THE IMPACT OF USING MEASUREMENT SOFTWARE IN THE QUANTITY SURVEYING CONSULTANCY

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A project report submitted in partial fulfilment of the requirements for the award of Bachelor of Engineering (Hons.) Quantity Surveying

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DECLARATION

I hereby declare that this project report is based on my original work except for citations and quotations which have been duly acknowledged. I also declare that it has not been previously and concurrently submitted for any other degree or award at UTAR or other institutions.

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APPROVAL FOR SUBMISSION

I certify that this project report entitled **"THE IMPACT OF USING MEASUREMENT SOFTWARE IN THE QUANTITY SURVEYING CONSULTANCY"** was prepared by **LIM MEOW YING** has met the required standard for submission in partial fulfilment of the requirements for the award of Bachelor of Science (Hons.) Quanity Surveying at Universiti Tunku Abdul Rahman.

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ABSTRACT

A quantity surveyor is a professional that work in the construction industry concerned with construction cost. The purpose of this research is to investigate the impact of measurement software to the quantity surveying consultancy. The objectives of this research are (i) to identify measurement software undertaken by quantity surveying consultant firms, (ii) to determine the benefits of using measurement software and (iii) to identify the negative impacts of using measurement software. Measurement software as a tool that helps quantity surveyors to do measurement and automatically quantification items that measured for BQ preparation in a short period time and improve the efficiency of the projects in estimating. Quantitative method approach was adopted in this research. A set of questionnaire was distributed to 138 quantity surveyors related personnel who work in consultant firms to identify software that undertakes by the firm and evaluate the relative importance on the impact of measurement software. From this research, Cubicost is the most commonly used measurement software. The finding showed that the highest 3 benefits of measurement impacts are *"It can store data and information"*, *"Can reduce measurement workload"* and *"Reduce measurement mistake"*. However, it has highest 3 negative impacts brought to quantity surveyors such as *"It is cost wasting because it has high installation cost"*, *"Quantity surveyors become more rely on it"* and *"Reduce number of employment"*. Mann-Whitney U test was conducted and the results revealed that there was a significant difference in the benefit of measurement software which was *"Can store data and information"* across gender. Moreover, Kruskal-Wallis test was conducted and the results showed that there was a significant difference in benefit and negative impacts of using measurement software across a different group of age and working experience such as *"Improve cooperation and communication among quantity surveyors"*, *"Attend measurement software training is wasting of time", "The implementation of measurement software will reduce number of employment"* and *"Able to do measurement without using measurement software"*. This research is helpful to the quantity surveying consultancy to gain the benefits of using measurement software so it will bring benefit to the construction industry.

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LIST OF SYMBOLS / ABBREVIATIONS

BQ	Bill of Quantities
QS	Quantity Surveyors
SMM2	Malaysian Standard Method of Measurement
BIM	Building Information Modelling
QTO	Quantity take-off
USA	United Stated of America
IT	Information Technology
AEC	Architecture, Engineering and Construction
TAS	Cubicost Takeoff for Architecture and Structure
TRB	Cubicost Takeoff for Rebar
TME	Cubicost Takeoff for Mechanical and Electrical
TBQ	Cubicost TBQ
IFC	Industry Foundation Classes
CAD	Computer-Aided Design
ME	Tolerated margin of error
SPSS	Statistical Package for Social Science
RII	Relative Importance Index
m^2	Meter square (Area)
n	Number of sample size
Z	Level of confidence
p	Estimated proportion of an attribute in the population
w	Weight of scale
A	Highest weight
N	Total number of respondent

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CHAPTER 1

INTRODUCTION

1.1 General Introduction

The construction industry involves many professional parties and one of the parties is quantity surveyor. The quantity surveyor plays an important role in construction development projects. Normally, the job scope of quantity surveyors are cost advice to the client based on the client requirement, prepare cost planning, tender documents to the tenderers, advice on tender procurement and contractual arrangements, negotiations with contractors, valuation of the works in progress and prepare final accounts (Low and Kok, 1997).

One of the roles of quantity surveyors is doing measurement for preparing the Bill of Quantities (BQ). Quantity surveyors measure items which follow the rules of the SMM2 (Akbar, et al., 2015). In traditional method, quantity surveyors need to refer 2D drawings for doing the measurement. Every single drawing must be studied carefully and identify the materials needed which unsure double count or omit any material. This process is very time-consuming. If there have large items to measure then there is a higher risk to make mistakes (Olsen and Taylor, 2017).

By solving this problem, some quantity surveying company introduce measurement software which has a 3D model for viewing that can improve the efficiency of projects in estimating. BIM software allows industry to start with BIM-based quantity take-off (QTO) and estimating (Olsen and Taylor, 2017). The measurement software that normally have been used in the construction industry Malaysia such as Binalink, Cubicost and Cost-X (Ting and Nurulhuda, 2016).

1.2 Problem Statement

Conventionally, quantity surveyors manually measure quantities from paper drawings then the dimensions are transferred to excel spreadsheets for preparing BQ (Wong, Salleh and Rahim, 2014). Zainon, et al. (2018) claimed that in the traditional method, measurement and BQ spend more working hours for preparing and have a higher risk of human errors. As a result, quantity surveyors

send 80% of working time for doing measurement (Tan and Yeoh, 2011). Since it is very time-consuming, the government of Malaysia has pushed to adopted information technology in improving the performance in the construction industry (Jaafar, et al., 2007). However, it is no easy job because the application of technology in the construction industry is late compare to other industries. This is because the application of technology at the early stage is not utilised among quantity surveying firms even though the technology will give benefit to them (Olatunji, 2011).

Based on the study done by Tan and Yeoh (2011), measurement software act as a useful tool that can assist quantity surveyors to reduce time when doing measurement work. Furthermore, measurement software also provides high accuracy to produced BQ and it can change the measurement easily. Besides, it also can automatically measure quantities which can reduce the time for measuring elements (Zainon, et al., 2018).

Although measurement software is useful for quantity surveyors there have some issues occur in quantity surveying firms. Quantity Surveyors have become more rely on measurement software. Because of reliant on software may cause some mistake or wrong budget estimated (Olatunji, 2015). There are many graduates quantity surveying students have deficient in their measurement skill therefore the standard of measurement has decreased (Keelagher Okey Klein, 2020). Therefore, this research is conducted to identify the current quantity surveyors practices regarding the measurement method and impacts of using measurement software in the quantity surveying consultancy in Malaysia.

1.3 Aim and Objectives

The aim is investigating the impacts of using measurement software in the quantity surveying consultancy. There are few objectives have been set out. The objectives are as follows:-

i. To identify measurement software undertaken by quantity surveying consultancy.
ii. To determine the benefits of using measurement software.
iii. To identify the negative impacts of using measurement software.

1.4 Research Scope and Limitation

There are two main limitations of this research. The research is examining the impacts of measurement software in the quantity surveying consultancy where the questionnaires only distributed to consultant quantity surveyors which is the limitation of samples. Then this research will be completed within a year from Jan 2020 to Sep 2020 where is very time-limited in collating data and completing the study.

1.5 Outline of the Report

This research is divided into 5 chapters. The chapter outlines are further described. Chapter 1 describes a brief introduction to the research background. Section 1.2 is about problem statement where to identify the current quantity surveyors practices regarding the measurement method and impacts of using measurement software in the quantity surveying consultancy. Section 1.3 is about aim and objectives of this research. Section 1.4 is about the research scope and limitation.

Chapter 2 is a literature review that provides an overview of the competitive strategies and theories of marketing mix from previous studies. A structure of competitive strategies was developed and discussed. Section 2.1 is about some background of quanatity surveying consultancy. Section 2.2 is about the overall role of quantity surveyor. Section 2.2.1 is related to the role of quantity surveyor during feasibility stage. Section 2.2.2 is about the role of quantity surveyor during design stage. Section 2.2.3 is about the role of quantity surveyor during tender stage. Section 2.2.4 is about the role of quantity surveyor during construction stage. Section 2.2.5 is about the role of quantity surveyor during completion stage. Section 2.3 is about some information about what is Bill of Quantities (BQ). Section 2.4 is about the evolation of measurement from traditional method improve to measurement software. Section 2.4.1 is about the meaning of scale ruler. Section 2.4.2 is about background of Excel Microsoft Office. Section 2.4.3 is about the electronic measurement and Section 2.4.4 is about the information of Building Information Modelling (BIM). Section 2.5 is about the measurement methods which are traditional measurement and software measurement. Section 2.5.1 is related to some information about the traditional measurement. Section 2.5.1 is information of measurement software.

Section 2.5.2.1 to 2.5.2.6 are the example and explaination of measurement software that use in the quantity surveying consultancy. Section 2.6 is about the benefit of using measurement software. Section 2.6.1 to Section 2.6.8 are explaining the benefits of using measurement software. Section 2.7 is about the negative impacts of using measurement software. Section 2.7.1 to Section 2.7.7 are explaining the negative impacts of using measurement software. Section 2.8 is comparison between traditional measurement and measurement software.

Chapter 3 is about the overview of the study's research methodology. It shows how the research design was constructed. Section 3.2 is about the research design and the common type of research design are qualitative method, quantitative method and mix method. Section 3.2.1 is explanation of quantitative method and quantitative research. Section 3.2.2. is selection of research method where this reseach is using quantitative method. Section 3.3 is about data collection method from fieldwork (primary data collection) or desk study (secondary data collection). Section 3.3.1 is explaining primary data that used in this reseach. Section 3.3.1.1 is about briefly explain survey questionnaires. Section 3.4 is about the sampling design. Section 3.4.1 is the target population of this research. Section 3.4.2 is the sampling frame and Section 3.4.3 is sampling techniques include probability sampling and non-probability sampling and briefly explain probability sampling and non-probability sampling . Section 3.4.4 is calculate the sampling size of this reseach. Section 3.5 is a about data analysis and the test used in this research. Section 3.5.1 is explaining descriptive analysis, Section 3.5.2 is reliability analysis and 3.5.3 is inferential analysis which include Kruskal-Wallis Test and Mann-Whitney Test used in this research.

Chapter 4 identified result of findings from questionnaires. This research is analysed and supported by the data received to verify the reliability. Section 4.2 is analysing the repondents background. Section 4.3 is about measurement software that undertaken by quantity surveying consultant firms. Section 4.3.1 is inferential analysis on the usage of measurement software which carry out by using Mann-Whitney Test. Section 4.4 is about the whether the quantity surveyors still using traditional method to do their measurement. Section 4.4.1 stated the items that measured by using traditional method and Section 4.4.2 is stated their reasons to use traditional method. Section 4.5.1 is analysing whether

the quantity surveyors use measurement software to measure all the items in the project and Section 4.5.2 stated the items that measured by using measurement software. Section 4.5.3 is about whether the firm has provided any measurement software training to the quantity surveyors. Section 4.5.4 is about hardware available in the firm either all computers have measurement software or only few computers have measurement software and Section 4.5.5 is the frequency of using measurement software in one project. Section 4.6.1 is about testing the reliability test on the benefits of using measurement software. Section 4.6.2 is analysing the mean ranking of the benefits of using measurement software. Section 4.6.3 is about the inferential statistics in the benefits of using measurement software based on gender, age and experience. Section 4.6.3.1 to Section 4.6.3.3 which carry out Mann-Whitney Test and Kruskal-Wallis Test between benefits of using measurement software based on gender, age and experience. Section 4.7.1 is about testing the reliability test on the negative impacts of using measurement software. Section 4.7.2 is analysing the mean ranking of the negative impacts of using measurement software. Section 4.7.3 is about the inferential statistics in the negative impacts of using measurement software based on gender, age and experience. Section 4.7.3.1 to Section 4.7.3.2 which carry out Mann-Whitney Test and Kruskal-Wallis Test between negative impacts of using measurement software based on gender, age and experience. Section 4.7.4 is extra negative impacts of using measurement software to the quantity surveyors profession.

Lastly, Chapter 5 is conclusion and recommendation. Section 5.1.1 to Section 5.1.3 are the summarises the entire research study regarding corresponding research objectives. Section 5.2 is the research limitation. Section 5.3 is suggestion for future research are given to improve the quality of similar future research.

CHAPTER 2

LITERATURE REVIEW

2.1 Quantity Surveying Consultancy

Quantity surveying consultancy are the firms that have the professional skill to advise and solve the problem occur in term of costing and contract in the project with the ability to identify which method to suit the project (BQSM, 2020). There are about 374 numbers of quantity surveying consultant firms that register or approved by the Board of Quantity Surveyors Malaysia (BQSM). These firms provide services to meet the client's value system in the construction industry such as feasibility study, cost planning, monitoring tender process, life-cycle costing, valuation of the works in progress, negotiations with the contractors (Low and Kok, 1997). The quantity surveying consultancy can be classified into 3 categories which are small, medium and large. The small-sized firms are when the firms are less than 10 members of the workforce which include all the administrative staff, quantity surveying and associates in a firm. Medium firms are consisting of 10 to 30 members and large firms are more than 30 members of the workforce (Abdullah and Haron, 2006).

2.2 Role of Quantity Surveyor

Quantity surveyor as a cost advisor of construction and concerns with construction cost and contractual administration from initiation stage to completion of construction (Tan and Yeoh, 2011). A quantity surveyor is a person who has the professional skill and understands all construction process (Pittard and Sell, 2016).

In other countries such as the United States of America (USA), they are not called quantity surveyors but call them project engineers or planning or estimators while other countries may call them building economists. This is because they are not only planning or cost estimating of projects but also responsible for engineering works. In the construction industry, quantity surveyors work with other construction professionals such as architects, engineers, contractors and conjunction with project owners (Wao, 2015).

One of the responsibilities of quantity surveyors is advising architects and engineers on the costing from the purpose design to ensure the client's budget and interest are preserve (Tan and Yeoh, 2011). The roles of quantity surveyors in every construction stage are different and have been shown in Figure 2.1.

