665.74		
	No. of Total Elements:	12	12			12			12			12			12			12		
	No. of CSE in Total:	7	4			4			4			4			5			3		
	CSE/TE (per cent):		***33.3%***			***33.3%***			***33.3%***			***33.3%***			***41.7%***			***25.0%***		
	Total Bill Value of CSEs/Actual Total Bill Value:		***68.1%***			***68.3%***			***76.7%***			***79.3%***			***77.0%***			***58.1%***		

As compared to the seven (7) elements identified as CSEs by Smith *et al.*, there are only three (3) elements i.e. 'Frame (columns, upper floors)', 'Finishes (wall, ceiling and floor)' and 'Services' of the projects are absolutely CSEs whereby the other four (4) elements i.e. 'Envelope (external walls plus windows)', 'Internal Sub division (internal walls, screens, doors)', 'Fittings and Furniture', and 'Preliminaries' are CSEs or NCSEs varies from project to project. 'Envelope (external walls plus windows)' and 'Internal Subdivision (internal walls, screens, doors)' are generally NCSEs for local projects, this is probably due to the reason that HRCPs' external walls and internal walls/partitions are constructed of reinforced concrete shear walls thus the quantities of the brick walls are very minimal and also the cost of the brick walls is relatively low as compared to the materials used in overseas projects. It is found that 'Fittings and Furniture' is a NCSE for all the projects, the reason is, in local practice the expensive items of fittings and furniture such as bedroom furniture including beds, divans, wardrobes; bathroom furniture including cupboards; kitchen cabinets and etc. are not included in the contract between the employer and the building contractor. 'Preliminaries' is normally a NSCE, it could be due to the reason that contractors would not price the element high in order to be competitive to win the jobs.

As compared to the five (5) elements identified as NCSEs by Smith *et al.*, four (4) elements i.e., 'Stairs', 'External Doors', 'Roof' and 'External Works' of the projects are absolutely NCSEs but only 'Substructure' varies from one project to another. This is because the designs of substructure can be very much different from one project with another especially for the pilling works, one project would only need to use normal precast reinforced concrete piles where the soil condition is good while another project would need to use multiple types of heavy designed piling like bored piles and spun piles.

The case study results have not been able to demonstrate a consistent pattern of the cost contribution of the total building cost. It is suspected that this is due the type of projects is having too diverse types of design. Project 1 consists of 2 blocks of 15 and 16 storey of condominiums with open carpark while the other 5 projects are with carpark podium ranging from 2 storey to 10 storey. Project 3 which is the oldest project among all was completed in September 1996. There was no shear wall design for both the external walls and internal walls. All the projects completed after year 2000 are with shear walls for both the external walls and internal walls. When comparing the external works, it can be seen that only in Project 1 it is a CSE whereas in all other 5 projects it is not. This is obviously that it is because there is no carpark due to the project is at the outskirt area of Klang Valley. Even though in this attempt the researcher has fail to derive at a cost estimation model as envisaged, there is some gaining of the ideas on the selection criteria of the projects in the later stage of the research.

4.3.4.2 Case Study Corrective Actions

After the failure to develop the cost estimation model in the first stage of case study data collections and analysis, the researcher without other choice but to embark onto the second stage of case study data collections and analysis.

Subsequently after the learn-from-mistake in the first stage of case study data collections and analysis, some corrective actions are carried out in the second stage.

In view of the completion dates of the 6 projects from which the case study data were collected are a bit outdated, i.e., ranging from September 1996 to September 2009, thus the first corrective action is to re-collect the case study data from other new projects rather than using back some of the cost data from those projects. The second corrective action is to change the method of case study data analysis from the one based on the breakdown comparison of 12 elements grouping method developed by Smith et al. to the one based on the breakdown comparison of 25 elements grouping method in accordance with the RISM's Manual for the preparation of ECA, as it has been proofed that the former method has failed to demonstrate a consistent pattern of the cost contribution in order to develop the cost estimation model. The third corrective action is to exclude HRCPs without carpark podium while the fourth is to exclude HRCPs without shear wall design. Lastly, the fifth correction is to exclude the HRCPs below 20 storey high due to the reason as discussed in section 5.5.

4.3.4.3 The Final Cost Estimation Model

The final cost estimation model based on CSEs of HRCPs has been developed successfully evolved from the cost data of 6 numbers of HRCPs in

Klang Valley, Malaysia completed in between March 2010 and June 2015. Detail information of the said HRCPs is discussed in the following paragraphs.

Table 4.8 shows the tabulation of brief specification of the case study projects. The table shows the 25 elements with their contents and brief specification of the materials used. In general, the structure of the buildings reinforced concrete with the traditional construction method using formwork i.e., cast in-situ works on site. Grade 30 concrete is used for beams, upper floor slabs, roof beams, roof slabs and staircases. Grade 35 concrete is used for columns and grade 45 concrete for shear walls. External walls and internal walls are constructed of common clay bricks. Staircases are associated with mild steel railings complete with gloss paint finish. Windows are made of aluminium frame complete with glass glazing. Doors are usually single leaf or double leaves timber doors with steel door frames and fire rated timber door sets. Lintels for doors and windows are precast concrete lintels. Wall finishes usually consist of cement and sand plastering, skim coat plastering, ceramic wall tiles, emulsion paint to interior surfaces and weather shield paint for exterior surfaces of the plastered walls. Ceiling finishes are usually consisted of either plasterboard suspended ceiling with emulsion paint finish or skim coat plastering to the undersides of reinforced concrete slab complete with emulsion paint finish. The fittings and furnishings provided for are usually signages, mirrors, carpark fittings and signages, and children playground equipment. Except the sanitary fittings and appliances, and refuse disposal which are usually parked under the main builder’s work, other essential services like plumbing installation, air-conditioning and mechanical system, electrical services, fire protection system, lift installation, special installation example extra low voltage system and telephone services are usually incorporated in the main building contract as prime cost sums. The builder's profit and attendance on services are usually priced at around 1 to 2 percent of the prime cost sum's amount. Builder's work in connection with services are works for instant concrete counter tops for basins, reinforced concrete ledges and upstands, brick encasement walls for the services and the like.

Table 4.8: Brief Specification of The Case Study Projects

ELEMENT	CONTENT OF ELEMENT	BRIEF SPECIFICATION
1. SUBSTRUCTURE		
1A) Work Below Lowest Floor Finish	column bases, pile caps, ground beams, stumps, loadbearing brickwork below lowest floor and ground slabs	Concrete G15 to blinding, G30 to ground beam and ground slab c/w formwork
2. SUPERSTRUCTURE		
2A) Frame	RC columns, floor beams, roof beams and fascia beams	Concrete G30 to Beam; G35 in column and G45 in shear wall c/w formwork
2B) Upper Floors	RC floor slabs, balconies and structural screeds, suspended floors over or in basements	Concrete G30 in floor slab c/w formwork
2C) Roof	Roof structure incl RC slabs, trusses, parapet walls and balustrades at roof level; roof coverings; roof drainage; roof lights	Concrete G30 c/w formwork to waterproofing RC flat roof slab; steel roof trusses; metal deck/concrete roof tiles covering
2D) Stairs	RC stair structure, stair finishes, stair balustrades and handrails	Concrete G30 c/w formwork, 900mm mild steel railing; cement rendering
2E) External Walls	External enclosing walls incl. basement walls, retaining walls and diaphragm walls, skin of brickwork to cladding/curtain walling; cladding, curtain walling, sheeting rails, nonstructural fins and sunscreens; BUT excluding load bearing RC walls	Common clay brick and dpc
2F) Windows & External Doors	lintels, sills, hoods, ironmongery and glazing	RC lintels; aluminium windows incl. glass glazing
2G) Internal Walls & Partitions	Excluding load bearing RC walls	Common clay brick and dpc
2H) Internal Doors	Incl. lintels, sills, hoods, ironmongery and glazing	RC lintels; timber doors with steel door frame; fire rated doors
3. FINISHES		
3A) Internal Wall Finishes	Finishes to surfaces of walls and columns internally	Cement sand plaster/skim coat plaster, ceramic tiles, painting
3B) Internal Floor Finishes	Preparatory work, screeds, skirtings and finishes to floor surfaces	Floor hardener, waterproofing, porcelain tiles, timber strip flooring, painting
3C) Internal Ceiling Finishes	preparatory work, plastering and finishes to soffits; suspended ceiling incl. finishes	Plasterboard suspended ceiling, skim coat plaster to soffit of concrete slab, painting
3D) External Finishes	Preparatory work and finishes to outside face of external walls, external floor and ceiling	External wall, floor and ceiling finishes similar to 3A~3C
4. FITTINGS AND FURNISHINGS	Fixed fittings incl. shelving, cupboards, wardrobes, benches, counters etc.; Blinds, blind boxes, curtain tracks and pelmets; Blackboards, pin boards, notice boards, signs, lettering, mirrors etc.; Ironmongery to fittings; Furniture, curtains, loose carpets and similar soft furnishing material; Works of art; Non-mechanical and non-electrical equipment e.g. gymnasium equipment	Signages, mirrors, carpark fittings & signages, children playground equipment.
5. SERVICES		
5A) Sanitary Appliances		Sanitary fittings and appliances
5B) Plumbing Installation	Cold and hot water plumbing, sanitary plumbing	PC sums
5C) Refuse Disposal	Waste compactor, shredders, waste bins, incinerators, skid tanks and the like	Waste bins
5D) Air-Conditioning & Ventilation System		Air-conditioning and mechanical system (PC sum)
5E) Electrical Installation	Electric supply, electrical fitting and lightning conductors	Electrical services (PC sum)
5F) Fire Protection Installation		Fire protection system (PC sum)
5G) Lift and Conveyor Installation		Lift installation (PC sum)
5H) Communication Installation	Public address system, telephone installations, PABX, MATV and the like	Communication installation (PC sum)
5J) Special Installation	Kitchen equipment, laundry, building automation, security system, gas installation and the like	Extra low voltage system/Telephone services (PC sums)
5K) Builder's Profit & Attendance on Services		Usually priced at 1~2 percent
5L) Builder's Work in Connection with Services		concrete counter top, rc ledge and upstand, brick encasement wall and the like

Figures 4.5 to 4.12 show the brief designs/shapes of the case study projects. Each figure shows the building layout and section of the building. The building layout is to show the plan shape of the building while the section is to show clearly the information such as numbers of storey of the building with the breakdown of for example basement carpark, common facilities, carpark podium, podium floor, condominiums and water tank level. It is observed during the case study data collection that the titles of the projects are inconsistent in regards with the actual numbers of storey of the building. For instant Case Study Project 1, the title of the project stated 20 storey condominiums but there are 20 levels of condominiums on one level of basement carpark plus 1 level of shops, 6 levels of carpark podium and 1 level of podium floor for common facilities. The total height of the building is actually 28 storey counted from the ground level. In the case for Case Study Project 3, the title of the project stated 32 storey condominiums but there are only 23 levels of condominiums on one level of carpark basement plus 8 levels of carpark podium and 1 level of podium floor for facilities. In view of the above problem in the project titles to reflect the actual number of floors of the buildings, the researcher has described the building title follow her own method for example ‘x’ number of storey condominiums on ‘y’ number of storey carpark basement plus ‘z’ number of carpark podium etc. in order to avoid puzzlement during comparisons among the projects.

Case Study Project 1 is designed with 1 level of carpark basement in an irregular staggered shape of layout on plan view due to the project is on a congested site in a city area. There are 2 residential blocks with and 1 office block. Block A and Block B are the residential blocks constructed of 20 storey of condominium units on the link podium which consists of 10 number of shop units on ground level, 6 levels of podium carpark and 1 level of podium floor with common facilities. The condominium floors of Block A and Block B are linked on each floor. Block C is an office block of 15 storey high which consists of 1 level of podium carpark on ground level and 14 levels office units. The whole office block including its basement can be conveniently separated thus is excluded from this research study.

Case Study Project 2 is designed with 2 levels of carpark basement in an irregular shape of layout on plan view where the project is also on a congested site in a very prime location of Kuala Lumpur city center. There are 3 residential blocks namely Tower A, Tower B and Block C. The carpark basement for Tower A and Tower B is interlinked while carpark basement for Tower C is separated to its own. All the 2 tower blocks are constructed of 22 storey of condominium units on double storey shops (6 units all together) on ground level (podium floor) and mezzanine level and 6 levels of podium carpark. The common facilities floors are on the topmost level of the tower blocks. The condominium floors of Tower A and Tower B are linked on each floor while Tower C is by its own.

Case Study Project 3 is another building designed with 1 level of carpark basement in an irregular shape of layout on plan view. There is only 1 tower block which is constructed of 23 storey of condominium units on the podium which consists of 8 levels of podium carpark and 1 level of podium floor with common facilities. The layout of the tower block is in a general L-shape on plan view.

Case Study Project 4 is designed with a five-storey carpark podium block consist of 2 levels of semi basement carpark and 3 levels of podium carpark in a long rectangular shape of layout on plan view. The project is located in a very prime area of Kuala Lumpur city center too. There are 2 residential blocks namely Tower A and Tower B. The carpark podium for Tower A and Tower B is interlinked. Both the tower blocks are constructed of 26 storey of condominium units on 1 level of multi-purpose podium floor on ground level. Tower A and Tower B are separated at two far ends on the long podium block. One level of water tank level is on the topmost floor on top of the condominiums.

Case Study Project 5 consists of 3 separate blocks of building which are Tower A, Tower B and 1 individual block of carpark podium. Tower A and Tower B are identical with 30 storey of condominiums on 4 levels of podium carpark while the individual block of carpark podium is constructed of 4 levels of podium carpark. All the blocks are designed in a long rectangular shape of layout on plan view. The roof top of the individual carpark podium is the multi-purpose podium floor. Tower A is linked to the individual carpark podium with a link bridge/passage on each floor including the podium floor, likewise for Tower B. One level of water tank floor is on the topmost floor on top of the condominiums for both the towers.

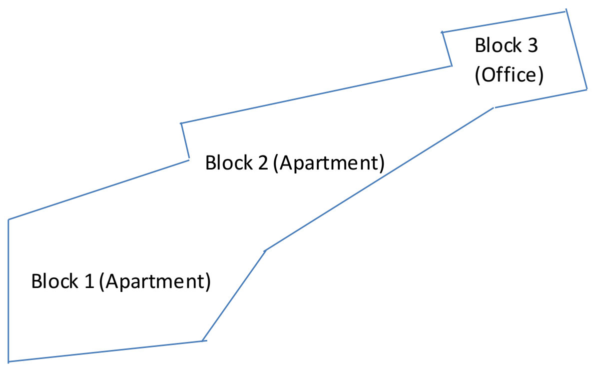
Case Study Project 6 is a very high-density condominium project designed with 2 levels of carpark basement and a two-storey carpark podium block in a Johnson Rafter Angle Square Ruler like shape of layout on plan view with a triangular shape of airwell in the center. There are 4 residential blocks namely Block A, Block B, Block C and Tower D. Block A and Block B are constructed of 34 and 34 storey of condominium units respectively on 1 level of shop units on the podium floor (ground level) and 1 level of facilities floor on Level 1. Block C and Block D are both constructed of 35 storey of condominium units on 1 level of shop units on the podium floor (ground level).

Case Study Project 7 is an odd shape building designed in an irregular shape on plan view. There is only 1 tower block which is constructed of 20 storey of condominium units on the podium which consists of 4 levels of podium carpark and 1 level of facilities floor. The podium floor is on top of the facilities floor. The building is constructed on a hilly site.

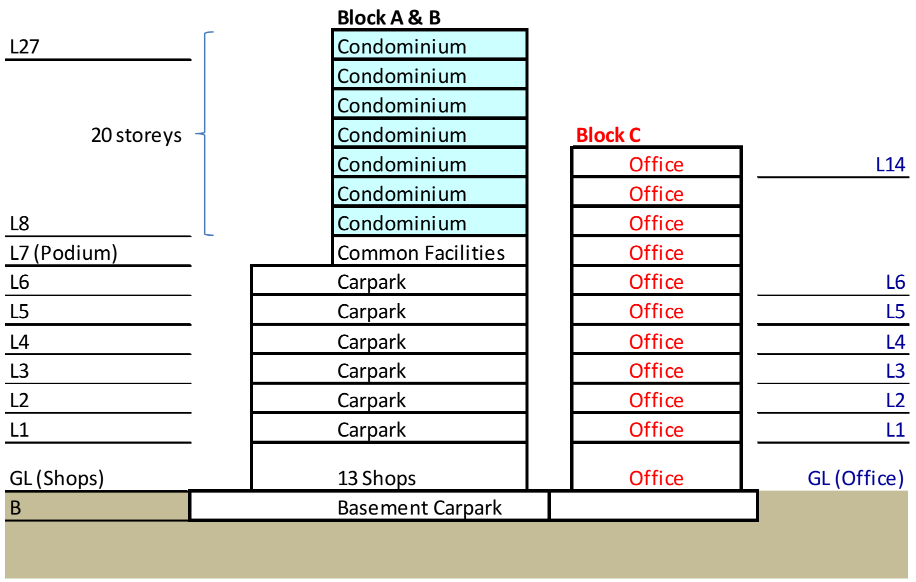
Case Study Project 8 is designed with 1 level of carpark basement in an irregular shape of layout near to a trapezium on plan view. There are 2 rectangular shape residential blocks, Block A and Block B constructed of 29 and 33 storey of condominium units respectively on the trapezium shape podium block which consists of 5 levels of podium carpark and 1 level of podium floor with common facilities. There is an annexed block of 5 storey high shops building which can be conveniently separated thus is excluded from this research study with the similar situation to Case Study Project 1.

Table 4.9 shows the brief description of all the case study projects from the Case Study Project 1 to the Case Study Project 8. All the 8 projects show differently for the orientation of condominium floors. However, they are generally designed with the condominium units at the outer faces and a corridor at the center to allow access to the condominium units. This is common for all condominium design where the living rooms must be facing outside for good scenery view. Total numbers of condominium units for the projects are ranging from the smallest number of 172 units for the Case Study Project 7 to 1502 units for the Case Study Project 6 which is a very high-density project. The numbers of condominium units per floor are ranging from 10 to 13 units. The average numbers (due to there are projects with more than one block of tower building) of storey of condominiums are ranging from 20 storey to 34 storey. The numbers of storey of podium carpark are ranging from 2 storey to 8 storey. The numbers of storey of others (facilities, shops etc.) are ranging from 1 storey to 2 storey except for the Case Study Project 8 where the facilities are parked in the podium carpark level. The total numbers of storey above ground are ranging from 25 storey (the Case Study Project 7) to 38 storey (the Case Study Project 6). The numbers of level of basement are ranging from 1 to 2. However, there are 3 projects with no basement. They are the Case Study Project 4, the Case Study Project 5 and the Case Study Project 7. The storey heights of the condominium floors are ranging from 3.00m to 3.50m. The Case Study Project 8 is designed with the highest storey height for the condominium units. The storey heights of the common carpark levels are measuring from 2.90m to 3.15m with the most common height of 3.00m. Even though the Case Study Project 6 is having the largest number of storey above ground, it is not the tallest building among all the case study projects. The tallest building is the Case Study Project 8. This is due to the reason that the Case Study Project 8 is having

3.50m for the storey height of the condominium floors whereas it is only 3.20m for the Case Study Project 6.