2.2.1 Quantity Surveyor's Roles During Feasibility Stage

According to Agyekum, Ayarkwa and Acheampong (2015), the roles of quantity surveyors are cost advisor, construction advisor and contract advisor. In this stage, the client will identify the objective of the project which includes the requirement of client against a budget of a project, technological, project surrounding and legislative constraints. Then, quantity surveyors will carry the feasibility study of the project whether the project is feasible to be constructed (Mbacu, 2015). As shown in Figure 2.1, quantity surveyors will provide preliminary cost estimates to the client without having detail drawings based on their experience on previous similar projects. For example, the client provides limited designs or gives a statement of areas, quantity surveyors still can provide cost advice to the client which either the functional building as a whole by applying a rate per m2 to the floor area of building or refining rates suitable to floor areas of parts of building such as hotel guest rooms or restaurants (Towey, 2017).

2.2.2 Quantity Surveyor's Roles During Design Stage

During this stage, the design team such as architects and engineers prepare brief drawings and specifications. The role of quantity surveyors make effective management of design costs by providing early cost advice, manage where the cost to be allocated in the project. Then, quantity surveyors advise clients and design team members about the cost implications of their design decisions and propose the solution if the cost exceeding the approved budget of the client (Cunningham, 2015). Another duty of quantity surveyor is advice on tendering methods and contractual ways as shown in Figure 2.1.

2.2.3 Quantity Surveyor's Roles During Tender Stage

After quantity surveyors produce an overall estimate then this cost will be approved and become a cost budget. Quantity surveyors will prepare a cost plan as a guideline for cost checking the final design which is not exceeding the cost budget before sent out to tender. In this stage, quantity surveyors have to prepare BQ as a final cost check and tender document (Cunningham, 2015). The tender documents will be used by the tenderers in competitive tendering, managing and quantity surveyors will recommend a more suitable contractor to the client when in the tender evaluation (Mbachu, 2015). Then, quantity surveyors prepare a letter of acceptance after the client has approved tender (Low and Kok, 1997). As shown in Figure 2.1, quantity surveyors will prepare all the expenditure statements for tax and accounting so that the client can know the expenses of the project. In addition, quantity surveyors will advise on technical auditing to improve the quality of infrastructure and increase project life with decrease life cycle cost.

2.2.4 Quantity Surveyor's Roles During Construction Stage

In this stage, the duty of quantity surveyors will compile the documents and prepare for contract documentation. Quantity surveyors will carry out monthly site valuation, evaluate variation and prepare estimates cost of variations on receipt of copies of architect's instruction. Consultant quantity surveyors will prepare a valuation for payment to the contractor. Besides, quantity surveyor needs to measure projects based on schedules of rates or BQ as the work proceed, either on-site or architect's drawings and value at contract rates (Low and Kok, 1997).

Quantity surveyors act as financial leader of the design team and need to control project costs to make sure the cost is within budget. In order to make sure the cost is in the range then quantity surveyors must regular review of the evolving design to ensure that the client and design team will receive up-to-date accurate cost report by quantity surveyors (Cunningham, 2015). The most services that provided quantity surveyors is cost advise. Quantity surveyors advise the architect about the contractor's claims (if any) for loss and expense, extension of time and liquidated damages (Low and Kok, 1997).

2.2.5 Quantity Surveyor's Roles During Completion Stage

After the construction complete, quantity surveyors need to prepare final account. Final account is the final contract sum which stated in the contract an agree on amount payable by the client to the contractor after completion of project. Besides, quantity surveyors need to ensure that all contracts instruction must follow and all the potential cost-related items need to calculate out such as provisional and prime cost sums, any loss and expense associated with extension of time and additional or omission items (RICS, 2015). After complete all the calculation then quantity surveyors advise on the final certificate issued by the architect and final payment that paid by the client to the contractor. Finally, quantity surveyors comment on cost data and prepare cost analysis of completed projects. These cost databases are useful in future projects (Low and Kok, 1997).

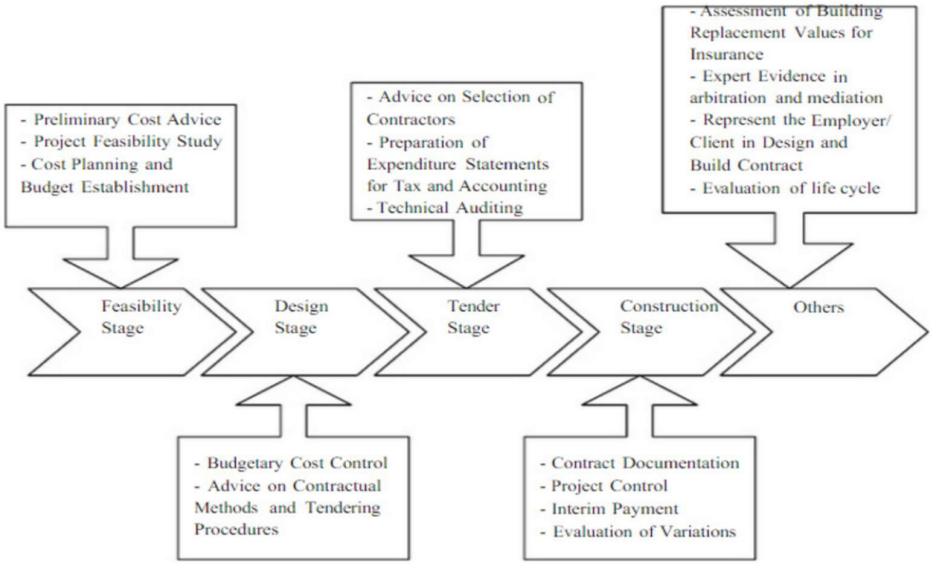

Figure 2.1: Different Roles of Quantity Surveyor in Every Stage (Editorialteam, 2015).

2.3 Bill of Quantities (BQ)

BQ act as a list of items with brief descriptions and estimate quantities of the works to be constructed and as a basis of payment to the contractor (Department 2018). BQ is defined as a document prepared by quantity surveyors on behalf of the client in the pre-tender stage of a project, the BQ uses for cost estimating and compare with other tender prices. When the post-tender stage, BQ uses for

cost planning, cash flow projection, control budget, interim payments, variation order valuations and final account settlements (Nadeem, Wong and Wong, 2015).

Quantities that measure by quantity surveyors can be in number, length, area, volume, weight and item. All the quantities are measured based on the SMM2 as a referred document that provides rules and guidelines of the measurement that needs to be followed by quantity surveyors when measuring the building works (Akbar, et al., 2015).

2.4 The Evolution of Measurement

One of the roles of quantity surveyors is doing the measurement. The purpose of measurement is to prepare BQ. Generally, measurement is a process transferring the architect drawing, engineer drawing, and specification into the figures or quantities for settlement the payments of the building and civil engineering work (Mayouf, Gerges and Cox, 2019). This process is known as taking-off (Lee, Trench and Willis, 2014). After quantity surveyors have done the measurement then import or export data into excel sheet (Yousif, Majeed and Al Azzawi, 2020). This process as known as traditional measurement (Nik Yahya and Heshna, 2018).

After that, in the 1980, introduced the digital software which is transformed the measurement task into the computer (Ting and Nurulhuda, 2016). With improving in technology, BIM has been introduced in Malaysian seen early 2000. Some BIM measurement software usually have been used in the industry such as Revit, Navisworks and Cost-X (Zainon, et al., 2018).

2.4.1 Scale Ruler

Historically, measurement is a heavily labour-intensive task for quantity surveyor (Pittard and Sell, 2016). This is because quantity surveyors spend more time using scale ruler and dimension paper to scale or measure the items or elements one by one from the 2D architect and engineer drawings (Olsen and Taylor, 2017).

2.4.2 Excel Microsoft Office

After get the quantities by using scale ruler then import to Excel. The excel spreadsheet of Microsoft Office software is normally adopted in the quantity surveying firms. This is because it is easy to used to do measurement and estimation of construction as using the formula, to sum up quantity (Moyanga, Agboola and Adegbembo, 2019). It acts as traditional measurement (Nik Yahya and Heshna, 2018). After quantity surveyors have done the measurement then import or export data into excel sheet (Yousif, Majeed and Al Azzawi, 2020).

2.4.3 Electronic Measuring

The introduction of computing is during the 1980s were transformed the measurement task into the computer. Due to generation transformation, quantity surveyors have used computer software for preparing trade bills such as Binalink, Cubicost and Cost-X (Ting and Nurulhuda, 2016). Electronic measuring such as hand-controlled digitisers for measuring from scaled plan drawings and is suitable when dimensions are not given. To obtain a reading, plans are placed flat on a workbench with a scale and unit of measurement are shown in digitiser (Towey, 2012).

The software that allows screen digitisers to calculate the number, area, linear and volumes of materials of works involved and total sum up all the quantities. The electronic design drawings such as pdf or Computer-Aided Design (CAD) files can be opened in a computer. Design can view three-dimensional figures (3D) which has high accuracy in measuring whatever the design is plan shapes or irregular depths (Towey, 2012).

2.4.4 Building Information Modelling (BIM)

BIM as the new concept develops by combining all information from project team members at different stages into a single repository that can easily be deposited, corrected and shared (Olugboyega, 2018). BIM has been introduced in Malaysian seen early 2000. Some BIM measurement software usually have been used in the industry such as Revit, Navisworks and Cost-X (Zainon, et al., 2018). BIM is a modern technology act as a connection process to generate, insert, share and operate all information in a single model that can access by all

parties to improve the design, construction, operations and maintenance processes as shown in Figure 2.2.

For quantity surveying practice, BIM provides an advantage over traditional drawings which is manually measured quantities from 2D drawings. As shown in Figure 2.3, it is replacing the traditional method that can help quantity surveyors to save time for measuring item one by one and provide an accurate quantity (Wong, Salleh and Rahim, 2014).

BIM measurement software has 3D model visualisation and reality that can detect any clashing in design errors by architect and engineer before the real construction on-site to reduce the variation orders and extra costs in the construction project. This trend can help all consultant team members to understand the project design and reduce mistakes, misunderstanding or communication problems between the consultant team members (Wong, Salleh and Rahim, 2014).

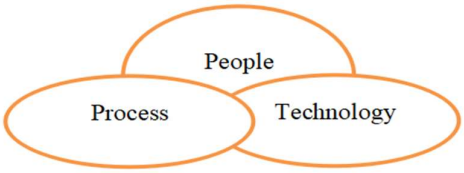

Figure 2.2: Key Components of BIM (Pittard and Sell, 2016).

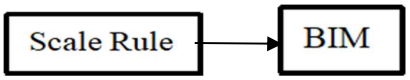

Figure 2.3: Replacement from Traditional Method to BIM.

2.5 Measurement Methods

To get the quantities of the building work there are two types of measurement one is traditional measurement another is using measurement software as shown in Figure 2.4. Then, the comparison between traditional measurement and software measurement as shown in Table 2.2.

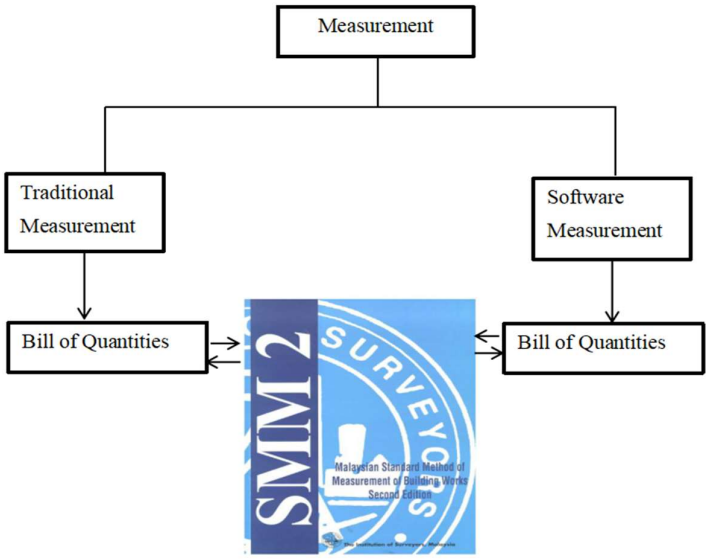

Figure 2.4: Types of Measurement

2.5.1 Traditional Measurement

Traditional measurement or in other words is manually measuring quantities of the building. Traditional measurement is dimension preparation (known as "Taking-off") which is calculated by manually using dimension papers Microsoft Office and scale ruler (Lee, Trench and Willis, 2014). Quantity surveyors have to measure through a set of drawings, architect drawings, engineer drawings, landscape drawings, mechanical drawings and plumbing drawings (Olsen and Taylor, 2017). According to Lee, Trench and Willis (2014), the normal format of dimension paper is shown as Figure 2.5 and all dimensions are in one five forms:

i) Cubic measurements
ii) Square or superficial measurements
iii) Linear measurements
iv) Enumerated items
v) Items

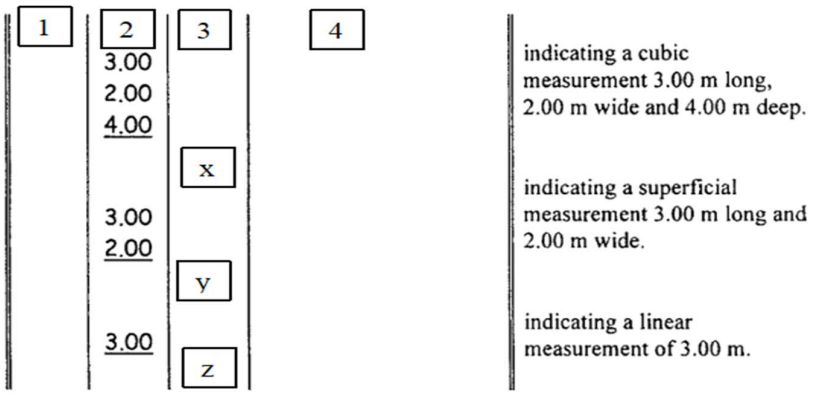

Figure 2.5: The Example of the Dimension Papers (Lee, Trench and Willis, 2014).