BUILDING LAYOUT



SECTION

Figure 4.5: Brief Design/Shape of The Case Study Project 1

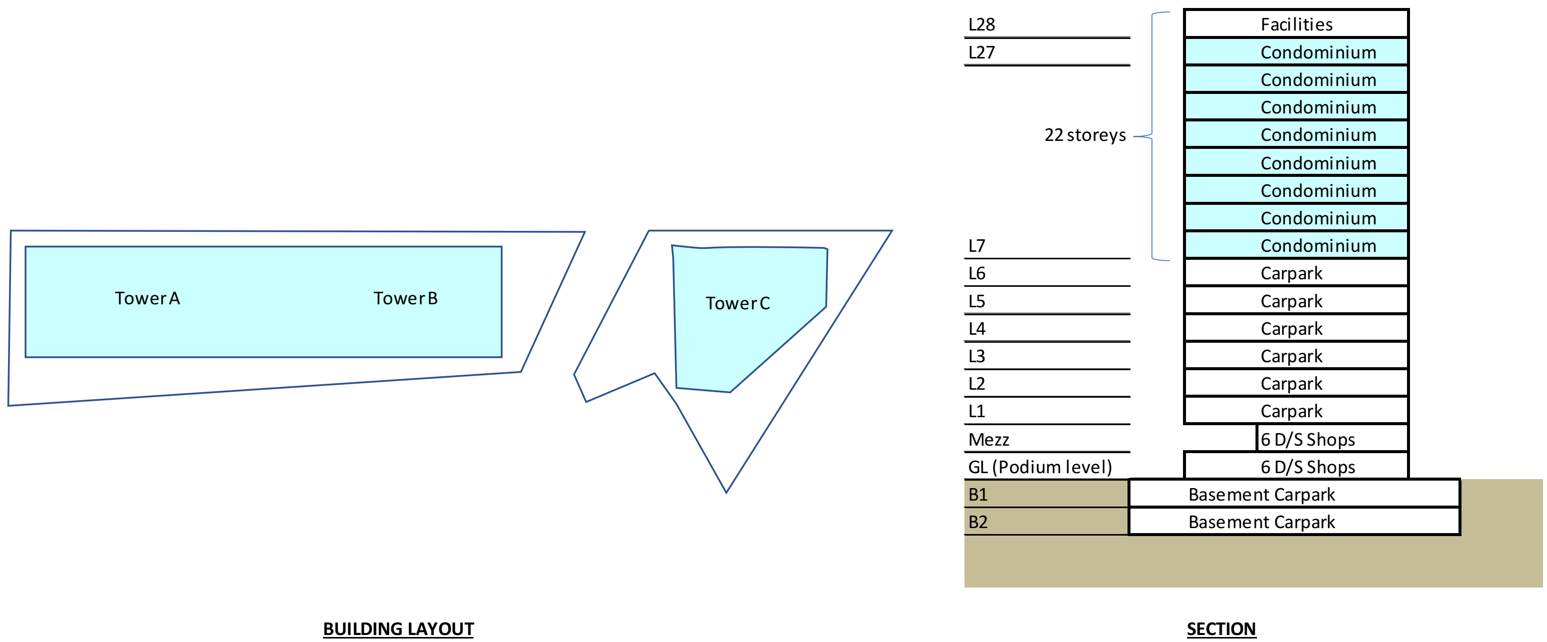
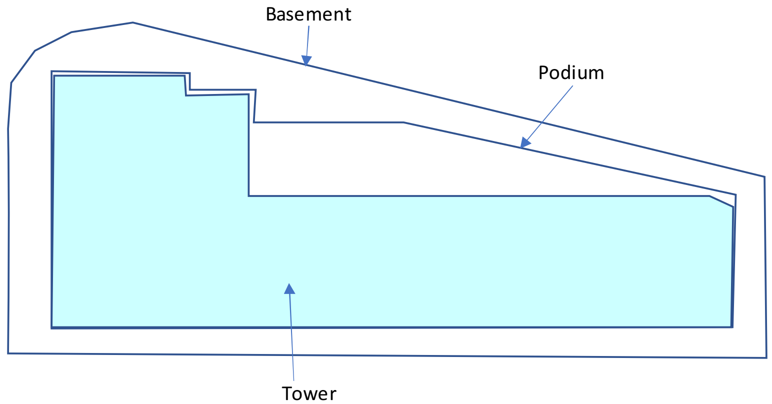
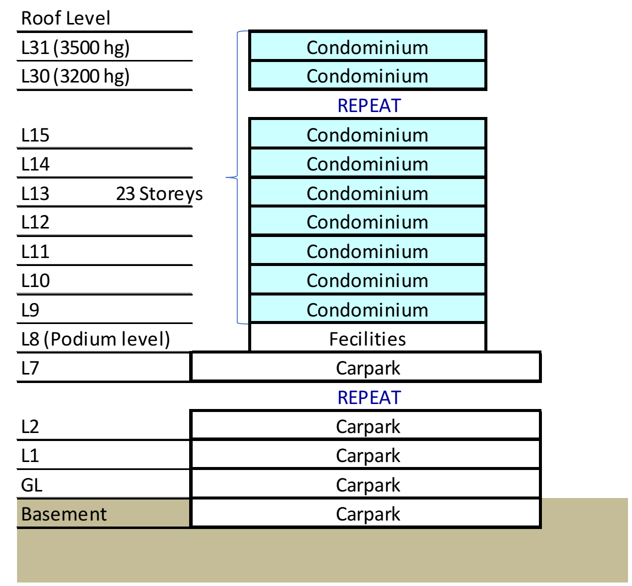


Figure 4.6: Brief Design/Shape of The Case Study Project 2



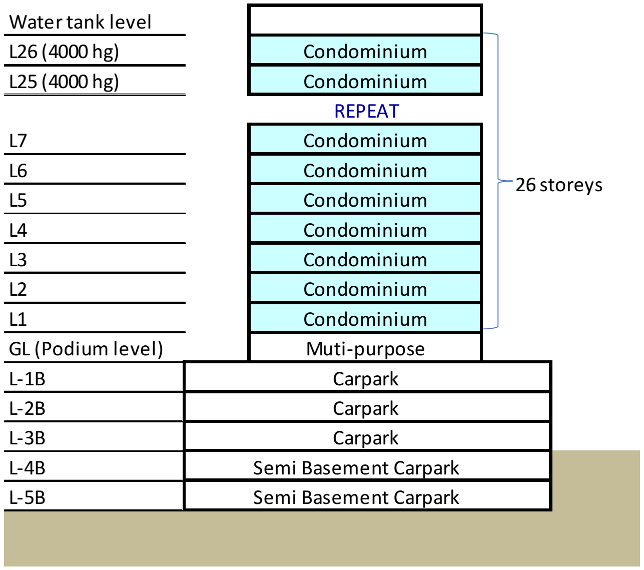
BUILDING LAYOUT



SECTION

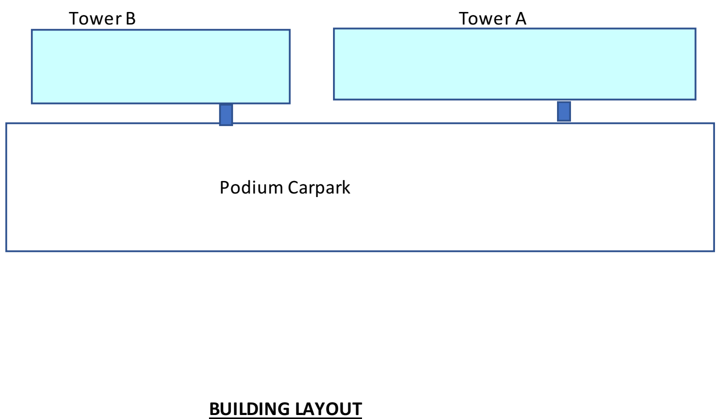
Figure 4.7: Brief Design/Shape of The Case Study Project 3

BUILDING LAYOUT



SECTION

Figure 4.8: Brief Design/Shape of The Case Study Project 4



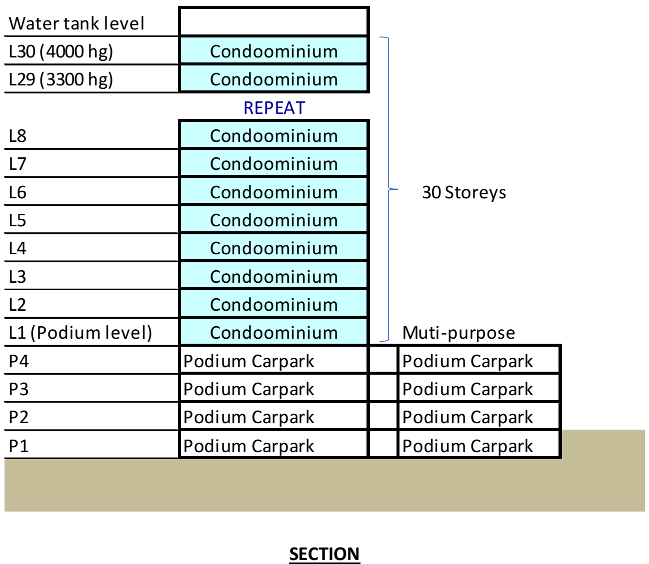


Figure 4.9: Brief Design/Shape of The Case Study Project 5

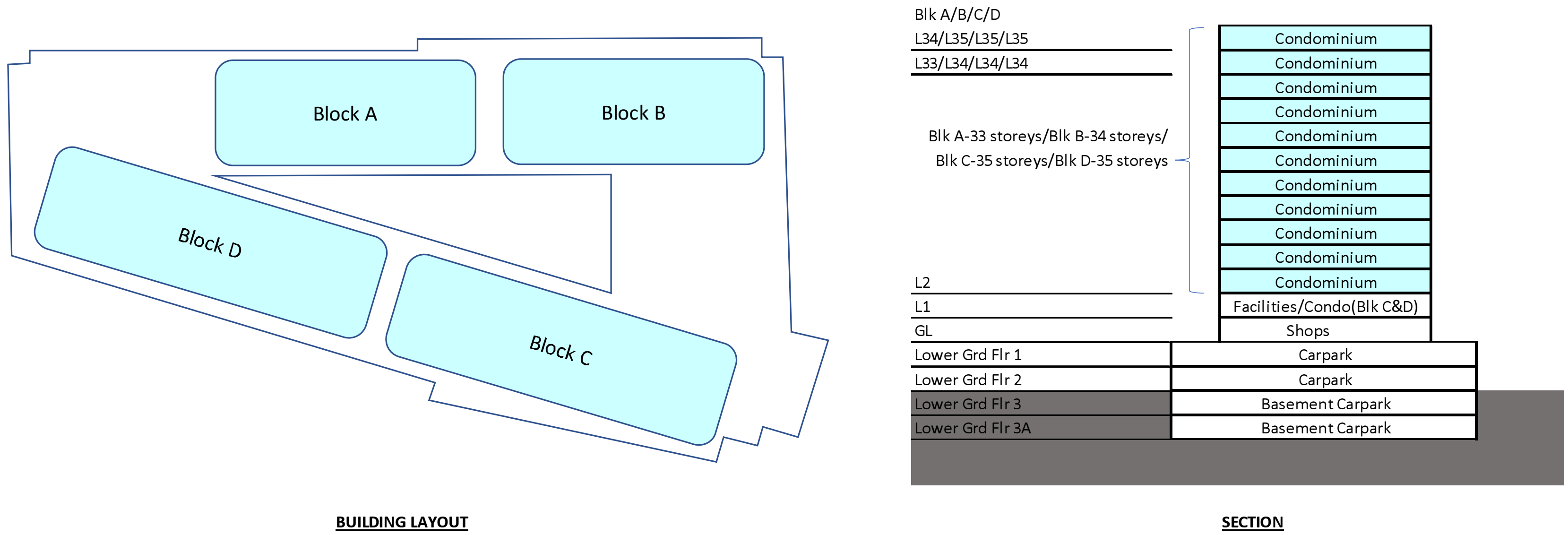
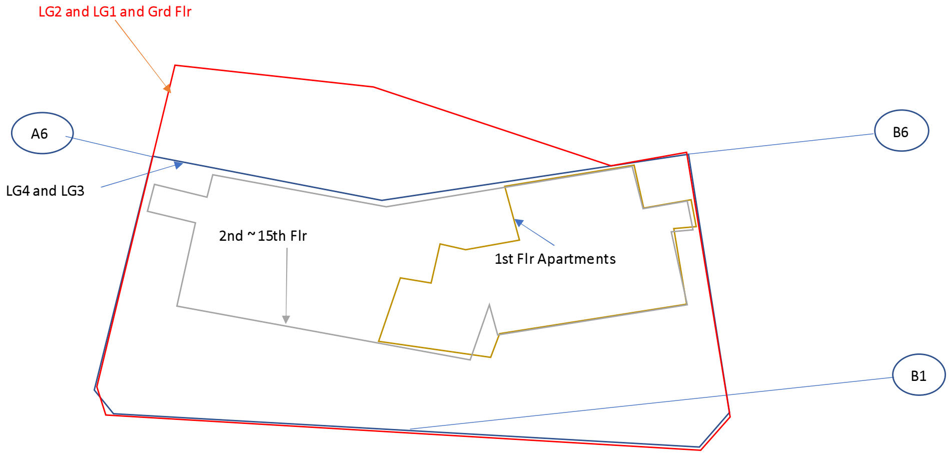
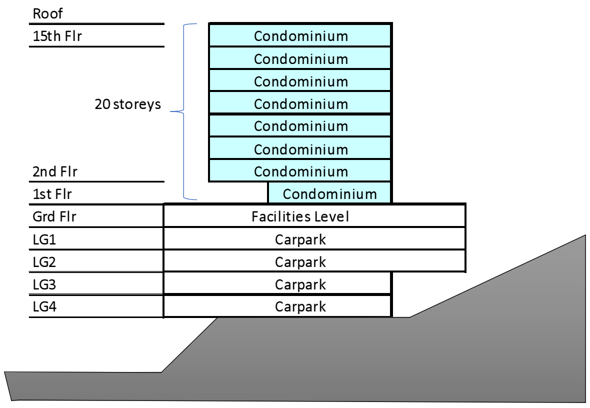


Figure 4.10: Brief Design/Shape of The Case Study Project 6



BUILDING LAYOUT



SECTION

Figure 4.11: Brief Design/Shape of The Case Study Project 7

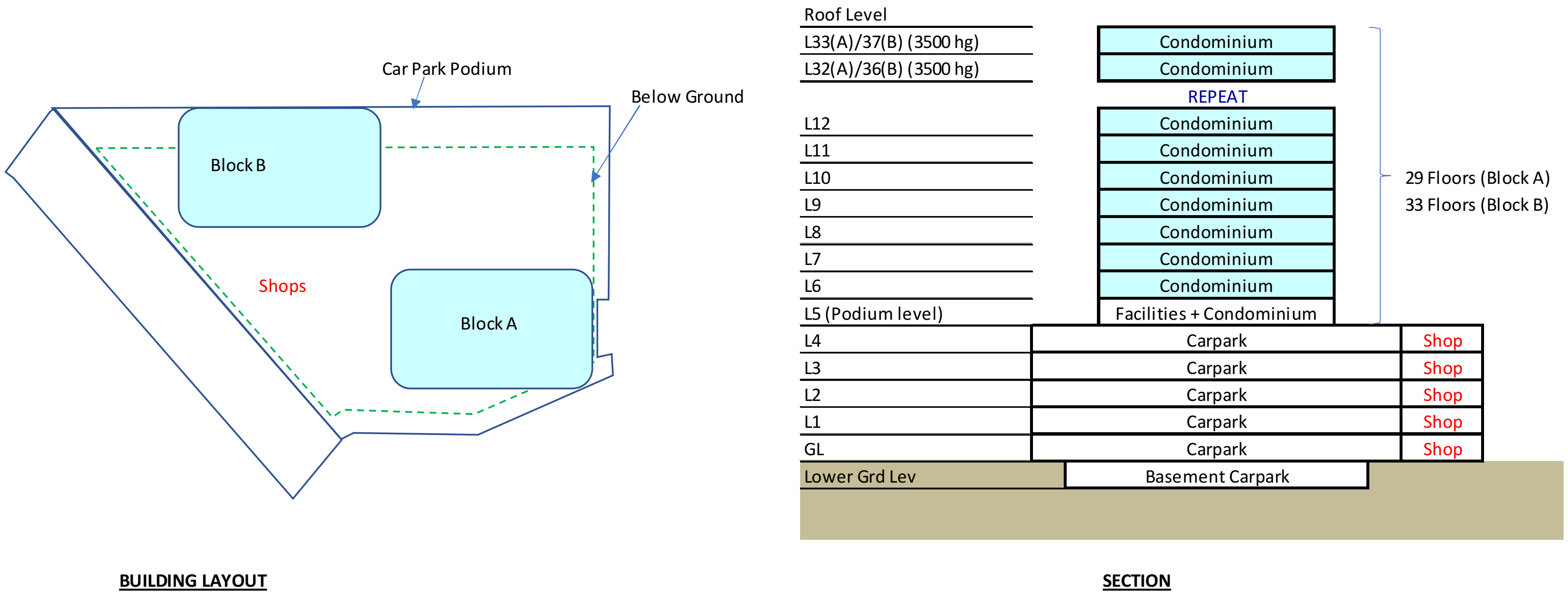


Figure 4.12: Brief Design/Shape of The Case Study Project 8

Table 4.9: Brief Description of The Case Study Projects

Item	Description	Project 1	Project 2	Project 3	Project 4	Project 5	Project 6	Project 7	Project 8
1	Orientation of condominium floors (common floors)	5~6 units parallel one side and 6~7 units parallel the other side with 2 lifts + 2 staircases.	5 units parallel one side and 6 units parallel the other side with 3 lifts + 2 staircases.	6~7 units parallel one side (outer) and 5~6 units parallel the other side(inner) with 3 lifts + 3 staircases.	4 units parallel one side and 4 units parallel the other side with 3 lifts + 2 staircases at centre.	4 units parallel one side with 4 lifts and one staircase and 4 units parallel the other side with one staircase. (long corridor at centre)	6 units parallel one side and 6 units parallel the other side with 4 lifts + 2 staircases at one side (long corrider at centre).	4 units parallel one side and 8 units parallel the other side with 3 lifts at 8 units side + 3 staircases. A long corridor at the middle.	10 units surrounding the lift core (4 nos) and staircase (2 nos) at the centre
2	Total number of condominium units	378	643	294	408	472	1502	172	606
3	Number of condominium units per floor	10~13	10~11	11~13	8	8	10~12	12	10
4	Number of storey of condominiums (average)	20	22	23	26	30	34	20	31
5	Number of storey of Podium Carpark	6	6	8	5	4	2	4	5
6	Number of storey of others (facilities, shops etc)	2	2	1	2	1	2	1	-
7	Total number of storey above ground	28	30	32	33	35	38	25	36
8	Number of levels of basement	1	2	1	-	-	2	-	1
9	Storey height - condominium floors	3.00m	3.15m	3.20m	3.20m	3.30m	3.20m	3.10m	3.50m
10	Storey height - common carpark levels	3.00m	3.15m	2.90m	3.00m	3.00m	3.00m	3.00m	3.00m

Table 4.10 shows the tabulation for results of elemental costs of the 6 case study projects from the Case Study Project 1 to the Case Study Project 6. This tabulation does not include the Case Study Project 7 and the Case Study Project 8 because they will be used for validation of the cost estimation model in the later stage. The CSE is determined by checking its elemental cost which value is greater than the mean bill value. It can be seen from the table that there are 8 numbers of CSEs in each of the 6 case study projects, and the CSEs are all the same for all the projects. The CSEs are 'Frame', 'Upper Floors', 'Window & External Doors', 'Internal Wall Finishes', 'Internal Floor Finishes', 'External Finishes', 'Plumbing Installation' and 'Electrical Installation'. The average cost and percentage of each of the element can be further developed from Table 4.10 to determine the mean ranking of the significance of the cost of each element. The result is displayed in Table 4.11.

In Table 4.11, it can be seen that out of the total 8 CSEs, 'Frame' (with the contribution of 22.34% to the actual total bill value), is ranked number 1; followed by 'Window & External Doors' (9.73%), ranked number 2; 'Upper Floors' (9.71%), ranked number 3; 'Electrical Installation' (8.61%), ranked number 4; 'Internal Floor Finishes' (7.19%), ranked number 5; 'Internal Wall Finishes' (5.49%), ranked number 6; 'External Finishes' (4.95%), ranked number 7; and 'Plumbing Installation' (4.73%), ranked number 8. All the 17 NCSEs are with the contributions of less than 4.00% to the actual total bill value. 'Air-Conditioning & Ventilation System' which is with the highest cost among all NCSEs, contributes 3.07% to the actual total bill value. The contribution rates of 'Work Below Lowest Floor Finish', 'External Walls', 'Lift and

Conveyor Installation', 'Communication Installation' and 'Roof' are in between 2% to 3% to the actual total bill value. For the lowest ranked 4 elements which are 'Refuse Disposal', 'Builder's Work in Connection with Services', 'Builder's Profit & Attendance on Services' and 'Special Installation', the contribution rates are extremely low which are ranging from 0.16% to 0.58%.

It is obvious that the 'Frame' element alone has contributed to more than 20% to the actual total bill value, plus 'Upper Floors' it comes to be more than 30% to the actual total bill value. The totaling-up of all the cost of the 8 CSEs has come to 72.75% to the actual total bill value. Thus, based on this phenomenon, a generic cost estimation model based on CSEs of HRCPs can be developed with a high level of confidence.