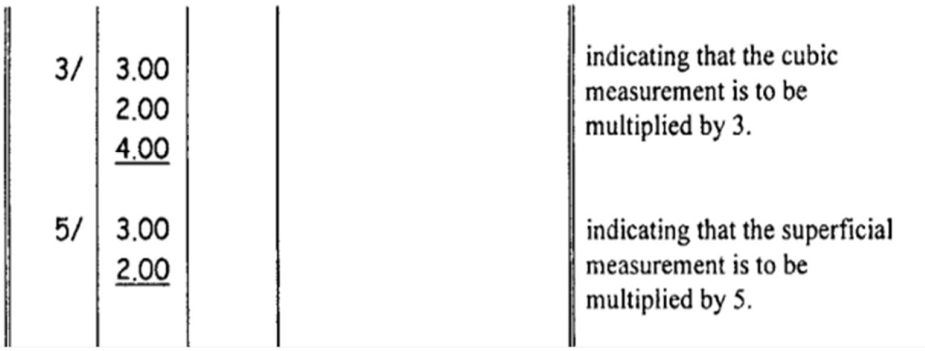

Figure 2.6: 'Timesing' Column Multiply with 'Dimension' Column (Lee, Trench and Willis, 2014).

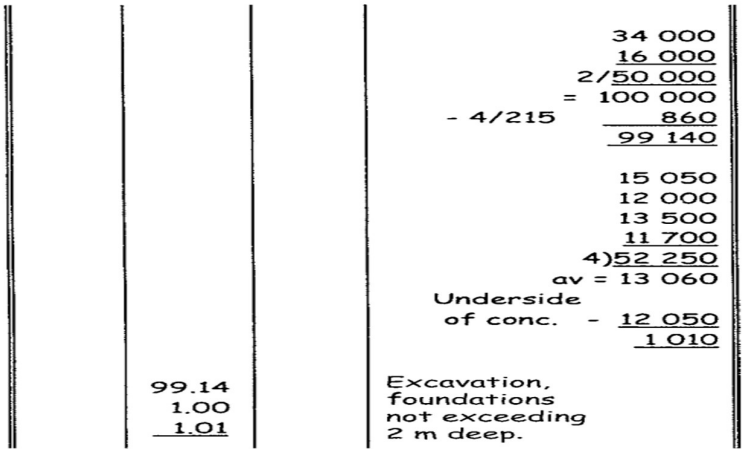

Figure 2.7: 'Waste Calculation' for the Build-up of the Figures Entered in the Dimension Column (Lee, Trench and Willis, 2014).

In Figure 2.5 and Figure 2.6 show column 1 of the dimension papers is the ‘timesing’ column which is used to multiply by figures which is more that one of the particular items that being measured. Column 2 is the ‘dimension’ column for the actual dimensions taken from the drawings. The example shows column 2 has 3(L) X 2(W) X 4(D) which meant L= Length, W= Width and D= Depth and is a cubic measurement. Then, column 2 has 3(L) X 2(W) which is a Square or superficial measurement. Next, column 2 has 3(L) which is a linear measurement (Lee, Trench and Willis, 2014).

Figure 2.5 shows column 3 is the ‘squaring’ column where the figure in column 1 multiply with column 2 will be recorded as x, y and z. After that sum up the figures in column 3 which is the quantity need to transfer in BQ (Lee, Trench and Willis, 2014).

Based on Figure 2.6 shows column 4 is the ‘description’ column where the description will be written based on the rules and guidelines of SMM2. This column also mentions where is the location of the dimensions. Within one description or at the below of description can put the ‘waste calculation’ or ‘side-casts’ as preliminary calculation as Figure 2.7 which shows the build-up of the figures entered in the dimension column (Lee, Trench and Willis, 2014).

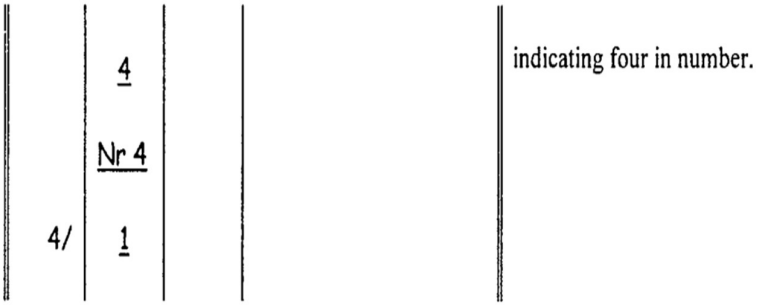

Figure 2.8: ‘Enumerated items’ in a Dimension Paper (Lee, Trench and Willis, 2014).

In Figure 2.8 shows ‘Enumerated items’ in a dimension paper. The example of Enumerated items are fitting, valve and water storage (Lee, Trench and Willis, 2014).

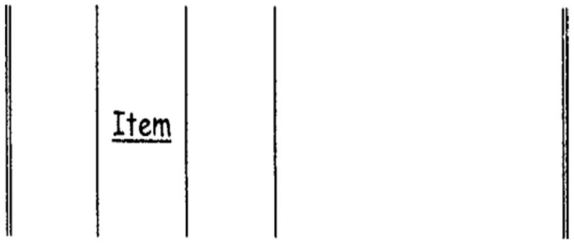

Figure 2.9: 'Item' in a Dimension Paper (Lee, Trench and Willis, 2014).

In Figure 2.9 'Item' in a dimension paper where there is a description without a measured quantity and normally is calculating the testing and drainage system. The description may contain dimensions for example the temporary screens (Lee, Trench and Willis, 2014).

2.5.2 Software Measurement

Nowadays, technology advances have led to continuous changes in the measuring method of professionals by traditional method improve to measurement software such as Binalink, Cubicost and Cost-X that can automatically measure quantities of the building work in the field of quantity surveying consultancy (Ting and Nurulhuda, 2016). Measurement software will bring some benefit to the quantity surveying that will further list and explain as below.

2.5.2.1 Cubicost Software

Glodon Company has one new brand named Cubicost is one of the measurement software. It combined with two words 'Cubic' and 'Cost'. 'Cubic' means 'the shape of a cube' which is applying the concept of BIM. 'Cost' meant the value of software which is to provide an integrated cost solution for customers in the Architecture, Engineering and Construction (AEC) industry. The products of Cubicost which are Cubicost Takeoff for Architecture and Structure (TAS), Cubicost Takeoff for Rebar (TRB), Cubicost Takeoff for Mechanical and Electrical (TME) and Cubicost TBQ (TBQ) normally focus on different requirement of quantity surveyors (Goldon Incorporation 2018).

2.5.2.1.1 Cubicost Takeoff for Architecture and Structure (TAS)

Cubicost TAS is a BIM-based quantity take-off software for architecture and structure work such as concrete and formwork. TAS as quick modelling that enables import the DWG or PDF drawing to draw a 3D model. Then, TAS can be set up with the local measurement methods which can automatically deduct among elements in the BIM model to ensure the calculation is correct. TAS can generate results by floors, element types and others. Based on the classification of the result in BIM models that can easily check and modify quantities. TAS has high efficiency of teamwork because it can has faster adjustment and reuse format of BIM models to decrease quantity surveyor's burden and increase the efficiency of team collaboration (Goldon Incorporation 2018).

2.5.2.1.2 Cubicsot Takeoff for Rebar (TRB)

Cubicost TRB is a BIM-based quantity take-off software for rebar. TRB similar to TAS, it can import DWG or PDF drawing. It can has variations quickly by only adjusting model information and measure again. Then, TRB can be set up with the local measurement methods which can automatically deduct based on the structural joints with rebar connections in the BIM model to ensure the calculation is accurate. After the measurement of the BIM model is done, the result can be generated and export to Excel for preparing BQ in a short time. TRB can support model sharing with TAS to ensure the quantity measurement of rebar and architectural and structural works in the same BIM model. It can also support the data sharing to TBQ for preparing BQ which can save time and improve efficiency of quantity surveyor (Goldon Incorporation 2018).

2.5.2.1.3 Cubicost Takeoff for Mechanical and Electrical (TME)

Cubicost TME is a BIM-based quantity take-off software for piping work and wiring. TME can automatically and accurately measure quantities from 3D models. TME supports and importing PDF, DWG and JPG files which can quickly identify devices piping work and wiring in different disciplines. It can complete measuring quantity in just 'one-click'. As professional BIM-based software TME allows custom settings for various types of drawings such as

calculation of pipeline support number, calculation of irregular pipe joints and advanced deductions (Goldon Incorporation 2018).

The purpose of TME is checking errors and omissions in real-time by using a check device and the quantities can trace in reports. Deal with drawings variations and update the calculation results and reports quickly by only adjusting models and calculate again. TME can provide 3D views of the model which makes it realistic and easy to check the quantities. TME provides types of reports which include system summary, quantity schedule and position summary. The quantities will be generated into BQ (Goldon Incorporation 2018).

2.5.2.1.4 Cubicost TBQ (TBQ)

Cubixost TBQ enables enterprises to manage project costs and tender prices. TBQ aims is to provide cost estimating services for consultancies, owners and contractors. The PDF, Excel and JPG files can be imported into TBQ for preparing BQ. PDF function is specially designed for converting paper BQ into electronic BQ with the accuracy of up to 99% (Goldon Incorporation 2018).

A professional BIM-based software, TBQ provide various schedules of rates in different country and regions. By using TBQ software just one-click for BQ items, data comparison, cost analysis and adjust the works. TBQ supports various customized set of reports. For consultancies, TBQ can automatically generate customized tenders (Goldon Incorporation 2018).

2.5.2.2 Buildsoft

Buildsoft is a measurement software, construction estimating software, electronic measurement preparing BQ as well as hard copy measure through the use of digitizers. It can help quantity surveyor to speed up when doing measurement, save time and money in preparation of BQ throughout the estimating process (Tan and Yeo, 2011). The products of buildsoft are Cubit and MudShark.

2.5.2.2.1 Cubit

Cubit is the natural estimator that can import PDF, DWG and DXF into a project. All the elements can be view in 3D and use as a cross-referencing tool to ensure there is no missing in every item and easy update the estimates more efficiently. Cubit can store pricing information as price lists or import supplier price lists that easy to start the estimate and ensure accurate results. Within Cubit that able to generate the trade, mark up, rate, measurement and BQ. All reports can be exported into Microsoft Excel files (Buildsoft a MiTek Company, n.d.).

2.5.2.2.2 MudShark

MudShark is a measurement software for delivering precise earthwork estimates. It is normally used by estimators, engineers, builders, contractors and quantity surveyors. MudShark has a 3D view which provides clear and easy visualization to the users. In the traditional method, cut and fill calculation is normally spends more time about hours, days or weeks to finish while MudShark can estimate the earthwork up to 5x faster than traditional methods. MudShark can provide accurate technical data in the form of quantities in an efficient manner (Buildsoft a MiTek Company, n.d.).

2.5.2.3 Masterbill

Since 1981, Masterbill has been produced by Construction Industry Software Solution for Quantity Surveyor. Masterbill has introduced some software products such as Masterbill Elite and QsCad. From the products, quantity surveyors can save time in measuring the elements which save about 75% of the time. Then, the measurement software can easily access and reuse the measurement and cost information from the previous project and it can save time, improve accuracy and create an overall audit trail for future reference (Masterbill Micro Systems Ltd, n.d.).

2.5.2.3.1 Masterbill Elite

Materbill Elite include cost planning facilities that can create a budget estimate or cost plan by making use of Cost Planning Library that can store the previous project. Masterbill Elite can combine the measurement of multiple quantity

surveyor's into a single professional document for tendering. Full sortation facilities and facilities page layout enable to sequence and present the document to meet client's need. Integrated CAD and BIM measurement enable measurement from PDF and CAD drawings to be imported and linked into an item dim sheet which can save time, efficient and accurate measurement compare with the traditional method (Masterbill Micro System Ltd, n.d.).

2.5.2.3.2 QsCad

QsCad modules include QsCad Siteworks which are enabled to increase speed and measure quantities of Cut and Fill with accuracy. QSCad Drainage is another specialist module enables Drainage measurement to be completed in a limited time which includes manholes, fitting and drain runs together with their associated excavation (Masterbill Micro System Ltd, n.d.).

2.5.2.4 Binalink

Bina Link Solutions Sdn Bhd is formed by Malaysians who are familiar with the local methods and procedures with providing IT solutions to the construction industry. The products of Binalink are Binalink BQ Module and Binalink CAD Measure. The Binalink BQ Module is used to preparing BQ and Lump Sum BQ in single and multiple column formats which can save time for manually preparing BQ. Binalink CAD Measure is used to automatically measure from CAD drawings or manual measurement method for area, perimeter, vertical area and lineal measurement which can save much time in measurement (Tan and Yeo, 2011).

2.5.2.5 Autodesk

Autodesk Incorporation is an American multinational software corporation that uses in architecture, engineering, construction and manufacturing. The normally product software of Autodesk are Revit, Civil 3D, AutoCAD and Navisworks. These tools help people to create more imaginatively before real construction, solve complex problems, build smarter in a short time and make better design decisions (Autodesk Incorporation, 2020).

2.5.2.5.1 Revit

Revit is one of the BIM software, it can be used for architecture, engineering, and construction professionals. By using Revit, project teams such as architect, engineer, contractor and quantity surveyor have a good collaborate on Revit because it can be worked anywhere, anytime with using BIM360 Design that secure cloud-based design collaboration and data management solution where design and work can together. By using Revit can improve the efficiency and accuracy across the project lifecycle, from conceptual design, realistic visualization and analysis to fabrication and construction. Then, Revit can automatically update floor plans, elevations and section as the model develop so it can help to get accuracy measurement easily in the project (Autodesk Incorporation, 2020).

2.5.2.5.2 AutoCAD

AutoCAD is computer-aided design (CAD) software that architect, engineers and construction professionals use to crease precise 2D and 3D drawings. AutoCAD can draft, import design 2D into 3D models, it can compare drawings, adding blocks and mesh objects. Then, it can auto-generate annotations, schedules, lists and tables. Then, AutoCAD has included industry-specific features and intelligent objects for the architect, mechanical engineering and electrical design such as draw piping, ducting and circuiting. It can be seamless workflows by accessing AutoCAD on virtually any device (Autodesk Incorporation, 2020).

2.5.2.6 Exactal

Exactal is a leading construction software company committed to innovation, service delivery and technology was established in October 2003 which develop estimating software that integrates the estimating process with CAD drawing files. Exactal has introduced some software measurement tools such as CostX and CostX Takeoff (Exactal Group Limited, 2020).