Table 4.10: Elemental Costs of The Case Study Projects

No.	Elements	Total Cost of Element																	
		Project 1: 2 blocks 20s (473 units) on 1s basement car park + 1s shops + 6s podium car park			**Project 2:** 3 block 22s (643 units) on 2s basement carpark + 2s shops at podium level + 6s podium car park			**Project 3:** 1 Block 23s (294 units) on 1s basement car park + 8s podium car park			**Project 4:** 2 Blocks 27s (408 units) on 2s semi-basement car park + 3s podium car park + 1 podium level			**Project 5:** 2 Blocks 30s (472 units) on 4s podium car park			**Project 6:** 4 Blocks 33~35s (1502 units) on 4 lower ground podium car park + 1s shops + 1s Facilities cum condo		
1	Work Below Lowest Floor Finish	3,074,746.73	3.74%		4,358,322.50	2.74%		2,749,353.58	3.69%		2,327,953.48	2.43%		1,875,412.53	1.36%		9,460,240.65	3.65%	
2	Frame	24,336,754.28	29.62%	CSE	33,484,750.95	21.08%	CSE	17,309,980.29	23.20%	CSE	19,748,463.83	20.58%	CSE	26,743,962.93	19.35%	CSE	59,072,469.81	22.81%	CSE
3	Upper Floors	8,898,293.65	10.83%	CSE	17,385,562.60	10.94%	CSE	7,351,503.16	9.85%	CSE	7,950,865.99	8.29%	CSE	11,798,368.42	8.54%	CSE	25,165,194.97	9.72%	CSE
4	Roof	1,394,410.00	1.70%		1,379,897.40	0.87%		1,702,350.90	2.28%		2,015,475.51	2.10%		3,883,687.10	2.81%		6,276,949.62	2.42%	
5	Stairs	1,386,256.50	1.69%		1,814,936.00	1.14%		646,600.15	0.87%		1,319,725.67	1.38%		1,250,177.83	0.90%		2,111,746.58	0.82%	
6	External Walls	1,557,513.55	1.90%		2,314,753.25	1.46%		1,117,679.69	1.50%		3,695,855.98	3.85%		5,420,062.96	3.92%		9,655,126.51	3.73%	
7	Windows & External Doors	4,252,589.01	5.18%	CSE	24,815,601.19	15.62%	CSE	4,786,068.41	6.42%	CSE	13,818,402.42	14.40%	CSE	16,522,013.79	11.96%	CSE	14,491,007.40	5.60%	CSE
8	Internal Walls & Partitions	1,189,139.00	1.45%		2,123,084.60	1.34%		1,232,162.55	1.65%		1,451,779.05	1.51%		2,849,745.72	2.06%		3,400,150.07	1.31%	
9	Internal Doors	1,298,357.29	1.58%		5,247,337.31	3.30%		672,192.35	0.90%		2,133,529.82	2.22%		1,824,519.57	1.32%		2,512,341.09	0.97%	
10	Internal Wall Finishes	4,257,223.75	5.18%	CSE	7,173,447.00	4.52%	CSE	4,792,339.19	6.42%	CSE	6,815,853.20	7.10%	CSE	6,331,649.88	4.58%	CSE	15,056,499.75	5.81%	CSE
11	Internal Floor Finishes	4,657,321.13	5.67%	CSE	8,086,509.80	5.09%	CSE	7,153,684.00	9.59%	CSE	8,973,796.70	9.35%	CSE	8,291,613.41	6.00%	CSE	20,947,986.93	8.09%	CSE
12	Internal Ceiling Finishes	1,401,893.00	1.71%		2,452,220.50	1.54%		1,360,468.92	1.82%		983,645.39	1.03%		1,344,478.90	0.97%		3,890,582.18	1.50%	
13	External Finishes	3,899,343.74	4.75%	CSE	7,006,221.10	4.41%	CSE	3,860,491.47	5.18%	CSE	4,498,571.22	4.69%	CSE	9,045,030.53	6.55%	CSE	11,689,684.34	4.51%	CSE
14	Fittings and Furnishing	576,723.55	0.70%		2,454,191.50	1.54%		821,011.59	1.10%		1,383,450.90	1.44%		2,373,627.49	1.72%		2,385,811.25	0.92%	
15	Sanitary Appliances	973,505.00	1.18%		1,959,520.20	1.23%		1,172,565.00	1.57%		1,400,000.00	1.46%		2,286,818.75	1.65%		3,220,363.47	1.24%	
16	Plumbing Installation	3,342,271.25	4.07%	CSE	6,600,000.00	4.15%	CSE	3,495,612.51	4.69%	CSE	4,200,000.00	4.38%	CSE	7,314,000.00	5.29%	CSE	13,300,000.00	5.14%	CSE
17	Refuse Disposal	179,197.00	0.22%		300,000.00	0.19%		134,900.00	0.18%		340,000.00	0.35%		25,863.00	0.02%		331,430.50	0.13%	
18	Air-Conditioning & Ventilation System	1,450,000.00	1.76%		4,200,000.00	2.64%		2,972,373.00	3.98%		1,800,000.00	1.88%		5,034,261.50	3.64%		9,400,000.00	3.63%	
19	Electrical Installation	8,788,000.00	10.70%	CSE	11,800,000.00	7.43%	CSE	5,330,341.75	7.15%	CSE	4,240,000.00	4.42%	CSE	11,784,000.00	8.53%	CSE	27,700,000.00	10.70%	CSE
20	Fire Protection Installation	2,036,018.00	2.48%		2,250,000.00	1.42%		995,700.00	1.33%		840,000.00	0.88%		2,260,000.00	1.64%		4,470,000.00	1.73%	
21	Lift and Conveyor Installation	1,299,000.00	1.58%		3,500,000.00	2.20%		2,070,000.00	2.77%		2,088,000.00	2.18%		4,280,000.00	3.10%		9,000,000.00	3.47%	
22	Communication Installation	1,512,000.00	1.84%		5,500,000.00	3.46%		1,847,256.20	2.48%		2,875,014.00	3.00%		2,946,000.00	2.13%		3,020,000.00	1.17%	
23	Special Installation	190,480.00	0.23%		1,163,000.00	0.73%		256,957.00	0.34%		180,000.00	0.19%		2,040,000.00	1.48%		900,000.00	0.35%	
24	Builder's Profit & Attendance on Services	184,272.89	0.22%		759,000.00	0.48%		419,445.75	0.56%		378,760.28	0.39%		611,680.00	0.44%		1,525,320.00	0.59%	
25	Builder's Work in Connection with Services	23,640.00	0.03%		724,548.90	0.46%		345,871.60	0.46%		477,811.58	0.50%		54,390.00	0.04%		11,034.90	0.00%	
A	Actual Total Bill Value:	82,158,949.32	100%		158,852,904.80	100%		74,596,909.06	100%		95,936,955.02	100%		138,191,364.31	100%		258,993,940.02	100%	
B	Mean Bill Value: (=A/D)	3,286,357.97			6,354,116.19			2,983,876.36			3,837,478.20			5,527,654.57			10,359,757.60		
C	Total Bill Value of CSEs:	62,431,796.81			116,352,092.64			54,080,020.78			70,245,953.36			97,830,638.96			187,422,843.20		
D	No. of Total Elements:	25			25			25			25			25			25		
E	No. of CSE in Total:	8			8			8			8			8			8		
F	CSE/TE (per cent): (E/D)	***32.00%***			***32.00%***			***32.00%***			***32.00%***			***32.00%***			***32.00%***		
G	Total Bill Value of CSEs/Actual Total Bill Value: (C/A)	***75.99%***			***73.25%***			***72.50%***			***73.22%***			***70.79%***			***72.37%***		
H	Cost Estimation Model Factor (CEMF) = G	**0.760**			**0.732**			**0.725**			**0.732**			**0.708**			**0.724**		

Table 4.11: Ranking of Cost Elements of The Case Study Projects

Mean Ranking	Elements	Average Elemental Cost (RM)	(%)	CSE/ NCSE
1	Frame	30,116,063.68	22.34%	CSE
2	Windows & External Doors	13,114,280.37	9.73%	CSE
3	Upper Floors	13,091,631.47	9.71%	CSE
4	Electrical Installation	11,607,056.96	8.61%	CSE
5	Internal Floor Finishes	9,685,152.00	7.19%	CSE
6	Internal Wall Finishes	7,404,502.13	5.49%	CSE
7	External Finishes	6,666,557.07	4.95%	CSE
8	Plumbing Installation	6,375,313.96	4.73%	CSE
9	Air-Conditioning & Ventilation System	4,142,772.42	3.07%	NCSE
10	Work Below Lowest Floor Finish	3,974,338.25	2.95%	NCSE
11	External Walls	3,960,165.32	2.94%	NCSE
12	Lift and Conveyor Installation	3,706,166.67	2.75%	NCSE
13	Communication Installation	2,950,045.03	2.19%	NCSE
14	Roof	2,775,461.76	2.06%	NCSE
15	Internal Doors	2,281,379.57	1.69%	NCSE
16	Fire Protection Installation	2,141,953.00	1.59%	NCSE
17	Internal Walls & Partitions	2,041,010.17	1.51%	NCSE
18	Internal Ceiling Finishes	1,905,548.15	1.41%	NCSE
19	Sanitary Appliances	1,835,462.07	1.36%	NCSE
20	Fittings and Furnishing	1,665,802.71	1.24%	NCSE
21	Stairs	1,421,573.79	1.05%	NCSE
22	Special Installation	788,406.17	0.58%	NCSE
23	Builder's Profit & Attendance on Services	646,413.15	0.48%	NCSE
24	Builder's Work in Connection with Service	272,882.83	0.20%	NCSE
25	Refuse Disposal	218,565.08	0.16%	NCSE
A	Actual Total Bill Value (Average of 6 projects):	134,788,503.76	100.00%	
	Mean Bill Value: (=A/25)	5,391,540.15	4.00%	

The overall cost estimation model factor is derived at by getting the arithmetic mean of the cost estimation model factors determined for all the 6 projects (see item H of Table 4.10). The cost estimation model factor for each project is the same value with the value of the total bill value of CSEs divided by the actual total bill value (item G). The only difference is that it is presented in number instead of percentage. Table 4.12 shows the cost estimation model factor for each of the 6 case study projects.

Table 4.12: Cost Estimation Model Factors

Building	Cost Estimation Model Factor (CEMF)
Case Study Project 1	0.760
Case Study Project 2	0.732
Case Study Project 3	0.725
Case Study Project 4	0.732
Case Study Project 5	0.708
Case Study Project 6	0.724
Arithmetic mean:	**0.730**

Table 4.13 shows the cost estimation model based on CSEs of HRCPs in Klang Valley, Malaysia developed by using the cost data from the 6 case study projects as discussed. The items from the BQs in the tender documents will need to be extracted and grouped into items as shown in the cost estimation model. The breakdown items are indicative only. Building contractors and QS consultants are advised to use their own methods of extraction and grouping of the items to their own convenience for pricing.

Table 4.13: The Cost Estimation Model Based on CSEs of HRCPs in Klang Valley, Malaysia

(CEMF = 0.730)

Item	Description	Unit	Qty	Rate	Amount
	CSE 1: Frame				
1	VRC Grade 40 (in column / beam / wall)	m3			
2	VRC Grade 35 (in column / beam / wall)	m3			
3	VRC Grade 30 (in column / beam / wall)	m3			
4	Bar and mesh reinforcement	tonne			
5	Formwork	m2			
	CSE 2: Windows and External Doors				
1	Precast concrete lintel	m			
2	Aluminium with glass glazing	m2			
3	Fire doors including frame and ironmongery and painting	No			
4	Timber doors including frame and ironmongery and	No			
	CSE 3: Upper Floors				
1	VRC Grade 30 (in floor slabs)	m3			
2	Bar and mesh reinforcement	tonne			
3	Formwork	m2			
	CSE 4: Electrical Installation				
1	Prime cost sum (estimated by Electrical Engineer)	Sum			
	CSE 5: Internal Floor Finishes				
1	Floor hardener	m2			
2	Waterproofing system	m2			
3	Ceramic floor tiles including skirting and backing screed	m2			
4	Porcelain floor tiles including skirting and backing screed	m2			
5	Homogeneous floor tiles including skirting and backing	m2			
6	Cement and sand paving	m2			
	CSE 6: Internal Wall Finishes				
1	Plastering to wall internally including painting	m2			
2	Skimcoating to wall internally including painting	m2			
3	Waterproofing system	m2			
4	Ceramic wall tiles including backing screed	m2			
5	Porcelain wall tiles including backing screed	m2			
6	Homogeneous wall tiles including backing screed	m2			
	CSE 7: External Finishes				
1	Floor hardener	m2			
2	Waterproofing system to floor	m2			
3	Ceramic floor tiles including skirting and backing screed	m2			
4	Porcelain floor tiles including skirting and backing screed	m2			
5	Homogeneous floor tiles including skirting and backing	m2			
6	Cement and sand paving	m2			
7	Plastering to wall externally including painting	m2			
8	Skimcoating to wall externally including painting	m2			
9	Waterproofing system to wall	m2			
10	Ceramic wall tiles including backing screed	m2			
11	Porcelain wall tiles including backing screed	m2			
12	Homogeneous wall tiles including backing screed	m2			
13	Skimcoating to concrete soffit externally including	m2			
14	Suspended ceiling board including painting	m2			
	CSE 8: Plumbing Installation				
1	Prime cost sums (estimated by Electrical Engineer)	Sum			
	Total amount of CSEs (RM):				
	Cost Estimation Model Factor (CEMF):				0.730
	Actual Total Bill Value (= Total amount of CSEs ÷ CEMF):				

Table 4.14 shows the tabulation for results of elemental costs of the 2 case study projects i.e., Case Study Project 7 and Case Study Project 8 which used for validation of the cost estimation model developed. It can be seen from the table that there are having the same 8 CSEs as compared to the previous 6 case study projects. The CSE is determined by checking its elemental cost which value is greater than the mean bill value. The CSEs are ‘Frame’, ‘Upper Floors’, ‘Window & External Doors’, ‘Internal Wall Finishes’, ‘Internal Floor Finishes’, ‘External Finishes’, ‘Plumbing Installation’ and ‘Electrical Installation’. From the tabulation, the sum of CSEs is the totalling-up of the total cost of the 8 CSEs. The actual bill value is the total sum of all the 25 elements. For example, for Case Study Project 7, the sum of CSEs is RM35,772,693.69 and the actual total bill value is RM49, 779,940.00.

Table 4.15 shows the test results for the Case Study Project 7 and the Case Study Project 8. These two case study projects were awarded quite recently in end of 2017 and early 2018. The total bill values were predicted by pricing the CSEs and dividing their sums by the cost model factor. The discrepancies were evaluated simply as the difference between the price predicted by the model and the actual total bill value divided by the actual total bill value (see the formula shown below). The actual total bill values used in the calculation are the actual total bill values of the successful tenders. The discrepancies of the cost estimation model are -2% and 1% for Project 7 and Project 8 respectively. As such, this means that the model achieves an accuracy of 98% to 99%.

Table 4.14: Elemental Costs of The Case Study Projects used to Validate the Cost Model

No.	Elements	Total Cost of Element: Project 7: 1 block 20s (229 units) on 4s podium car park + 1s facilities floor			Project 8: 2 Blocks 29 & 33s (606 units) on 1 level ground floor car park + 4s podium carpark + 1 podium level Facilities		
1	Work Below Lowest Floor Finish	1,904,633.92	3.83%		5,298,520.21	3.34%	
2	Frame	11,502,195.72	23.11%	CSE	37,560,684.96	23.66%	CSE
3	Upper Floors	5,480,957.55	11.01%	CSE	21,819,412.12	13.74%	CSE
4	Roof	786,554.84	1.58%		2,821,128.20	1.78%	
5	Stairs	668,896.07	1.34%		1,555,322.89	0.98%	
6	External Walls	1,860,369.55	3.74%		3,606,940.93	2.27%	
7	Windows & External Doors	3,473,945.79	6.98%	CSE	13,602,945.43	8.57%	CSE
8	Internal Walls & Partitions	587,191.63	1.18%		4,192,729.08	2.64%	
9	Internal Doors	593,574.23	1.19%		3,318,199.19	2.09%	
10	Internal Wall Finishes	2,466,417.77	4.95%	CSE	12,676,885.22	7.98%	CSE
11	Internal Floor Finishes	3,036,317.63	6.10%	CSE	10,035,385.35	6.32%	CSE
12	Internal Ceiling Finishes	1,021,987.11	2.05%		2,899,993.82	1.83%	
13	External Finishes	2,512,059.23	5.05%	CSE	6,456,849.84	4.07%	CSE
14	Fittings and Furnishing	168,738.13	0.34%		324,867.24	0.20%	
15	Sanitary Appliances	749,461.60	1.51%		3,835,476.59	2.42%	
16	Plumbing Installation	2,818,400.00	5.66%	CSE	6,396,920.00	4.03%	CSE
17	Refuse Disposal	1,031.25	0.00%		150,000.00	0.09%	
18	Air-Conditioning & Ventilation System	1,247,200.00	2.51%		4,700,000.00	2.96%	
19	Electrical Installation	4,482,400.00	9.00%	CSE	9,029,450.00	5.69%	CSE
20	Fire Protection Installation	802,400.00	1.61%		1,250,000.00	0.79%	
21	Lift and Conveyor Installation	1,460,000.00	2.93%		3,830,000.00	2.41%	
22	Communication Installation	1,200,000.00	2.41%		2,424,000.00	1.53%	
23	Special Installation	400,000.00	0.80%		385,000.00	0.24%	
24	Builder's Profit & Attendance on Services	299,568.00	0.60%		-	0.00%	
25	Builder's Work in Connection with Services	255,640.00	0.51%		601,529.88	0.38%	
A	Actual Total Bill Value:	49,779,940.00	100%		158,772,240.94	100%	
B	Mean Bill Value: (=A/D)	1,991,197.60			6,350,889.64		
C	Total Bill Value of CSEs:	35,772,693.69			117,578,532.92		
D	No. of Total Elements:	25			25		
E	No. of CSE in Total:	8			8		
F	CSE/TE (per cent): (E/D)	***32.00%***			***32.00%***		
G	Total Bill Value of CSEs/Actual Total Bill Value: (C/A)	***71.86%***			***74.05%***		
H	Cost Estimation Model Factor (CEMF) = G	**0.719**			**0.741**		

$$\text{Discrepancy of Cost Model} = \frac{\text{(Estimated Total Bill Value - Actual Total Bill Value)}}{\text{Actual Total Bill Value}} \times 100\%$$

Table 4.15: Test Results of The Cost Estimation Model for HRCPs in Klang Valley, Malaysia

		Project 7	Project 8
(A)	Sum of CSEs	35,772,693.69	117,578,532.92
(B)	Estimated Total Bill Value (A/CEMF)	49,003,689.99	161,066,483.45
(C)	Actual Total Bill Value	49,779,940.00	158,772,240.94
(D)	Discrepancy of cost model [(B) - (C))/ (C)] x 100%	-2.00%	1.00%

Cost Estimation Model Factor (CEMF = 0.730)

4.4 Chapter Summary

This chapter has explained in detail all the results generated from the questionnaire data. The summary of questionnaire data and analysis methods or tests has been tabulated to clearly show the purposes, nature of the questions and types of analysis methods or tests used for each section of the questionnaire. Pie charts were used to present the computation of survey questionnaire, the response rate and the respondents' demographic both by breakdowns according to the nature of current company and the years of experience in pricing HRCPs in Klang Valley, Malaysia. The computation of survey questionnaire demonstrates comprehensibly the development of the final 112 eligible questionnaire data for analysis from the originally distributed 200 questionnaires. The response rates both in general responses and usable data are considered high and the sample size target has been achieved. The presentation using pie charts show that there has been quite a balanced distribution for the number of respondents from building contractors and QS consultants, and the same for the number of respondents from different categories of years of experience of the respondents in pricing HRCPs in Klang Valley, Malaysia.

By analyzing the questionnaire data, it is determined that the common method currently used in the local construction industry in estimating construction costs of HRCPs in Klang Valley, Malaysia is still the traditional method by pricing every single item of each element of BQs with no other alternative method. It is also found that the level of awareness of the Cost Significance Technique is very low. The results of Cronbach's Alpha Reliability test derived show that both the pilot test data and final data are highly reliable. The results of mean ranking analysis have revealed the respondents' conception on which are the CSEs of HRCPs in Klang Valley, Malaysia and which are not. Finally, the results of Mann-Whitney U test show that the respondents' conception on which are the CSEs of HRCPs in Klang Valley, Malaysia is having very slight difference between the building contractors and QS consultants. Meanwhile the Kendall's tau-b's results show that there are poor correlations between the respondents' years of experience in pricing HRCPs in Klang Valley, Malaysia and their level of agreement on the elements that they are CSEs of HRCPs in Klang Valley, Malaysia.

On the other hand, the discussions in the initial sub sections of case study show the development process of how the researcher reached to the main aim of this study and what were the failures the researcher had been through during the case study data collection and analysis. However, the final cost estimation model which is the cost estimation model based on CSEs of HRCPs has eventually been developed successfully by using the cost data collected from 6 number of appropriate case study projects. The results of the tests carried out on two recently completed HRCPs to validate the model have also successfully proved that the accuracy of the model to be very high.

CHAPTER 5

DISCUSSIONS OF THE RESULTS

5.1 Introduction

This chapter discusses on the results of both the questionnaire survey and the case study further to the explanation done in Chapter 4.

5.2 Discussion of Questionnaire Survey Results

Besides the basic findings from the results of Mean Analysis that conclude the building contractors' and CQSs' levels of cost significance awareness of HRCPs in Klang Valley, Malaysia is low, it is worthwhile to scrutinise further to find out to what extend the lack of cost significance knowledge of these so called 'cost expert' by referring to the mean scores tabulated in Table 4.4.

Even though Smith et al. (2016) justifications of what elements are CSEs were based on 12 elements, this study is based on the RISM ECA's 25 elements, the theories may be used to check the respondents' understanding in a general respect. Referring to Table 2.4 for the justifications, substructure is a NCSE because the costs of foundations are spread over a relatively large floor area for multi-storey projects. However, the mean score for the element Works Below

Lowest Floor Finish (WBLFF) is reading quite high at 3.77. Furthermore, building contractors and CQSs should have the basic knowledge that WBLFF does not include piling works but they have still failed to observe that it should be not cost significant. Frame and Upper Floors are the elements that the respondents are most aware of that they are very cost significant elements with the highest mean scores of 4.35 and 4.17. These tally the justification that Frame (column, upper floors) are relatively high-cost elements representing 10 to 20 percent of the total cost. Stairs are justified as NCSE and the mean score is 2.60 that means the respondents have generally got it right. The justification the Envelope (external walls and windows) is CSE couldn't be compared with the mean scores as for the ECA's breakdowns, External Walls is one element by its own, and Windows and External Doors are grouped as one element. Roof as easily understood should be NCSE as similar to the theory of substructure, however, has a mean score 3.11. The justifications for other elements couldn't be compared owing to the much different in grouping of the works between Smith et al. (2016) and the RISM ECA.

Merely rely on the results of Table 4.4 of the overall respondents' level of agreement on the statement that each of the 25 elements listed is a CSE of HRCPs in Klang Valley, Malaysia is not good enough to show the awareness levels. Hence, they shall be paired to the results for the ranking of cost elements of the case study projects for a better evaluation on the building contractors' and QS consultants' levels of cost significance awareness of HRCPs in Klang Valley, Malaysia. Table 5.1 displays the building Contractors' and QS Consultants' Levels of Cost Significance Awareness of HRCPs in Klang Valley, Malaysia.

It demonstrates a very clear picture on the overall respondents' agreements on each element is a CSEs with the mean value to indicate the degree of their agreement to that particular element. Except for item 1 and items 3 to 6 where the agreement levels are quite high which the means are ranging from 3.85 to 4.35, the respondents have failed to understand which are the CSEs and NCSEs of HRCPs in Klang Valley, Malaysia. Even though the results for the ranking of cost elements of the case study projects shows that from item 9 onwards, the elements are all NSEs yet the mean values for the respondents' levels of agreement on the statement that each of the elements listed is a CSE are still above 3.00 the neutral point except item 21 and items 23 to 25 which the means are ranging from 2.35 to 2.64. This means that the respondents were merely 'guessing by feeling'. They somehow or rather understand that 'Frame', 'Upper Floors', 'Electrical Installation', 'Internal Floor Finishes' and 'Internal Wall Finishes' are high-cost elements; and 'Stairs', 'Builder's Profit & Attendance on Services', Builder's Work in Connection with Services' and 'Refuse Disposal' are low-cost elements but are not really sure on the elements' levels of cost significance. Moreover, they thought that 21 out of the 25 elements are CSEs which is not true. Therefore, it is concluded that the building contractors' and CQSs' levels of cost significance awareness of HRCPs in Klang Valley, Malaysia are low.