2.5.2.6.1 CostX

CostX is one of the products of Exactal. The application of the CostX measurement is used to improve accuracy and efficiency in estimating. CostX can save time just single click from drawings. CostX can produce a powerful and flexible BQ and cost plan. Digital design data is used to ensure accurately estimate quantities and costs (Exactal Group Limited, 2020).

CostX is a useful tool that can compare old and new drawings, highlight the changes and automatically update quantities so that it does not miss any quantities. CostX has strong spreadsheet-based workbooks which link to the drawings and cost database to reduce copy-paste error (Exactal Group Limited, 2020). There are comparing the features between CostX products as shown in Table 2.1.

2.5.2.6.2 CostX Takeoff

CostX Takeoff is a software to perform the measurement. The software supports take-off form 3D/BIM models as well as 2D hard drawings which provide a better view for quantity surveyors to easily understand the project, improve the accuracy of measurement and reduce paper handling. CostX Takeoff is the most cost-effective because it can automatically measure and estimate project cost before real construction start. CostX Takeoff can support to compare the drawings and highlight the changes to identify variations that need attention by estimator or quantity surveyors (Exactal Group Limited, 2020).

Table 2.1: Comparing the Features between CostX and CostX Takeoff (Exactal Group Limited, 2020).

Features	CostX	CostX Takeoff
2D drawings (include PDFs)	√	√
3D/BIM Model	√	√
Workbooks + Report	√	
Auto -Revisioning	√	√
Subcontractor Comparing/ Bid Day	√	

2.6 Benefits of Using Measurement Software

2.6.1 Time

Historically, quantity surveyors use scale ruler and dimension paper to measure the items one by one from 2D architect and engineer drawings which is very time-consuming. While in the 1980s, quantity surveyors transformed the task into the computer which allows direct measure their dimensional values with semi-automate billing. (Pittard and Sell, 2016). Nowadays, quantity surveyors have used a faster way which is BIM software for measuring the items or elements. By using BIM software, quantity surveyors can save much time to extract measurement quantities from the models (Olsen and Taylor, 2017).

		time [minutes]	
Category	**Contents**	**Manual**	**Revit**
Table of rooms	Floor and ceiling composition	40	20
Foundations	Pads, belts, slabs	125	20
Construction phase	Walls, pillars, girders	420	10
Vertical constructions	Masonry, isolation	450	30
Wall surface	Plasters, paints	330	20
Ceiling composition	Ceiling composition	20	15
Floor composition	Floor composition	40	15
Wall composition	Wall composition	100	20
Facade	Facade	240	20
Roof composition	Roof composition	20	5
Balcony composition	Balcony composition	50	15
Groundwork	Excavations, embankments, removal	120	-
Staircases	Staircases	60	-
Other construction and work	Cleaning, shining, covering	70	20
Tables for take-offs		-	130
Total		**2085**	**340**

Figure 2.10 Time-saving by Using BIM Software (Olsen and Taylor, 2017).

2.6.2 Accurate Cost Estimate

Another factor is because BIM software provides high accuracy in measuring quantity. Traditional measurement has 2D drawings only where quantity surveyors have difficulty to visualize and measure the items changes, addition, omission or new item and will affect cost implication, then probably there will be under measured or over measured occur in measurement process (Zainon, et al., 2018). However, BIM software can find design changes reflected consistently in all drawing views. The changes will automatically calculate quantity by floors and items. BIM software can detect any design clashing

before real construction. BIM software can integrate and merge all the design into a 3D model which has better visualization to identify any design error. Hence, quantity surveying can reduce the mistake occurs such as double measure items or under measure items when preparing cost estimate (Wong, Salleh and Rahim, 2014).

2.6.3 Automatically Quantification for BQ Preparation

Next, BIM software can automatically quantification for BQ preparation but the traditional measurement can only manually prepare BQ. By using BIM, after measurement will automatically generate the quantities from the model for preparing BQ (Wong, Salleh and Rahim, 2014). If there are design changes, then measurement software will auto-update and generate the quantities to prevent double measure (Tan and Yeoh, 2011). This can enhance quantity surveyors' job performance as in traditional measurement may take days or weeks to complete the BQ but now it can be done in hours (Wong, Salleh and Rahim, 2014).

2.6.4 Intelligent Information Management System Allow Data to be Stored in a Central Coordinated Model

BIM is known as intelligent information management store information in a database for easier sharing and receiving the information compared with the traditional method is difficult to store information (Wong, Salleh and Rahim, 2014). Measurement software such as Cubit can store pricing information like price lists or import supplier price lists that easy to start the estimate and ensure accurate results (Buildsoft a MiTek Company, n.d.). All information is stored in the model allows quantity surveyors to estimate quantities and cost of the project (Wong, Salleh and Rahim, 2014).

2.6.5 Productivity

In the traditional method, measurement and BQ will take a longer time for preparing and there may have a high risk of human error (Zainon, et al., 2018). However, in the modern method, quantity surveyors use IT to complete their tasks which can automatically measure quantity and cost calculation in a short

period. Hence, IT can increase the productivity of quantity surveyors (Smith, 2011).

2.6.6 Quality

The traditional method cannot detect any errors in design. The purpose of doing measurement is to prepare BQ. Quantity surveyors use measurement software that can detect any clashing or error that occurs from the design before real construction started. Hence, measurement software can increase the quality of BQ compared to the traditional method (Tan and Yeoh, 2011).

2.6.7 Improve Communication

Traditionally, drawings, schedules and specifications from an architect and engineer are important for quantity surveyors to estimate costs. The information exchange between project members is inefficient which need to send paper documents. If there have design changes, then new drawings will be prepared and send again to project members, therefore this is a problem for quantity surveyors in receiving information that is time-limited to get the latest information. However, measurement software can import drawings such as CAD files, JPGs and PDF files then form a 3D model that helps all consultant team members to understand the project design and reduce misunderstanding or communication problems between the consultant team members (Wong, Salleh and Rahim, 2014). Then, this easy access allows better exchange and sharing information between project members which can improve communication or information errors (Nik Yahya and Heshna, 2018).

2.6.8 Measurement Workload

Since BIM can detect any clashing items or any discrepancies between architect design and engineer design so this can reduce design errors and discrepancies that always occur by using traditional methods. This will help to reduce the workloads of quantity surveyor for revising cost estimates (Wong, Salleh and Rahim, 2014).

2.7 The Negative Impacts of Using Measurement Software

2.7.1 High Hardware Installation Cost

The price of measurement software is too high compare with the traditional method, some quantity surveying consultancy film only limited some PCs to install the software that causes to quantity surveyors spend longer time for preparing BQ (Tan and Yeo, 2011). The company spend a high capital cost for purchase of measurement software where only low margins resulting in little scope for investment (Agyekum, Ayarkwa and Acheampong, 2015).

2.7.2 Training Problem

The training problem is one of the negative impacts of using measurement software. This is because measurement software is a new tool for quantity surveyors to do measurement which is not familiar compare with traditional measurement (Tan and Yeo, 2011). Hence, quantity surveyors who are inexperienced need to attend training. Quantity surveyors face training problems because they have to spend time learning how to use measurement software which is very time wastage (Shen and Chung, 2007).

2.7.3 Technical Problem

Information technology (IT) is difficult to be used in the quantity surveying consultancy firms due to technical reasons. The problems are measurement software is new technology to the quantity surveyors because it is difficult to understand and there are less skill quantity surveyors who are expert in the measurement software. Then, there is a low rate of using BIM software because it needs to combine all the important or detail information for excellent practical strategies to be developed. Other than that, quantity surveyors have to make sure each data developed is estimable because it is a technical requirement of BIM (Zainon, et al., 2018).

2.7.4 Low Return Investment

Although many firms know the benefit of measurement software but some of the firms still use the traditional method (Nik Yahya and Heshna, 2018). This is

because of the high cost of measurement software, so the small or medium-sized firms may not be able to purchase expensive software rather than use traditional method (Yousif, Majeed and Al Azzawi, 2020).

2.7.5 Rely on Measurement Software

Although measurement software is useful to quantity surveyors but in the instance that most measurement software are used for estimating and tender analysis rely on manual capturing of input. Because of relying on software may cause some mistake or wrong budget estimated (Olatunji, 2015). With the advance of measurement software, there are many graduate quantity surveying students have deficient in their measurement skill therefore the standard of measurement has decreased (Keelagher Okey Klein, 2020).

2.7.6 Security Problem

Since measurement software is on the laptop or computer therefore it is not safe to store the measurement and estimating cost of the project in the computer compare to the traditional method which is in papers works. According to Tan and Yeoh (2011) and AME Group (2020) stated that all the data has been stored in the measurement software which is easily for quantity surveyors to update the measurement and costing but there may occur computer hackers who stole the data from the company which causes a data security problem.

2.7.7 Learning and Remember Many Procedures

Furthermore, learning and remembering many procedures is also one negative impact on the quantity surveyors. This is because of measurement software as a new tool therefore senior quantity surveyors are lack of awareness (Smith, 2011). Finding from Abdullah and Haron (2006) showed there are 98% of quantity surveying firms use traditional measurement which are scale rulers and calculator when measuring quantities but only 37% of quantity surveying firms are using measurement software as shown in Figure 2.11. Hence, measurement software has a negative impact because it has many procedures to be remembered by quantity surveyors during measuring quantities.

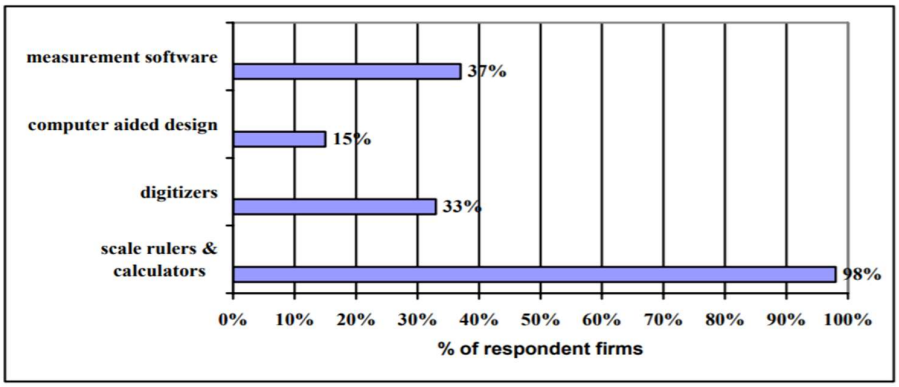

Figure 2.11: Measurement Tools (Abdullah and Haron, 2006).

2.8 Comparison between Traditional Measurement and Measurement Software

Nowadays, quantity surveyors have a faster way which is software for doing the measurement. Figure 2.10 shown by using BIM software, quantity surveyors can save much time to extract measurement and material quantities from the models compare to traditional measurement which will take a longer time to do measurement (Olsen and Taylor, 2017).

Then, BIM software provides high accuracy in measuring quantity compare with traditional measurement which is not user-friendly and the approximated costs are not very accurate (Yousif, Majeed and Al Azzawi, 2020). This is because BIM software can merge or combine all the drawing to become a model, easy to find design changes from drawing views and automatically calculated the quantities by floors and items can reduce the mistake occurs prevent overlooking items while traditional measurement need to compare new 2D drawings with old drawings if there is a changes then can only manually re-measure is necessary. As the result, there is a higher risk of overlooking items because of the difficulty to capture everything especially in a complex project (Wong, Salleh and Rahim, 2014). Traditional measurement requires longer working hour to do measurement and prepare BQ so there is higher risk to make human error (Zainon, et al., 2018). Hence, measurement software can improve the quality of BQ compared with the traditional method (Tan and Yeoh, 2011). Furthermore, according to Wong, Salleh and Rahim (2014) stated all the quantities can be automatically generated to prepare BQ which can reduce the

burden or workload of quantity surveyors compare with traditional measurement.

In addition, BIM software can store all the information in the model to allow quantity surveyors estimate quantities and cost of the project while the traditional method difficult to store information because all the information is in papers form (Wong, Salleh and Rahim, 2014). According to Smith (2011) researched quantity surveyors use IT to complete their tasks which can automatically measure quantity and cost calculation in a short period. Hence, IT can increase the productivity of quantity surveyors.

Measurement software has 3D model that helps all consultant team members to understand the project design and reduce misunderstanding or communication problems between the consultant team members. Then, this easy access allows better sharing of information between project team members and reduce information errors compare with traditional measurement which is time-consuming to get new information (Wong, Salleh and Rahim, 2014).

In contrast, the installation cost of measurement software is higher than the traditional measurement as shown in Table 2.2. Because of measurement software is a new tool for quantity surveyors to do measurement which is not familiar compare with traditional measurement (Tan and Yeo, 2011). As a result, quantity surveyors face training problems because they need to attend the training which is very time-wastage (Shen and Chung, 2007).

For instance, because of the high cost of measurement software, so small or medium-sized quantity surveying consultancy may not be able to purchase expensive software rather than use traditional method (Yousif, Majeed and Al Azzawi, 2020). Since the measurement software is useful and easy for quantity surveyors to generate quantities so many quantity surveyors become more reliable to the software that may cause some careless mistake or wrong budget estimated (Olatunji, 2015).

Besides, measurement software has a security problem compare with traditional measurement. This is because all the data has been stored in the measurement software which is easily for quantity surveyors to update the measurement and cost but there may occur computer hackers who store the data

from the company which causes a data security problem (Yeoh, 2011) and (AME Group, 2020).

Furthermore, Smith (2011) claimed that measurement software has many procedures or steps to be remembered by quantity surveyors during measuring quantities. However, traditional measurement only manually measuring elements by using scale ruler and calculator (Abdullah and Haron, 2006).

Table 2.2: The Comparison Between Traditional Measurement and Measurement Software.

Traditional measurement	**VS**	**Measurement software**
Longer time	**Time to do measurement**	Shorter time
No so accurate	**Accuracy**	High accuracy
No	**Automatically quantification for prepare BQ**	Yes
No	**Stored Data**	Yes
Low	**Productivity**	High
Low	**Quality**	High
No	**Communication**	Yes
Cannot reduce	**Measurement Workload**	Can reduce
Low	**Cost**	High
No	**Training problem**	Yes
No	**Technical problem**	Yes
-	**Return Investment**	Low
No	**Rely on Measurement Software**	Yes
No	**Security Problem**	Yes
No	**Many Procedure**	Yes

CHAPTER 3

METHODOLOGY AND WORK PLAN

3.1 Introduction

Overall, in Chapter 3 will discuss the research design in this study, data collection method for primary and secondary data, sampling design which will discuss further as below that required for the study. Then, it will also discuss the tool used for research data collection and data analysis.

3.2 Research Design

The purpose of the research design is to ensure the collected data to answer the research questions and hypothesis. The most common types of research design are a qualitative method, quantitative method and mix method which combine the qualitative and quantitative methods (Bhattacherjee, 2012).

3.2.1 Quantitative Research and Qualitative Research

Table 3.1: The Difference Between Quantitative and Qualitative (Saeb, Mohamed, Danuri, Zkaria, 2018; Tuli, 2010; Bhattacherjee, 2012; Naoum, 2007).

Criteria	Qualitative	Quantitative
Approach	Interview	Questionnaires
Research Question	The questions are designed in open-ended.	The questions are designed in closed-ended.
Sample Size	Small	Large
Respondent	Selected	Randomly selected
Data	Non-measureable	Measureable
Data Analysis	Non-statistical	Statistical
Direction of Theory Construction	Begins from “reality”	Begins from theory
Nature of Data	Rich and deep	Hard and reliable

Qualitative method is an inductive approach which is interview approach while quantitative is through questionnaires to collect data and analyse the data. Qualitative method is the questions are designed in open-ended which can analysis in test or picture that represents the opinion given by respondents while quantitative method is the questions are designed in closed-ended which only can analysis the numeric data to represent the respondent's idea. Normally, the sample size of the qualitative method is small while the sample size of the quantitative method is large. The qualitative method, the respondents have been selected for interview while the quantitative method the respondents are not selected to answer the questionnaires. Then, the data analysis of qualitative method is non-measurable and non-statistical while the quantitative method is measurable and statistical information and discoveries are unquestionable and usually detailed in nature. The qualitative method is begins from "reality" which is the opinion of the respondents while the quantitative method begins from the theory or literature review. Hence, the data from the qualitative method is rich and deep while the quantitative method is hard and reliable.

3.2.2 Selection of Research Method

In this research, the quantitative method is more suitable to be used to achieve the objectives of research. The objectives of the research are examined quantity surveyors related personnels who work in quantity surveying consultancy against benefits of using measurement software and the explore the negative impacts that might brought by using measurement software. The quantitative research method selected in this research because it studies a small group of people to represent a large group of people of the population and generate data from the sample. The questionnaire survey can be distributed to many respondents and collected through the online at a shorter period. After all the data has been collected within 5 weeks, the results can be analysed effectively way by using the Statistical Package for the Social Sciences (SPSS) therefore the result can be presented more clearly to the reader.

3.3 Data Collection Method

To choose data collection methods have depended on the nature of the investigation and type of data and information that are required and available. Generally, there are two types of data collection methods which are fieldwork (primary data collection) and desk study (secondary data collection).

3.3.1 Primary Data

Primary data is the data collected from the first-hand source. The information can be collected and analysis through interviews, questionnaires or case studies. These survey methods can be carried out through e-mail or the Internet via Google drive or personal interviews. Primary data through the Internet via Google drive which includes questionnaires with opened-ended and closed-ended questions are adopted to respondents to answer the questions and it has been used for this research (Naoum, 2007).

3.3.1.1 Survey Questionnaires

In this research, the data has been collected from the questionnaires that setted in the form of Internet via Google form which distributed through e-mail and Facebook. The advantage of using this method is because it can save time and cost-efficiency. It allows for a large amount of information to be collected from the respondents.

The questions in the questionnaire are designed based on the opened-end, closed-end or structured questions which can answer based on the respondent's opinion and select an answer from a given set of choices. The closed-end or structured questions can easy to be processed in analysing the data. The questionnaires are divided into 4 sections which are Section A, B, C and D. Section A is about the respondent's background. Section B is about measurement software undertaken by quantity surveying consultancy firms. Section B also ask the respondents whether they have still used the traditional method to do measurement and what items to be measured by using the traditional method with the reasons given. Next, ask respondents whether they have used measurement software to do measurement and what items to be measured by using measurement software. In addition, whether the firm has

provided measurement software training to the quantity surveyors and every computer has measurement software or only some computers have measurement software. Then, asking the frequency of respondents use measurement software to do measurement.

Section C is about the benefits of using measurement software such as whether using measurement software can save time, get accurate cost estimate, the quantity can automatically for BQ preparation, can store data and information, reduce measurement mistake, improve cooperation and communication among quantity surveyors, able to identify overlapping or clashing elements in 3D model, flexible to edit the measurement and can reduce the measurement workload. Section D is about the negative impact of using measurement software such as whether using measurement software has high installation cost, it is a low return investment, attend the training is wasting of time, it is difficult to understand and has many steps to remember, it will lower down the measurement skills of respondents, it has security problem, it will cause reduce the number of employment, quantity surveyors become more rely on it and ability of quantity surveyors to carry out measurement without using measurement software. These section C and D are designed based on the LIKERT scale which is strongly disagree, disagree, neutral, agree and strongly agree or not capable, slightly capable, moderately capable, very capable and extremely capable to determine the relationship between dependent variables and independent variables.

3.4 Sampling Design

Sampling is a statistical process of selecting a subcategory, named “sample” of a population of interest in making observations and statistical inferences about that population. Because of cost and time constraints therefore for this research it is choosing a sample that can be representative of the population and derived this sample to generalize back to the population interest (Naoum, 2007).

3.4.1 Target Population

The target population for this research is the construction industry in Malaysia. The target respondents are individual whose work are relating to the quantity

surveyor nature in consultant firms. Quantity surveying consultancy are the firms that have the professional skill to advise and solve the problem occur in term of costing and contract in the project with the ability to identify which method to suit the project (BQSM, 2020). These firms provide services to meet the client's value system in the construction industry from initial stage to completion stage of the project. The quantity surveying consultancy have 3 categories which are small, medium and large. The small firm is less than or equal to 10 QS, medium firm is 11-30 QS and large firm is more than 30 QS.

3.4.2 Sampling Frame

The sampling frame is defined as a list with contact information of sampling from the target population where the sample can be drawn (Naoum, 2007). According to BQSM stated there are 374 numbers quantity surveying consultancy firm are registered in Malaysia (BQSM, 2020). In this research, there are 138 respondents who are working in the consultant firms have been non-randomly chosen as the sample. The location of the research is set at the whole register quantity surveying consultancy firm in Malaysia.

3.4.3 Sampling Techniques

Sampling techniques can be divided into two categories which are probability sampling and non-probability sampling. Probability sampling is defined as a random selection of samples from the target population. Non-Probability sampling or non-random selection of samples where some of the sample have zero chance of selection or the probability of election cannot be accurately determined (Bhattacherjee, 2012).

This research has chosen non-probability sampling techniques such as convenience sampling and snowball sampling had been selected in this research. Convenience sampling is a sample drawn from part of population that is readily available and it is convenient. Snowball sampling is starting some respondents who match the criteria for inclusion in the research and ask them to recommend to others who also can meet criteria of research (Bhattacherjee, 2012).

3.4.4 Sampling Size

The sample size can be calculated through the formula below:

$$n = \frac{Z^2 \times \{p(1-p)\}}{ME^2}$$

Where,

n = number of sample size

Z = level of confidence

p = estimated proportion of an attribute in the population

ME = tolerated margin of error

In this research assume the confident level is 95% (Z= 1.96) whilst the p-value assume as 0.1 with margin error is 5% (ME= 0.05). Thus, the sample size of this research can be obtained:

$$n = \frac{1.96^2 \times \{0.1(1-0.1)\}}{0.05^2} = 138$$

Hence, the questionnaires will be prepared and distributed to the quantity surveyors who are working in the consultancy company in Malaysia to receive 138 responses.

3.5 Data Analysis

Data analysis is a process to analyse data that answer from the respondents through questionnaires to generalise the finding. In this research, the software used to analysis data is using the Statistical Package for Social Science (SPSS).

Many types of statistical test can be carried out by using SPSS. There are two major types of statistical test which are parametric test and non-parametric test. Parametric tests such as t-tests, ANOVA and regression need assumptions that the data are normally distributed and used to analyse ordinal data. Parametric tests are suitable for sample size which is more than 30 (n>30) because it is easy to detect the differences and relationship between the independent group. However, non-parametric tests do not assume the

distribution of data. Non-parametric tests such as Mann-Whitney test, Wilcoxon Signed Rank test, Friedman test and Kruskal Wallis test usually depend on ranks rather than the actual data (Marshall and Boggis, 2016). In this research, many tests carried out which are frequency analysis, Cronbach's Alpha Reliability method, Kruskal-Wallis test and Mann-Whitney test.

3.5.1 Descriptive Analysis

The descriptive analysis is carry out in this research which include frequency analysis and mean. Frequency analysis is used in this research to analyse frequency or percentage for the demographic profile of respondents included gender, age, working experience and use of measurement software in the firm. Then, mean ranking is used in the inferential statistics on measurement software used by different firm size. Frequency and inferential statistics on benefits and negative impacts of using measurement software. The results are presented in the form of a table showing percentage for easy referring.

3.5.2 Reliability Analysis

Cronbach's Alpha Reliability method is measuring the internal consistency reliability to find correlation value between the score of every item and the total score for all items in the test. Normally, this test is used when a Likert scale is used in the questionnaire. Cronbach's Alpha has the range 0 to 1 which has shown in Table 3.2. In this method, the higher the correlation value, the more reliable to the questionnaire (Pallant, 2010).

Table 3.2: Internal Consistency of Cronbach's Alpha Reliability Method (Pallant, 2010).

Cronbach's Alpha Value	Internal Consistency
0.90-1.00	Excellent
0.80-0.89	Good
0.70-0.79	Acceptable
0.60-0.69	Questionable
0.50-0.59	Poor
≤0.50	Unacceptable

3.5.3 Inferential Analysis

There are two inferential statistic test which are Kruskal-Wallis test and Mann-Whitney test used in the research. Both of the tests are non-parametric test.

3.5.3.1 Kruskal-Wallis Test

The Kruskal-Wallis test as extension of Mann-Whitney test is used to examine the statistically significant difference in means of 2 or more group from different populations (Marshall and Boggis, 2016). This test is carried out by using SPSS. There are two hypotheses formulated to detect the significance differences between age and working experience of respondents. The null hypothesis (H_0) which the p-value is larger than 0.05, it means there is no significant difference between the groups whereas the alternative hypothesis (H_A) which the p-value is smaller than 0.05, it means there is a significant difference between the group (Bhattacherjee, 2012).

When the Kruskal-Wallis test there is significant result, it means it has one or more samples is different from the other samples. Then, double click on the output for the test and a second screen appears with more information appear to include the post-hoc test with Bonferroni adjustment. Select 'Pairwise comparisons" from the list in the bottom right hand then it will show where are the differences occur or how many differences occur (Marshall and Boggis, 2016). In this research, this test is used to analyse the data and evaluate according to the respective mean rank of difference between age and working experience of respondents against the benefits and negative impacts of using measurement software.

3.5.3.2 Mann-Whitney Test

Mann-Whitney test is similar to the Kruskal-Wallis test. It also used to examine the statistically significant difference between the two groups of sample. This test is the non-parametric equivalent to the independent t-test. There are two types on Mann-Whitney test. If the shape of distribution for both groups are the same then the medians can be compared. If not then use the default test which compares the mean ranks (Marshall and Boggis, 2016). In this research, Mann-Whitney test is used to identify any significant difference between 3 firm sizes

such as small, medium and big that undertake which types of software such as Excel, Cubicost, Binalink, Buildsoft, Revit, Masterbill, Exactal, AutoCAD and Buildspace. The firms compare as less than or equal to 10 QS and 11-30 QS, less than or equal to 10 QS and more than 30 QS, 11-30 QS and more than 30 QS. This test also used to identify any significant difference between gender, male and female on the benefits of measurement software.

3.6 Chapter Summary

In this reseach, the Quantitative method had been choosen and questionnaire had been distributed to the respondents and collected through the online such as email and Facebook within 5 weeks. The target respondents are individual whose work are relating to the quantity surveyor nature in consultant firms. There are total 138 respondents that calculated and have been non-randomly chosen as the as sample. The non-probability sampling techniques such as convenience sampling and snowball sampling had been selected in this research. There are four statistical tests used in this reseach which included frequency analysis, Cronbach's Alpha Reliability method, Kruskal-Wallis test and Mann-Whitney test. The statistical tests had been carried out by using SPSS software.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents and discusses the data collected from the 138 sets of questionnaires from individuals works as a quantity surveyor related profession in the consultant firms through e-mail and Facebook. The duration of collecting data was around 5 weeks which started from 2nd July 2020 until 26th July 2020. There were some methods to analyse data such as descriptive analysis was carried on the demographic data, frequency of measurement methods, reliability analyse and inferential statistics were incorporated across the gender, age, working experience and size of firm.

4.2 Respondents Background

This question was asking about some of the backgrounds of the respondents whether they were male or female, the age of them, the years of working experience and the number of quantity surveyors in their firm. Based on this data collected may give some impact to the result of this research.

Table 4.1: General Information of Respondents, (N=138).