The reason why the building contractors' and CQSs' levels of cost significance awareness of HRCPs in Klang Valley, Malaysia are low is that till to date, the local construction industry stakeholders are still using the traditional method for pricing tenders i.e., by pricing every single item of the BQs and it is the only method used. This is proved with the result of the section 6 of the questionnaire survey to determine the local practice (see Table 4.2).

Table 5.1: Building Contractors' and QS Consultants' Levels of Cost Significance Awareness of HRCPs in Klang Valley, Malaysia Compared to Case Study Findings

Item	Elements	Ranking of Significance	% of cost contribution	CSE/NCSE	Ranking by Respondents	Mean by Respondents
1	Frame	1	22.34%	CSE	1	4.35
2	Windows & External Doors	2	9.73%	CSE	12	3.52
3	Upper Floors	3	9.71%	CSE	2	4.17
4	Electrical Installation	4	8.61%	CSE	4	3.94
5	Internal Floor Finishes	5	7.19%	CSE	3	3.96
6	Internal Wall Finishes	6	5.49%	CSE	5	3.85
7	External Finishes	7	4.95%	CSE	10	3.60
8	Plumbing Installation	8	4.73%	CSE	11	3.59
9	Air-Conditioning & Ventilation System	9	3.07%	NCSE	8	3.71
10	Work Below Lowest Floor Finish	10	2.95%	NCSE	6	3.77
11	External Walls	11	2.94%	NCSE	9	3.66
12	Lift and Conveyor Installation	12	2.75%	NCSE	7	3.77
13	Communication Installation	13	2.19%	NCSE	19	3.07
14	Roof	14	2.06%	NCSE	18	3.11
15	Internal Doors	15	1.69%	NCSE	21	3.02
16	Fire Protection Installation	16	1.59%	NCSE	13	3.45
17	Internal Walls & Partitions	17	1.51%	NCSE	16	3.22
18	Internal Ceiling Finishes	18	1.41%	NCSE	14	3.34
19	Sanitary Appliances	19	1.36%	NCSE	17	3.16
20	Fittings and Furnishing	20	1.24%	NCSE	15	3.28
21	Stairs	21	1.05%	NCSE	23	2.60
22	Special Installation	22	0.58%	NCSE	20	3.05
23	Builder's Profit & Attendance on Services	23	0.48%	NCSE	24	2.45
24	Builder's Work in Connection with Services	24	0.20%	NCSE	25	2.35
25	Refuse Disposal	25	0.16%	NCSE	22	2.64

Another possible attribute to the low level of building contractors' and CQSs' cost significance awareness might be due to that they are unfamiliar with the use of the RISM ECA elemental cost breakdown method. In the local construction practice, the format of the elements is not standardised. Different consultant QS companies are using different types of formats for their BQs.

5.3 Discussion of Case Study Results

As highlighted in Section 4.3.4.1, the determination of the CSEs using the 6 projects collected from September 1996 to September 2009 by using Smith et al. (2016)'s 12 elements grouping method has not been viable. The results have been able to achieve a consistent pattern thus the data was abandoned. The researcher did not attempt to try the RICS ECA's 25 elements on these projects owing to the reason that these projects are outdated and most of the design of the reinforced concrete structure of the buildings are mostly based on conventional structure designs without shear walls and transfer beams. As such, the model if being by chance be successfully developed, it wouldn't be useful in view of the current HRCPs in Klang Valley are usually designed with heavy shear wall and transfer beam types of structures. It is very obvious for the conventional reinforced concrete frame structure buildings; the cost of external walls is higher as compared to the shear wall structure where the external brickwalls are substituted with the reinforced concrete walls. As shear walls are load bearing walls, the cost is allocated to the Frame element thus External Walls usually become not cost significant.

Even though the final set of case study projects have enabled the very smooth development of the cost significant model, using the model to predict the total building cost must be handled with cares. Same to the use of the Element Cost Analysis (ECA), one must know how to choose the correct type of ECA to be the basis for estimating the cost of the new building. Most importantly, the grouping of the costs to the relevant elements need to be carried out by a skilful and experienced estimator.

It is observed that the 8 buildings which the historical cost data were used to develop the cost estimation model varies a lot in the building layout design, but generally are tall building more than 20 storey high. The brief description of the case study projects which is shown in Table 4.9 serves a very important information for the estimator who intends to use the cost model. For example, the maximum number of levels of basement is only 2. So, it would be disastrous to base on this cost model to estimate cost of a HRCP with deep basement design.

5.4 Conclusion

Since the cost estimation model has been successfully developed and has been proved to be highly accurate, it shall be significantly helpful for the use by the local construction industry to vastly minimize the time spent for cost estimation process during tendering. However, in Malaysia the traditional bill of quantities is still the most widely used method for tendering purpose. Thus, unless it is with the government's enforcement, the practice wouldn't be changed easily. Moreover, the cost significance knowledge is still in the very outset stage and the path to get it promoted to the local construction industry is still a long way to go. Nonetheless, the cost estimation model can also serve as a tool to do cost checking as an alternative to 'a rate per unit of floor area' method and ‘elemental cost analysis’ method during tendering. Also, it can be useful for cost estimation during preliminary estimates stages.

CHAPTER 6

CONCLUSION

6.1 Introduction

This chapter displays the subsections on the summary of research findings; achievements of research objectives from research objective 1 to research objective 4; significance of the study; limitation of the study; and recommendation for future study.

6.2 Summary of Research Findings

The researcher by using both the quantitative and qualitative approaches discussed previously, has successfully achieved the three research objectives set in chapter 1, i.e.:

Researh Objective 1: To determine the building contractors' and CQSs' levels of cost significance awareness of HRCPs in Klang Valley, Malaysia.

Researh Objective 2: To appraise the CSEs of HRCPs in Klang Valley, Malaysia.

Researh Objective 3: To develop a building cost estimation model based on CSEs of HRCPs in Klang Valley, Malaysia.

6.2.1 Achievement of Research Objective 1

Research objective 1 is to measure the building contractors' and CQSs' levels of cost significance awareness of HRCPs in Klang Valley, Malaysia. In order to achieve this objective, survey questionnaire was designed and sent to building contractors and QS consultants to collect their replies for analysis. The answers from the respondents in Section 5 of the questionnaire were analyzed using mean analysis. The results have been discussed in detail in sub section 4.2.5 of Chapter 4. The researcher has also discussed in detail on this matter in Chapter 5. Overall, it could be concluded that the building contractors' and CQSs' levels of cost significance awareness of HRCPs in Klang Valley, Malaysia are low. Even though the experience groups of respondents with more than 20 years of experience in pricing HRCPs have failed to understand clearly which are supposed to be CSEs. Research objective 1 is therefore achieved.

6.2.2 Achievement of Research Objective 2

Research objective 2 is to appraise the CSEs of HRCPs in Klang Valley, Malaysia. In order to achieve this objective, case studies were carried out on eight (8) numbers of HRCPs in Klang Valley, Malaysia. Results from the in-dept case study manifest the consistency of the contribution of the elemental cost. It was found that all the case study projects consistent have the same 8 number of CSEs out of the total 25 number of elements according to the RISM's ECA's way of breakdown of the elements. As such, research objective 2 is also achieved.

6.2.3 Achievement of Research Objective 3

Research objective 3 is to develop a building cost estimation model based on CSEs of HRCPs in Klang Valley, Malaysia. In order to achieve this objective, case study is carried out on six numbers of completed HRCPs in Klang Valley, Malaysia, the same projects used to appraise the CSEs for achieving research objective 2. The identification of the CSEs enables the development of a generic cost estimation model based on CSEs of HRCPs with a high level of confidence using the other two projects, thus the research objective has been successfully achieved.

6.3 Significance of the Study

The success of this study has derived at 4 significant contributions; the first contribution is that it has bridged the research gap of the studies on the use of cost significance modelling methods. The second contribution is that the building contractors' and CQSs' levels of cost significance awareness of HRCPs in Klang Valley, Malaysia are determined. The third contribution is that the cost estimation model developed will considerably reduce the time needed for estimating the tender amount using traditional approach of pricing bulk volume of items in the tender documents. Lastly, the knowledge of cost significance will help the building contractors and CQSs in identifying area of works to be emphasized for cost checking purpose.

Most of the various studies carried out on development of cost significance model were merely for use of smaller infra-structure projects except Poh and Horner (1995); and Tas and Yaman (2004) who had developed cost significant models for estimation of building costs. However, the techniques used by them took long time and tedious process to identify and abstract the cost significant items from the BQs of the projects. Moreover, the models developed can only be used for low-rise residential building as they were constructed based on only four to five storey buildings. This type of model is no longer of significance use nowadays as high-rise residential dwellings have become dominant in the urban area due to scarcity of lands. Hence this research study has bridged the research gap and constitutes a good contribution to the body of knowledge.

It is very important for both the building contractors and CQSs to gain the cost significance knowledge as it will help in identifying what are the elements of the BQs to be checked. One real life scenario experienced by the researcher was that during the visit to one QS consultant office to collect case study cost data, a client of the CQS has encountered issues on over budget of construction cost and would like to perform remeasurement of the quantities for the project. However, they were not sure which are the important cost elements to remeasure. With the results generated from the case study the researcher could therefore advise the CQS to carry out remeasurement only on those CSEs because NCSEs are less worth spending resources for remeasurement.

To improve the level of awareness in relation to CSEs, it is suggested that higher learning institutions shall include cost significance theory in their syllabus and the related professional bodies shall organize workshops, seminars and talks on cost significance theory and its applications.

6.4 Limitations of the Study

The limitations of this study are mainly the data sizes for both the questionnaire survey and the project case study.

The problem encountered during survey questionnaire collection was the difficulty in getting the relevant personnel to answer the questionnaire and understand what is meant by cost significant element. Moreover, the local construction industry's stakeholders are generally tied up with high workload thus were very reluctant to answer or spend time reading the long-worded questionnaire. Thus, the response rate for the survey was low initially. As such, the researcher had to get qualified respondents through interpersonal relationship. To address the problem of respondents might not understand what is cost significant element, the definition of it was included in the questionnaire with a comprehensive example. Moreover, the researcher's contacts were provided for clarification.

Limitation encountered for case studies was difficulty in getting historical projects' BQs for analysis as the cost data in the BQs is of utmost private and confidential. As such, the researcher has spent long period of time to approach the building contractors and CQSs that the researcher had formerly been dealt with while working in the construction industry as many of them were reluctant to allow access to the cost data. 6 case study projects were used to develop the cost estimation model and 2 case study projects for validation, this is with reference and close resemblance to the approach used by Poh and Horner (1995). In addition, sample size in qualitative survey relies on the principle of data saturation. Case studies are among the most difficult types of qualitative research to classify. Yin (2009) recommended at least six sources of evidence. Creswell (2007) recommended no more than 4 or 5 cases. However, the larger sample size would be preferable to generate more reliable results for sure especially for building the cost estimation model based on CSEs of HRCPs as private high-rise residential buildings are with high variety in design.