Respondent's Profile	**Characteristics**	**Frequency (n)**	**Percentage (%)**
Gender	Male	68	49.3
	Female	70	50.7
Age	Below or equal to 25 years old	39	28.3
	26-35years old	34	24.6
	36-45 years old	31	22.5
	Above 45 years old	34	24.6

Table 4.1 (Continued)

Respondent's Profile	Characteristics	Frequency (n)	Percentage (%)
Working Experience	Less than or equal to 1 year	39	28.3
	1 year, <=5 years	38	27.5
	5 years, <=10 years	31	22.5
	More than 10 years	30	21.7
Number of quantity surveyors	Less than or equal to 10 QS	39	28.3
	11 – 30 QS	56	40.6
	More than 30 QS	43	31.2

Table 4.1 shown the frequencies and percentage of quantity surveying consultant firms on various categories of characteristics. Firstly, there were 49.3% of males and 50.7% of female who had answered these questionnaires where 39 respondents (28.3%) are below or equal to 25 years old, the respondents were between the range 26 to 35 years old and above 45 years old had the same percentage of 24.6% and only 22.5% of respondents were between 36 to 45 years old. In the aspect of respondent's working experiences in the construction industry, most of the respondents had working experience in the range of less than or equal to 1 year (28.3%) as considered fresh graduate quantity surveyors. Then, there were 38% of respondents who had more than 1year but less than or equal to 5 years of working experience in the construction industry. The next followed by the respondents who had more than 5 years but less than or equal to 10 years of working experience in the construction industry (22.5%). The rest of 30 respondents who had more than 10 years of working experience in the construction industry as considered experience quantity surveyors.

As the result, 56 quantity surveyor consultant firms where had 11 to 30 quantity surveyors considered the highest percentage which was 40.6% compared to others. Next, there were 43 firms (31.2%) that had more than 30

quantity surveyors and 39 firms (28.3%) that had less than 10 quantity surveyors in their firm.

4.3 Measurement Software Undertaken by Quantity Surveying Consultant Firms

The respondents were asked to select what software they were using to do the measurement in their firm. This question asked to identify whether the firm was using measurement software or traditional method for doing their measurement. Multiple selections were allowed in this question.

Table 4.2: Frequency of Software used in Quantity Surveying Consultant Firms, (N=138).

Software	**Frequency (n)**	**Percentage (%)**
Use One Software		
Microsoft Excel	19	13.8
Cubicost	9	4.3
Buildsoft	3	2.2
Exactal	3	2.2
Masterbill	2	1.4
Binalink	1	0.7
AutoCAD	1	0.7
Total	**38**	**22.3**
Use one Measurement Software and Excel		
Cubicost, Excel	54	39.1
Binalink, Excel	24	17.4
Revit software, Excel	4	2.9
Buildsoft, Excel	4	2.9
Masterbill, Excel	3	2.2
AutoCAD, Excel	3	2.2
Total	**92**	**66.7**

Table 4.2 (Continued)

Software	Frequency (n)	Percentage (%)
Use Two Measurement Software and Excel		
Cubicost, Exactal, Excel	2	1.4
Binalink, Revit, Excel	2	1.4
Cubicost, Binalink, Excel	2	1.4
Masterbill, Revit, Excel	1	0.7
Cubicost, BuildSpace, Excel	1	0.7
Total	**8**	**5.6**

Table 4.2 shown the combination of the software used by quantity surveyors to represent what kind of software used in the firm. From Table 4.2, the overall 66.7% of the firms were using the combination of one measurement software and Excel which was the highest frequency compared to others. The highest frequency of combination of software with the Excel was Cubicost, Excel which was 39.1%.

There were 22.3% of the firms were using one single software. Next, there were only 5.6% of the respondents claimed that their firms were using two types of measurement software together with Excel. The total of 11.5% of respondents claimed that they only used software to do measurement now and never use Excel. There are 19 firms (13.8%) did not have measurement software so they were using traditional method which was using hard copy of drawings, scale ruler and Excel. After quantity surveyors have done the measurement then import or export data into excel sheet (Yousif, Majeed and Al Azzawi, 2020).

Table 4.3: Summary of Software Used by Consultant Firms.

Code	Software	Frequency (n)	Percentage (%)
A1	Excel	119	86.2
A2	Cubicost	68	49.3
A3	Binalink	24	17.4
A4	Buildsoft	11	8.0

Table 4.3 (Continued)

Code	Software	Frequency (n)	Percentage (%)
A5	Revit	7	5.1
A6	Masterbill	6	4.3
A7	Exactal	5	3.6
A8	AutoCAD	4	2.9
A9	BuildSpace	2	1.4

Table 4.3 shown overall there were 86.2% of respondents used Excel to do measurement but 72.4% of respondents had measurement software in a place where Excel was assisting to do measurement in the firms. However, only 13.8% of the respondents purely used Excel in doing their measurement. Then, the highest frequency of measurement software was Cubicost which were 68 respondents (49.3%). The second higher percentage of measurement software was Binalink (17.4%) followed by Buildsoft (8.0%), Revit (5.1%), Masterbill (4.3%), Exactal (3.6%), AutoCAD (2.9%) and BuildSpace (1.4%).

4.3.1 Inferential Analysis on the Usage of Measurement Software

Kruskal-Wallis test was carried out to define whether there were any significant differences between 3 size of firms such as small, medium and big which undertook measurement software. The small-size firm which was less than or equal to 10 QS, medium-size firm which was 11 to 30 QS and large-size firm which was more than 30 QS. This firm size was tested to identify whether the firm size would affect the choice of using measurement software. Result showed significant different on the usage of measurement software, i.e. Cubicost, Excel and AutoCAD based on different firm sizes.

Table 4.4: Inferential Statistics on Measurement Software Used by Different Firm Size.

Code	Software	Asymptotic Significance
A1	Cubicost	0.000
A7	Excel	0.005
A9	AutoCAD	0.006

Table 4.5: Mann-Whitney Test on Measurement Software Used by Different Firm Size.

	Asymp. Sig. (2-tailed)		
Group	**Group 1**	**Group 2**	**Group 3**
Cubicost	0.000	0.000	-
Excel	-	0.019	0.006
AutoCAD	0.015	0.032	-

Notes:

Group 1: Small-size firms compare with medium-size firms

Group 2: Small-size firms compare with large-size firms

Group 3: Medium-size firms compare with large-size firms

The Mann-Whitney Test of two independent groups is applied to three software which weas less than 0.05 as shown in Table 4.4 and 4.5. In Table 4.5, *"Cubicost"* tested had significant difference between small-size firms compared with medium-size firms (p=0.000) and small-size firms compared with large-size firms (p=0.000) where the asymptotic significance was less than 0.05. The mean rank of *"Cubicost"* used in the small-size firms (61.19) was higher than the medium-size firms (38.81). The mean rank of *"Cubicost"* used in the small-size firms (51.69) was higher than the large-size firms (32.26). This result shown that many firms used measurement software for measurement. It is differ from the opinion of the previous study from Abdullah and Haron (2006) claimed that only 37% of quantity surveyor firms are using measurement software.

For "*Excel"* tested had significant difference between the small-sized firms compared with large-size firms (p=0.019) and medium-size firms

compared with large-size firms (p=0.006) where the asymptotic significance was less than 0.05. The mean rank of "*Excel"* used in the small-size firms (37.15) was lower than the medium-size firms (45.44). The mean rank of "*Excel"* used in the medium-size firms (45.54) was lower than large-size firms (55.81). The large firms had used Excel more frequently than medium firms because it is easy to do measurement and estimation of construction as using a formula to sum up quantity (Moyanga, Agboola and Adegbembo, 2019).

In Table 4.5, "*AutoCAD"* tested had significant difference between small-size firms compared with medium-size firms (p=0.015) and small-size firms compared with large-size firms (p=0.032) where the asymptotic significance was less than 0.05. The mean rank of "*AutoCAD"* used in the the small-size firms (45.13) was lower than the medium-size firms (50.00). The mean rank of "*AutoCAD"* used in the small-size firms (32.29) was lower than the large-size firms (43.50). This is because they think it is not necessary to use measurement software as it is a new tool where quantity surveyors need to attain training and time waste (Nik Yahya and Heshna, 2018). Another reason is because the small-size firms may not be able ot purchase expensive software rather than use traditional method (Yousif, Majeed and Al Azzawi, 2020).

4.4 Traditional Methods

Table 4.6: Traditional Methods Used by Quantity Surveyor, (N=138).

	Frequency (n)	**Percentage (%)**
Yes	55	39.9
No	83	60.1
Total	**138**	**100.0**

The purpose of the question was to find out whether quantity surveyors nowadays still use the traditional method which includes scale ruler, printer drawings and Excel to do measurement as claimed by Lee, Trench and Willis (2014). Table 4.6 shown that only 39.9% of quantity surveyors still had used traditional method while overall 60.1% of quantity surveyors did not use traditional method. Refer to Table 4.3 and Table 4.6, the total Excel frequency

was 119 respondents and 55 respondents were using the traditional method. That meant 64 respondents who were also using Excel to do measurement but never referred to printed drawings and scale ruler in performing their measurement. They may referring to softcopy drawings in JPGs or PDF files into MoziDiffer to do their measurement.

4.4.1 Items that have been Measured by Using Traditional Method

There were only 55 respondents who still used traditional method would answer this question. This question was defining what items had been measured by using traditional method and the reason why they were using traditional method to do measurement but not measurement software. There were total of 36 items listed to the respondents which items they measured by using traditional method.

Table 4.7: Items that have been Measured by Using Traditional Method, (N=55).

Items	**Frequency (n)**	**Percentage (%)**	**Rating**
Excavation and earthwork	39	70.9	5
Piling	38	69.1	6
Foundation	39	70.9	5
Ground beam	36	65.5	8
Column	38	69.1	6
Floor beam	36	65.5	8
Floor slab	36	65.5	8
Roof slab	36	65.5	8
Roof finishes	36	65.5	8
Roof covering and rainwater drainage	36	65.5	8
Staircase	41	74.5	3
Staircase finishes and railing	41	74.5	3
External walls	36	65.5	8
Internal walls and partitions	36	65.5	8
Windows	44	80.0	2

Table 4.7 (Continued)

Items	Frequency (n)	Percentage (%)	Rating
Door	45	81.8	1
Builder's work in connection with services and sundries	38	69.1	6
Ironmongery	40	72.7	4
Internal wall finishes	36	65.5	8
Internal floor finishes	36	65.5	8
Internal ceiling finishes	36	65.6	8
External wall finishes	36	65.5	8
Sanitary wares and fitting	40	72.7	4
Ramp	37	67.3	7
Road marking	37	67.3	7
Road kerb	37	67.3	7
Roadworks	37	67.3	7
Surface water drainage	37	67.3	7
Sewerage work	38	69.1	6
Retaining wall	37	67.3	7
Boundary wall fencing	37	67.3	7
Hard landscaping works	38	69.1	6
Water reticulation	38	69.1	6
Cold water plumbing system	37	67.3	7
Sanitary plumbing system	37	67.3	7
Miscellaneous	35	63.6	9
Total	**1358**	**2469.1**	

As summarized from Table 4.7, the majority of items that measured by using traditional method were door and window which were 81.8% and 80.0%. The third and fourth items that also calculated by using traditional method were staircase, staircase finishes and railing, ironmongery and sanitary wares and fitting where the percentage were 74.5%, 74.5%, 72.7% and 72.7%.

The percentage of excavation and earthwork, foundation, piling, column, builder's work in connection with services and sundries, sewerage work, hard landscaping works and water reticulation were 70.9% and 69.1% as rating 5 and 6. Furthermore, respondents used the traditional method to calculate the external works' items which were ramp, road marking, road kerb, roadworks, surface water drainage, retaining wall, boundary wall fencing, cold water plumbing system and sanitary plumbing system with the same percentage 67.3%.

4.4.2 Reasons for Using Traditional Method

Table 4.8: Reasons of Using Traditional Method.

Reasons	**Frequency (n)**	**Percentage (%)**
Because I am familiar with using scale ruler for doing measurement	21	15.2
Because my company does not use measurement software	19	13.8
Because excel is easier as compare to software when doing simple measurement like the number, length can direct get the quantity from the drawing. So, don't waste time to draw/keyin into software	11	8.0
Because measurement software is a new tool and I am not familiar with it.	6	4.3
Because my company does not equip with measurement software to every computer and I think it is time-consuming for me to wait other quantity surveyors to complete the task by using measurement software.	6	3.6
Because no softcopy, have to get a hardcopy of drawing	2	1.4
Because my boss ask me to measure items by traditional method	1	0.7

The most common reasons that the respondents were using the traditional method because they were more familiar with using scale ruler for doing measurement and there were 4.3% of respondents claimed that measurement software was a new tool so they were no familiar as shown in Table 4.8. There were 13.8% of respondents claimed that because of their company did not use measurement software so they were no other choice to do their measurement.

As the reason shown in Table 4.8, 8% of respondents chose traditional method because Excel was easier for some items especially items measured in number as the data shown in Table 4.7 where door and window, ironmongery and sanitary wares which measured in number could direct get the quantity from the drawing. So, quantity surveyors didn't waste time to draw or key in into software.

Furthermore, 3.6% of respondents chose to use the traditional method because of their company did not equip with measurement software to every computer so it was time-consuming to wait other quantity surveyors to complete the task by using measurement software as stated in Table 4.8. There were 1.4% of respondents use the traditional method because there was no softcopy and only hardcopy of drawings were available.

4.5 Measurement Software

Nowadays, the measuring method of professionals by traditional method improve to measurement software such as Binalink, Cubicost and Cost-X that can automatically measure quantities of the building work in the field of quantity surveying consultancy (Ting and Nurulhuda, 2016). There were some measurement software used in Malaysia such as Cubicost, Revit, Buidsoft, Masterbill, Binalink and Exactal. Then, measurement software would bring some benefits and negative impacts to the quantity surveyors which would be discussed and analysed the data collected from the respondents as below.

4.5.1 Measurement Software to Measure all the Items in the Project

Table 4.9: Measurement Software to Measure all the Items in the Project, (N=138).

Description	Frequency (n)	Percentage (%)
Yes, I am using the measurement software to measure all the elements in a project.	19	13.8
No, I only use the measurement software to measure certain elements in a project.	100	72.5
No, my firm does not have measurement software.	19	13.8
Total	**138**	**100.0**

Table 4.9 shows the frequency and percentage of quantity surveyors who were using or were not using measurement software to measure items. There were 72.5% of respondents had used measurement software to measure certain elements in a project. 13.8% of respondents had fully used measurement software to measure all items in a project. There were only 19 respondents did not use measurement software because their firm did not install measurement software. This result was differ from the opinion of the previous study from Abdullah and Haron (2006) claimed that most quantity firms use traditional measurement which are scale rulers and calculator to do measurement.

4.5.2 Items that have been Measured by Using Measurement Software

There were only 19 firms did not have measurement software as shown in Table 4.9. So 119 respondents who were using measurement software would answer this question. This question was defining what items had been measured by measurement software in their project. There were total of 36 items listed to the respondents which items they had measured by using measurement software.

Table 4.10: Items that have been Measured by Using Measurement Software, (N=119).

Items	Frequency (n)	Percentage (%)	Rating
Excavation and earthwork	90	75.6	3
Piling	90	75.6	3
Foundation	90	75.6	3
Ground beam	100	84.0	1
Column	90	75.6	3
Floor beam	100	84.0	1
Floor slab	100	84.0	1
Roof slab	100	84.0	1
Roof finishes	100	84.0	1
Roof covering and rainwater drainage	98	82.4	2
Staircase	88	73.9	4
Staircase finishes and railing	88	73.9	4
External walls	100	84.0	1
Internal walls and partitions	100	84.0	1
Windows	50	42.0	9
Door	50	42.0	9
Builder's work in connection with services and sundries	46	38.7	12
Ironmongery	48	40.3	10
Internal wall finishes	100	84.0	1
Internal floor finishes	100	84.0	1
Internal ceiling finishes	100	84.0	1
External wall finishes	100	84.0	1
Sanitary wares and fitting	55	46.2	8
Ramp	78	65.5	5
Road marking	78	65.5	5
Road kerb	78	65.5	5
Roadworks	78	65.5	5

Table 4.10 (Continued)

Items	Frequency (n)	Percentage (%)	Rating
Surface water drainage	68	57.1	6
Sewerage work	68	57.1	6
Retaining wall	63	52.9	7
Boundary wall fencing	63	52.9	7
Hard landscaping works	55	46.2	8
Water reticulation	68	57.1	6
Cold water plumbing system	68	57.1	6
Sanitary plumbing system	68	57.1	6
Miscellaneous	47	39.5	11
Total	**2863**	**2405.9**	

Table 4.10 shown the majority of structural works except for foundation and column, ground beam, floor beam, floor slab, roof slab, roof finishes, walls and partitions, finishes of walls and internal ceiling finishes measured by using measurement software. All of these items are different to image before construction so by using measurement software they can view 3D model to identify any design error therefore it can reduce mistake occurs in measurement (Wong, Salleh and Rahim, 2014).

The second higher percentage of an item that 82.4% of respondents used measurement software for measuring was roof covering and rainwater drainage. The third higher percentage of items that 75.6% of respondents measured were excavation and earthwork piling, foundation and column. They were using measurement software to do measurement because it can safe much time to extract measurement quantities from the 3D models (Olsen and Taylor, 2017).

Next, the percentage of staircase and staircase finishes and railing that calculated by using measurement software were 73.9% as rating fourth because it can detect any clashing items or discrepancies in the design so it can reduce workloads of quantity surveyor for revising cost estimates as claimed by Wong, Salleh and Rahim (2014). The percentage of the ramp, road marking, road kerb and roadworks were 67.2% as the moderate rating to measure by using

measurement software because it can automatically generate quantity from the model for preparing BQ. This can enhance quantity surveyors' job performance as in traditional measurement, they may take days or weeks to complete the BQ but now this can be done in hours (Wong, Salleh and Rahim, 2014).

4.5.3 Training Provided by the Firms

Table 4.11: Measurement Software Training Provided to the Quantity Surveyors, (N=138).

	Frequency (n)	**Percentage (%)**
Yes	79	57.2
No	40	29.0
No, my firm does not have measurement software.	19	13.8
Total	**138**	**100.0**

By referring Table 4.11, the majority company 79 out of 138 firms had provided measurement software training to the quantity surveyors. To make sure quantity surveyors knew how to use the measurement software so the firm provided training to them. Next, there are 29.0% of firms did not provide training to the quantity surveyors and 13.8% of the firms did not use measurement software so no training provided to the quantity surveyors.

4.5.4 Hardware Available in the Firm

Table 4.12: The Firm Equip with Measurement Software in Every Quantity Surveyor's Computer, (N=119).

Description	**Frequency (n)**	**Percentage (%)**
Yes	89	74.8
No, only a few computers have the software	30	25.2
Total	**119**	**100.0**

Table 4.12 shown there were 89 out of 119 respondents noticed that their firm had equipped with measurement software in every company while there were 30 respondents had noticed that their firm only equipped with measurement software in some of the computers so they may prefer to use traditional method to do the measurement. As previous researcher Tan and Yeo (2011) claimed that quantity surveying consultancy film only limited some PCs to install the software that causes to quantity surveyors spend longer time for preparing BQ. Another reason is they thought it was time-consuming to wait other quantity surveyors to complete the task by using measurement software.

4.5.5 The Frequency of Measurement Software Used in one Project

Table 4.13: Frequency of Using Measurement Software to do Measurement, (N=119).

Description	**Frequency (n)**	**Percentage (%)**
Never (0% of your projects)	-	-
Seldom (30% of your projects)	8	6.7
Sometimes (50% of your projects)	26	21.8
Always (70% of your projects)	34	28.6
Every Project	51	42.9
Total	**119**	**100.0**

Table 4.13 stated that the majority of respondents which who 51 out of 119 respondents using measurement software in every project. Next, 28.6% of respondents always used measurement software about 70% of their projects. There are 26 respondents (21.8%) claimed that they would sometimes use measurement software while 8 respondents (6.7%) claimed that they would seldom use measurement software in their project. All 138 respondents agreed that measurement software could provide benefit to quantity surveyors but not all respondents used measurement software due to the firms did not equip with measurement software or their firm only equipped with measurement software in some of the computers.

4.6 The Benefits of Using Measurement Software

This question asked the respondent's opinion on the benefits brought to them by using measurement software with ranking the benefit by using 5 Likert scales from strongly disagree to strongly agree. There were total 9 benefits of using measurement software that listed where *"Can store data and information", "Can reduce of measurement workload" and "Reduce measurement mistakes"* were the top three benefits that ranked by the respondents.

4.6.1 Cronbach's Alpha Reliability Coefficient

By conducting the Cronbach's Alpha reliability test, it showed that the value of Cronbach's Alpha is 0.796 as shown in Table 4.14 which was based on the 9 benefits of using measurement software that assessed by 138 quantity surveyors who worked in the consultant firms.

Table 4.14: Reliability Statistics of Measurement Software's Benefits.

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
0.796	0.797	9

The value of Cronbach's Alpha used to measure the internal consistency in the survey. The higher the Cronbach's Alpha value, the higher of the reliability of sampling from the respondents. By referring Table 4.14 shown that value of Cronbach's Alpha was 0.796 was considering acceptable result based on the 9 benefits of using measurement software to the quantity surveyors who worked in the consultant firms (Pallant, 2010).

4.6.2 Frequency of Measurement Software's Benefits

Table 4.15: Overall Mean of Measurement Software's Benefit.

Code	Definition	Mean	Rank
C1	Save time	4.14	5
C2	Get an accurate cost estimate	4.09	6
C3	Quantity automatically for BQ preparation	3.88	7

Table 4.15 (Continued)

Code	Definition	Mean	Rank
C4	Can store data and information	4.51	1
C5	Reduce measurement mistakes	4.20	3
C6	Improve cooperation and communication among quantity surveyors	3.81	8
C7	Able to identify overlapping or clashing elements in 3D model	4.14	5
C8	Flexible to edit the measurement	4.17	4
C9	Can reduce of measurement workload	4.22	2

Overall, most of the respondents (84.1%) agreed and strongly agreed with the benefit of measurement software C4= "*Can store data and information*" which was the highest mean ranking (4.51) compared to others as shown in Table 4.15. Another benefit of measurement software C9= *"Can reduce of measurement workload"* which was at the second higher ranking (4.22) that agreed and strongly agreed by 83.3% of respondents. The benefit that ranked by the respondents as third higher ranking was C5= *"Reduce measurement mistakes"* where the mean was 4.20.

4.6.3 Inferential Statistics in the Benefits of Using Measurement Software Based on Gender, Age and Experience

Mann-Whitney U test used to examine the statistically significant difference in the benefit of using measurement software by gender. The Kruskal-Wallis test used to examine the statistically significant difference in the benefit of using measurement software by the age and experience of respondents.

4.6.3.1 Inferential Statistics Test Between Benefits of Using Measurement Software Based on Gender

Table 4.16: Inferential Statistics test on Benefit of Using Measurement Software on Gender.

Null Hypothesis	Asymptotic Significance
The distribution of measurement software can store data and information across categories of "Male" and "Female"	0.040

Table 4.16 shown that only C4=*"Can store data and information"* had significanlly difference between male and female where the asymptotic significance was less than 0.05. As shown in Table 4.16, the mean of C4 =*"Can store data and information"* was computed through Mann-Whitney test. This test showed it was the male/female respondent group contributed to the difference between the five per cent significance level (p=0.040). There was mean rank difference between male (63.31) and female (75.51). There was more female thought the measurement software was more useful because it could store data and information in the storage where they could find data and information easily in the software (Wong, Salleh and Rahim, 2014).

4.6.3.2 Inferential Statistics on Benefit of Measurement Software on Age

Table 4.18 was the rejected null hypothesis regarding the benefit of measurement software after conducted the poc hoc test to pairwise comparing differences of the age group against the respondent's attributes.

Table 4.17: Mean Ranking for Benefit of Using Measurement Software.

Code	Definition	Group	N	Mean Rank
C6	Improve cooperation and communication among quantity surveyors	Below or equal to 25 years old	39	70.29
		26 – 35 years old	34	74.06
		36 – 45 years old	31	*79.37
		Above 45 years old	34	#55.03
	Total		**138**	

Notes = * indicated the highest mean rank of the age group on the benefit of using measurement software

indicated the lowest mean rank of the age group on the benefit of using measurement software

Table 4.18: Inferential Statistics on Benefit of Using Measurement Software Based on Age.

Null Hypothesis	Asymptotic Significance
The distribution of improving cooperation and communication among quantity surveyors across categories of "above 45 years old" and "36-45 years old".	0.046

From Table 4.18 significant test, the following pairs of respondents had a statistically significant difference in the opinion of using measurement software's benefit among the age group of respondents.

i) The age group 36-45 years old thought the measurement software could improve more in cooperation and communication among quantity surveyors (mean rank=79.37) than the age group above 45 years old (mean rank=55.03).

4.6.3.3 Inferential Statistics Test between Benefits of Using Measurement Software on Working Experience

In the conclusion of Kruskal-Wallis test between benefits of measurement software on working experience, since the all the benefit of measurement software's p-value were larger than 0.05 therefore there was failed to prove that there was a significant difference between working experience. The null hypothesis was failed to reject. The mean of the benefit of using measurement software were computed through Kruskal-Wallis test and further explained the differences in the group of working experience of respondents as shown in Table 4.19.

Table 4.19: Mean Ranking for Benefits of Using Measurement Software.

Code	Definition	Group	N	Mean Rank
C1	Save time	Less than or equal to 1 year	39	*77.24
		1 year, <=5 years	38	65.20
		5 year, <=10 years	31	#64.84
		More than 10 years	30	69.70
	Total		**138**	
C2	Get an accurate cost estimate	Less than or equal to 1 year	39	*78.74
		1 year, <=5 years	38	69.61
		5 year, <=10 years	31	#59.26
		More than 10 years	30	67.93
	Total		**138**	
C3	Quantity automatically for BQ preparation	Less than or equal to 1 year	39	70.22
		1 year, <=5 years	38	*71.11
		5 year, <=10 years	31	69.71
		More than 10 years	30	#66.32
	Total		**138**	

Table 4.19 (Continued)

Code	Definition	Group	N	Mean Rank
C4	Can store data and information	Less than or equal to 1 year	39	#59.23
		1 year, <=5 years	38	71.30
		5 year, <=10 years	31	71.02
		More than 10 years	30	*79.00
	Total		**138**	
C5	Reduce measurement mistakes	Less than or equal to 1 year	39	68.58
		1 year, <=5 years	38	#66.18
		5 year, <=10 years	31	67.18
		More than 10 years	30	*77.30
	Total		**138**	
C6	Improve cooperation and communication among quantity surveyors	Less than or equal to 1 year	39	68.88
		1 year, <=5 years	38	75.95
		5 year, <=10 years	31	*76.11
		More than 10 years	30	#55.30
	Total		**138**	
C7	Able to identify overlapping or clashing elements in 3D model	Less than or equal to 1 year	39	70.72
		1 year, <=5 years	38	71.26
		5 year, <=10 years	31	*77.16
		More than 10 years	30	#57.77
	Total		**138**	
C8	Flexible to edit the measurement	Less than or equal to 1 year	39	#65.00
		1 year, <=5 years	38	70.83
		5 year, <=10 years	31	67.15
		More than 10 years	30	*76.10
	Total		**138**	

Table 4.19 (Continued)

Code	Definition	Group	N	Mean Rank
C9	Can reduce of measurement workload	Less than or equal to 1 year	39	#63.77
		1 year, <=5 years	38	73.00
		5 year, <=10 years	31	68.74
		More than 10 years	30	*73.30
	Total		**138**	

Notes = * indicated the highest mean rank of the working experience group on the benefits of using measurement software

indicated the lowest mean rank of the working experience group on the benefits of using measurement software

Table 4.19 shown the mean rank of the less than or equal to 1 year working experience was the highest 77.24 compared to the mean rank of the more than 5 years but less than or equal to 10 years was the lowest 64.84 in *C1=Saving time*. Next, the mean rank of the less than or equal to 1 year working experience was the highest 78.74 compared to the mean rank of the more than 5 years but less than or equal to 10 years was the lowest 59.26 in *C2= Get an accurate cost estimate*. The respondents who were working more than 5 years but less than or equal to 10 years as senior quantity surveyors thought measurement software as a new tool for measuring the elements and many procedures therefore senior quantity surveyors think it is not very save time to use measurement software (Smith, 2011).

The quantities of items in the measurement software could automatically for BQ preparation, the mean rank of more than 1 year but less than or equal to 5 years working experience was the highest 71.11 compared to the mean rank of the more than 10 years was the lowest 59.26. This showed that the respondents who were working more than 10 years no very supportive to use measurement software as it is a new tool for them (Smith, 2011).