Other limitations of this study are firstly, the historical projects are from different clients and designers leading to doubt of each individual project cost is developed with different pricing strategy; secondly, there is a wide range on definition of high-rise and the projects taken are ranging from the shortest of 20 storeys to 35 storeys high. Even though the researcher has checked on 2 HRCPs of near to but shorter than 20 storey and found that the cost significant elements became different from those of the historical projects taken, it should be further testified by taking more numbers of projects of such category; thirdly, the cost model developed is only applicable for the use for estimating HRCPs in Klang Valley, Malaysia other types of building for example low-rise apartments, terrace houses, hotels etc. or projects at other locations out of Klang Valley would not be viable.

6.5 Recommendation for Future Study

In view of the limitations discussed in the previous sub section, it is recommended that for future research, the range of the historical projects taken shall be much narrowed down and preferably projects to be obtained from one sole client in order to obtain cost estimation model with higher accuracy. In addition, cost significant models for project types other than HRCPs may also be developed based on the same technique employed by this research. It would be good also to develop cost estimation model based on public projects where the designs of the projects are more uniform. It would be good also to carry out the similar study in other locations.

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APPENDIX A

QUESTIONNAIRE

LEVEL OF COST SIGNIFICANCE AWARENESS OF HIGH-RISE CONDOMINIUM PROJECTS AMONG QUANTITY SURVEYING CONSULTANTS AND MAIN CONTRACTORS IN THE MALAYSIAN CONSTRUCTION INDUSTRY

Dear Sir/Madam,

You are invited to participate in this survey if you are working in the capacity of Quantity Surveying (QS) related job especially with experience in pricing construction costs of high-rise condominium projects in Klang Valley Malaysia.

This survey aims to measure the level of cost significance awareness of High-rise Condominium Projects among Quantity Surveying Consultants and Main Contractors, as part of the research project titled "Building Cost Estimation Model Based on Cost Significant Elements of High-rise Condominium Projects in the Malaysian Construction Industry" conducted by Sr Lim Cheng Sim of University Tunku Abdul Rahman as a research for PhD study.

It will take about 5-10 minutes of your time to complete the questionnaire. The questionnaire will be kept anonymous and the information obtained from this survey is completely confidential. Your participation is entirely voluntary.

You are free to contact the researcher at email chengsim65@gmail.com or at 012-2393279 to discuss the survey.

Thank you for your participation and assistance. Your involvement in this survey is very much appreciated.

Yours sincerely,

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SECTION 1: PREQUALIFICATION EXERCISE

1. Are you working in the capacity of QS related job especially with experience in pricing for tendering/pre-tender estimate?

   ( ) Yes, please proceed to the survey.

   ( ) No, you may leave the survey.
   (Submit form. Thank you for your time)

2. Have you been involved in pricing construction costs of high-rise condominium projects in Klang Valley Malaysia?

   ( ) Yes, please proceed to the survey.

   ( ) No, you may leave the survey.
   (Submit form. Thank you for your time)

SECTION 2: SURVEY CONSENT

1. Having read and understood the survey consent, I:

   ( ) Agree to proceed.
   (Please proceed to the next section)

   ( ) Disagree to proceed.
   (Submit form. Thank you for your time)

SECTION 3: RESPONDENT'S CONTACT

1. Please fill in your name and email address below so that a copy of the final research results be provided to you in due course.

Name:

____

Mobile phone no.:

____

Email address:

____

SECTION 4: DEMOGRAPHIC INFORMATION

1. What is the nature of business of your current company?

[ ] QS Consultant

[ ] Main Contractor

2. How long is your experience in pricing construction costs of high-rise condominium projects in Klang Valley Malaysia?

[ ] 5 years and below

[ ] 6 to 10 years

[ ] 11 to 15 years

[ ] 16 to 20 years

[ ] More than 20 years

SECTION 5: AWARENESS OF COST SIGNIFICANT ELEMENTS

Instructions:

Please show your level of agreement that each element shown in the list below is a Cost Significant Element by ticking one number on the 1 to 5 point scales, where 1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree Nor Disagree, 4 = Agree, and 5 = Strongly Agree.

(Note 1: The scope of the study covers only main building works; EXCLUDING Earthworks, Piling, External Works, Preliminaries and Contingency Sums.)

(Note 2: High-rise condominium projects referred to are ten (10) storeys and above in height; with common facilities such as swimming pool, gymnasium, landscape, 24 hours security system, sports courts and so on; with podium carparks instead of open

Definition of Cost Significant Element (Example a building project with 4 elemental bills with cost breakdowns as follows):

Building Project XXX	Amount (RM)		Significance	
Element no. 1	20,000	-	**not significant**	(very much less than MBV)
Element no. 2	80,000	-	**less significant**	(less than but close to MBV)
Element no. 3	120,000	-	**significant**	(higher than but close to MBV)
Element no. 4	180,000	-	**very significant**	(very much higher than MBV)
Total Bill Value (Total Cost of Building):	400,000			
Mean Bill Value, MBV (=Total Bill Value ÷ No. of Elements):	100,000			

	1 Strongly Disagree	2 Disagree	3 Neither Agree Nor Disagree	4 Agree	5 Strongly Agree
1A) Work Below Lowest Floor Finish (incl. column bases, pile caps, ground beams, stumps, load-bearing brickwork below lowest floor and ground slabs)	( )	( )	( )	( )	( )
2A) Frame (RC columns, floor beams, roof beams and fascia beams)	( )	( )	( )	( )	( )
2B) Upper Floors (RC floor slabs, balconies and structural screeds, suspended floors over or in basements)	( )	( )	( )	( )	( )
2C) Roof (Roof structure incl RC slabs, trusses, parapet walls and balustrades at roof level; roof coverings; roof drainage; roof lights)	( )	( )	( )	( )	( )
2D) Stairs (RC stair structure, stair finishes, stair balustrades and handrails)	( )	( )	( )	( )	( )
2E) External Walls (External enclosing walls incl. basement walls, retaining walls and diaphragm walls, skin of brickwork to cladding/curtain walling; cladding, curtain walling, sheeting rails, non-structural fins and sun screens; BUT excluding load bearing RC walls)	( )	( )	( )	( )	( )
2F) Windows & External Doors (Incl. lintels, sills, hoods, ironmongery and glazing)	( )	( )	( )	( )	( )
2G) Internal Walls & Partitions (excluding load bearing RC walls)	( )	( )	( )	( )	( )
2H) Internal Doors (Incl. lintels, sills, hoods, ironmongery and glazing)	( )	( )	( )	( )	( )
3A) Internal Wall Finishes (Finishes to surfaces of walls and columns internally)	( )	( )	( )	( )	( )
3B) Internal Floor Finishes (Preparatory work, screeds, skirtings and finishes to floor surfaces)	( )	( )	( )	( )	( )
3C) Internal Ceiling Finishes (preparatory work, plastering and finishes to soffits; suspended ceiling incl. finishes)	( )	( )	( )	( )	( )
3D) External Finishes (Preparatory work and finishes to outside face of external walls, external floor and ceiling)	( )	( )	( )	( )	( )
4. FITTINGS AND FURNISHINGS (Fixed fittings incl. shelving, cupboards, wardrobes, benches, counters etc.; Blinds, blind boxes, curtain tracks and pelmets; Blackboards, pin boards, notice boards, signs, lettering, mirrors etc.; Ironmongery to fittings; Furniture, curtains, loose carpets and similar soft furnishing material; Works of art; Non-mechanical and non-electrical equipment e.g. gymnasium equipment)	( )	( )	( )	( )	( )
5A) Sanitary Appliances	( )	( )	( )	( )	( )
5B) Plumbing Installation (Cold and hot water plumbing, sanitary plumbing)	( )	( )	( )	( )	( )
5C) Refuse Disposal (Waste compactor, shredders, waste bins, incinerators, skid tanks and the like)	( )	( )	( )	( )	( )
5D) Air-Conditioning & Ventilation System	( )	( )	( )	( )	( )
5E) Electrical Installation (Electric supply, electrical fitting and lightning conductors)	( )	( )	( )	( )	( )
5F) Fire Protection Installation	( )	( )	( )	( )	( )
5G) Lift and Conveyor Installation	( )	( )	( )	( )	( )
5H) Communication Installation (Public address system, telephone installations, PABX, MATV and the like)	( )	( )	( )	( )	( )

	1 Strongly Disagree	2 Disagree	3 Neither Agree Nor Disagree	4 Agree	5 Strongly Agree
5J) Special Installation (Kitchen equipment, laundry, building automation, security system, gas installation and the like)	( )	( )	( )	( )	( )
5K) Builder's Profit & Attendance on Services	( )	( )	( )	( )	( )
5L) Builder's Work in Connection with Services	( )	( )	( )	( )	( )

SECTION 6: LOCAL PRACTICE

1. What method have you been using in estimating construction costs of high-rise condominium projects in Klang Valley during tendering/pre-tender estimate?

   ( ) Traditional method i.e. price every single item of each element of bills of quantities

   ( ) Other method(s)
   Please specify:

   ____

   ____

2. Have you heard of Cost Significance Technique an alternative method to traditional method of estimating construction cost of a project?

   ( ) Yes, please proceed to next section.

   ( ) No, you may leave the survey.
   (Submit form. Thank you for your time)

3. Have you ever used the Cost Significance Technique to estimate construction costs of high-rise condominium projects in Klang Valley during tendering/pre-tender estimate?

   ( ) Yes, please proceed to next section.

   ( ) No, you may leave the survey.
   (Submit form. Thank you for your time)

4. How accurate do you think the Cost Significance Technique is?

   ( ) Not accurate

   ( ) Less accurate

   ( ) Neutral

   ( ) Moderately accurate

   ( ) Very accurate

APPENDIX B

(Date)

(Company's Name)
(Address)

Attn.: (Name of Person in Charge)

Dear Sir/Madam,

Data Collection for PhD Study on Level of cost significance awareness of high-rise condominium projects among quantity surveying consultants and main contractors in the malaysian construction industry

Our academic staff, Sr Lim Cheng Sim is pursuing Doctor of Philosophy (PhD) in Science at our university. Her research title is 'Building Cost Estimation Model Based on Cost Significant Elements of High-rise Condominium Projects in the Malaysian Construction Industry'.

As part of her study, she needs to have the project cost data of high-rise condominium projects in Klang Valley. As such, I wish to seek for your kind permission for her to access to the contract documents of high-rise condominium projects in your organization.

All the information gathered are solely for the purpose of her research, will be kept confidential and will not be disclosed to any other party.

For further inquiries or clarification please do not hesitate contact Sr Lim Cheng Sim (+6012-2393279 or lcsim@utar.edu.my) or the undersigned (+6012-2932683 or yongyy@utar.edu.my).

Looking forward to your favourable reply.

Thank you.

Yours sincerely,

____

Dr. Felicia Yong Yan Yan
Assistant Professor / Head of Department
Department of Surveying
Lee Kong Chian Faculty of Engineering and Science
Universiti Tunku Abdul Rahman

c.c. Sr Lim Cheng Sim