In addition, the *C4= Can store data and information* had highest mean rank 79.00 in the group of more than 10 years working experience while the

lowest mean rank 59.23 in the group of less than or equal to 1 year working experience. It was seen that the respondents who were more than 10 years working experience had frequently store information in the model so that they can estimate quantities and cost of the project easily which claimed by Wong, Salleh and Rahim (2014).

The mean rank of more than 10 years working experience was the highest 77.30 compared to the mean rank of more than 1 year but less than or equal to 5 years working experience was the lowest 66.18 in *C5=Reduce measurement mistake*. Most of the respondents (84.8%) who were agreed and strongly agreed that measurement software could reduce measurement mistake. The mean rank of more than 5 years but less than or equal to 10 years working experience was the highest 76.11 compared to the mean rank of more than 10 years working experience was the lowest 55.30 in *C6=Improve cooperation and communication among quantity surveyors.* Measurement software can import drawings such as CAD files, JPGs and PDF files then form a 3D model that helps all consultant team members to understand the project design and reduce misunderstanding or communication problems between the consultant team members (Wong, Salleh and Rahim, 2014).

Furthermore, the *C7=Able to identify overlapping or clashing elements in 3D model* had highest mean rank 77.16 in the group of more than 5 years but less than or equal to 10 years working experience while the lowest mean rank 57.77 was in the group of more than 10 years working experience. Quantity surveyors use measurement software that can detect any clashing or error that occurs from the design before real construction started. Hence, measurement software can increase the quality of BQ compared to the traditional method (Tan and Yeoh, 2011).

The mean rank of more than 10 years working experience was the highest 76.10 compared to the mean rank of less than or equal to 1 year working experience was the lowest 65.00 in *C8=Flexible to edit the measurement*. Then, the mean rank of more than 10 years working experience was the highest 73.30 comparing to the mean rank of less than or equal to 1 year working experience was the lowest 63.77 in *C9=Can reduce of measurement workload.* 87% of respondents agreed and strongly agreed on measurement software can reduce

measurement workload as it can detect any clashing items or any discrepancies between architect design and engineer design so this can reduce design errors and discrepancies that always occur by using traditional methods. This will help to reduce the workloads of quantity surveyor for revising cost estimates (Wong, Salleh and Rahim, 2014).

4.7 Negative Impacts of Using Measurement Software

This question asked the respondent's opinion on the negative impact brought to them by using measurement software with ranking the negative impact by using 5 Likert scales from strongly disagree to strongly agree. There were total 9 negative impacts of using measurement software that listed where *"It is cost wasting because it has high installation cost", "Quantity surveyors become more rely on it"* and *"The implementation of measurement software will reduce number of employment"* were the top three negative impacts that ranked by the respondents.

4.7.1 Cronbach's Alpha Reliability Coefficient

By conducting the Cronbach's Alpha reliability test, it showed that the value of Cronbach's Alpha was 0.734 as shown in Table 4.20 which was based on the 9 negative impacts of using measurement software that assessed by 138 quantity surveyors who were working in the consultant firms.

Table 4.20: Reliability Statistics of Measurement Software's Negative Impacts.

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
0.734	0.733	9

By referring Table 4.20 shown that value of Cronbach's Alpha was 0.734 as considered acceptable result based on the 9 negative impacts of using measurement software to the quantity surveyors who were working in the consultanct firm.

4.7.2 Frequency of Measurement Software's Negative Impacts

Table 4.21: Overall Mean of Measurement Software's Negative Impact.

Code	Definition	Mean	Rank
D1	It is cost wasting because it has high installation cost	3.78	1
D2	It is a low return investment	3.07	9
D3	Attend measurement software training is wasting of time	3.20	6
D4	It is difficult to understand and has many steps to remember	3.11	8
D5	It will lower down measurement skills	3.30	5
D6	It has security problem	3.14	7
D7	The implementation of measurement software will reduce number of employment	3.54	3
D8	Quantity surveyors become more rely on it	3.60	2
D9	Able to do measurement without using measurement software	3.51	4

Overall, most of the respondents (70.3%) agreed and strongly agreed with the negative impact of measurement software D1= *"It is cost wasting because it has high installation cost"* was the highest mean ranking (3.78) as shown in Table 4.21. Since the cost of measurement software was high so 39.8% of respondents agreed and strongly agreed that *"It was a low return investment"* especially in small firms as said by Zainon, et al. (2018) where they did not have high profit than large firms.

Table 4.21 shown that D8= *"Quantity surveyors become more rely on it"* was the second higher mean ranking (3.60) that agreed and strongly agreed by the 57.9% of respondents. In addition, the negative impact that ranked by the respondents as third higher ranking was D7= "*The implementation of measurement software will reduce number of employment"* where the mean was 3.54.

4.7.3 Inferential Statistics in the Negative Impacts of Using Measurement Software on Gender, Age and Working Experience

Mann-Whitney U test used to examine the statistically significant difference on the negative impact of using measurement software by gender. The Kruskal-Wallis test used to examine the statistically significant difference on the negative impact of using measurement software by the age and experience of respondents.

4.7.3.1 Inferential Statistics Test Between Negative Impacts of Using Measurement Software Based on Gender

In the conclusion of Mann-Whitney Test between negative impact of measurement software on gender, since all the negative impacts of measurement software's P-value were larger than 0.05 therefore there was failed to prove that there was a significant difference between male and female. The null hypothesis was failed to reject. The mean of the negative impacts of using measurement software computed through the Mann-Whitney Test and further explained the differences in the group gender as shown in Table 4.22.

Table 4.22: Mean Ranking for Negative Impacts of Using Measurement Software Based on Gender.

Code	Definition	Group	N	Mean Rank
D1	It is cost wasting because it has high installation cost	Male	68	67.65
		Female	70	71.30
	Total		**138**	
D2	It is a low return investment	Male	68	68.81
		Female	70	70.21
	Total		**138**	
D3	Attend measurement software training is wasting of time	Male	68	69.06
		Female	70	69.93
	Total		**138**	

Table 4.22 (Continued)

Code	Definition	Group	N	Mean Rank
D4	It is difficult to understand and has many steps to remember	Male	68	65.85
		Female	70	73.04
	Total		**138**	
D5	It will lower down measurement skills	Male	68	75.43
		Female	70	63.74
	Total		**138**	
D6	It has security problem	Male	68	72.16
		Female	70	66.91
	Total		**138**	
D7	The implementation of measurement software will reduce number of employment	Male	68	71.18
		Female	70	67.86
	Total		**138**	
D8	Quantity surveyors become more rely on it	Male	68	72.92
		Female	70	66.18
	Total		**138**	
D9	Able to do measurement without using measurement software	Male	68	68.96
		Female	70	70.02
	Total		**138**	

In Table 4.22 shown there was no much mean rank difference between male and female in D1= *"It is cost wasting because it has high installation cost",* the mean rank of male was 67.65 and female was 71.30. Because there were more female thought the cost of measurement software was too high that may affect the income of the firm. So the mean rank of male is 68.81 while female was 70.21 in D2= *"It is a low return investment".*

Next, the mean rank of male was 69.03 and female was 69.93 which was almost similar in D3= *"Attend measurement software training is wasting of time".* The mean rank of male was 65.85 which was lower than female was 73.04 in D4= *"It is difficult to understand and has many steps to remember".*

Most of the female thought measurement software was difficult to understand as the reasons stated in Table 4.8, it was a new tool so they were not familiar with it.

Furthermore, the mean rank of male was 75.43 which was higher than female 63.74 in D5= *"It will lower down measurement skills".* The mean rank of male was 72.92 which was higher than female 66.18 in D8= *"Quantity surveyors become more rely on it*". This was because measurement software was too beneficial for the quantity surveyors that could measure items and generate the quantity to them so as time longer, they were relying on it may cause some mistake or wrong budget estimated (Olatunji, 2015).

In addition, the mean rank of male was 72.16 which was higher than female 66.91 in D6= *"It has security problem".* It had security problem because there may occur computer hackers who stole the data from the company which caused a data security problem as claimed by Tan and Yeoh (2011) and AME Group (2020). The mean rank of male was 71.18 which was higher than female 67.86 in D7= *"The implementation of measurement software will reduce number of employmen*t*".* 57.2% of respondents agreed and strongly agreed that this was one of the negative impacts of measurement software.

4.7.3.2 Inferential Statistics on Negative Impacts of Using Measurement Software on Age and Working Experience

Table 4.24 was the rejected null hypothesis regarding the negative impact of measurement software after conducted the poc hoc test to pairwise comparing differences of the age group and working experience group against the respondent's attributes.

Table 4.23: Mean Ranking for Negative Impacts of Using Measurement Software Based on Age and Working Experience.

Code	Definition	Group	N	Mean Rank
D3	Attend measurement software training is wasting of time	Below or equal to 25 years old	39	69.78
		26 – 35 years old	34	#58.18
		36 – 45 years old	31	64.44
		Above 45 years old	34	*85.12
	Total		**138**	
D7	The implementation of measurement software will reduce number of employment	Below or equal to 25 years old	39	#56.37
		26 – 35 years old	34	74.04
		36 – 45 years old	31	66.45
		Above 45 years old	34	*82.79
	Total		**138**	
D9	Able to do measurement without using measurement software	Below or equal to 25 years old	39	#51.56
		25 – 35 years old	34	*79.04
		35 – 45 years old	31	72.08
		Above 45 years old	34	78.18
	Total		**138**	
D7	The implementation of measurement software will reduce number of employment	Less than or equal to 1 year	39	#59.38
		1 year, <=5 years	39	72.83
		5 year, <=10 years	31	62.83
		More than 10 years	30	*85.33
	Total		**138**	

Table 4.23 (Continued)

Code	Definition	Group	N	Mean Rank
D9	Able to do measurement without using measurement software	Less than or equal to 1 year	39	#53.27
		1 year, <=5 years	39	76.04
		5 year, <=10 years	31	74.39
		More than 10 years	30	*77.27
	Total		**138**	

Notes = * indicated the highest mean rank on the negative impacts of using measurement software

indicated the lowest mean rank on the negative impacts of using measurement software

Table 4.24: Inferential Statistics on the Negative Impacts of Using Measurement Software Based on Age and Working Experience.

Null Hypothesis	Asymptotic Significance
The distribution of attending measurement software training is wasting of time across categories of "26-35 years old" and "above 45 years old"	0.022
The distribution of the implementation of measurement software will reduce the number of employment across categories of "below or equal to 25 years old" and "above 45 years old"	0.022
The distribution of the ability to do measurement without using measurement software across categories of "below or equal to 25 years old" and "above 45 years old"	0.019
The distribution of the ability to do measurement without using measurement software across categories of "below or equal to 25 years old" and "26-35 years old"	0.014

Table 4.24 (Continued)

Null Hypothesis	Asymptotic Significance
The distribution of the implementation of measurement software will reduce the number of employment across categories of "working experience less than or equal to 1 year" and "working experience more than 10 years"	0.035
The distribution of the ability to do measurement without using measurement software across categories of "working experience less than or equal to 1 year" and "working experience 1 year, <= 5 years"	0.009
The distribution of the ability to do measurement without using measurement software across categories of "working experience less than or equal to 1 year" and "working experience 5 year, <= 10 years"	0.022
The distribution of the ability to do measurement without using measurement software across categories of "working experience less than or equal to 1 year" and "working experience more than 10 years"	0.010

From the above significant test, the following pairs of respondents had a statistically significant difference in the opinion of using measurement software's negative impacts among the age group and working experience group of respondents.

i) The age group above 45 years old thought that attending measurement software training was very wasting of time (mean rank=85.12) than age group 26-35 years old (mean rank=58.18). As the result shown that the age group above 45 years old had experience than age group 26-35 years old so they thought it not necessary to use measurement software. Hence, they have faced training problems because they have to spend time learning how to use measurement software which is very time wastage (Shen and Chung, 2007).

ii) The age group above 45 years old highly agreed that the implementation of measurement software would reduce the number of employment (mean rank=82.79) than age group below or equal to 25 years old (mean rank=56.37). This is because of measurement software as a new tool therefore senior quantity surveyors are lack of awareness (Smith, 2011).

iii) The age group above 45 years old very capable to carry out measurement without using measurement software (mean rank=78.18) than age group below or equal to 25 years old (mean rank=51.56). Since the age group above 45 years old had more experience than age group below or equal to 25 years old so they there were not necessary to use measurement software. With the advance of measurement software, many graduate quantity surveyors students have deficient in their measurement skill therefore the standard of measurement has decreased (Keelagher Okey Klein, 2020). Because of the fresh graduated quantity surveyors too rely on measurement software so their has less capable than experience quantity surveyors to carry out measurement without using measurement software.

iv) The age group 26-35 years old highly capable to carry out measurement without using measurement software (mean rank=79.04) than age group below or equal to 25 years old (mean rank=51.56). It seen that many graduated quantity surveying students were more rely on measurement software. Hence, they have deficient in their measurement skill therefore the standard of measurement has decreased (Keelagher Okey Klein, 2020).

v) There were 57.2% of working experience group which was more than 10 years highly agreed that implementation of measurement software will reduce number of employment (mean rank=85.33) than working experience group was less than or equal to 1 year (mean rank=59.38).

vi) The working experience group which was more than 1 year but less than or equal to 5 years highly capable to measure without using

measurement software (mean rank=76.04) than working experience group was less than or equal to 1 year (mean rank=53.27). Since the fresh graduated quantity surveyors rely on software may cause some mistake or wrong budget estimated (Olatunji, 2015).

vii) The working experience group which was more than 5 years but less than or equal to 10 years highly capable to measure without using measurement software (mean rank=74.39) than working experience group was less than or equal to 1 year (mean rank=53.27). Keelagher Okey Klein (2020) claimed that with the advance of measurement software, the graduate quantity surveying students have lower down measurement skill so they are less capable to measure without using measuremenet software.

viii) The working experience group which was more than 10 years highly capable to measure without using measurement software (mean rank=77.27) than working experience group was less than or equal to 1 year (mean rank=53.27). It seen that many graduated quantity surveying students have deficient in their measurement skill therefore the standard of measurement has decreased (Keelagher Okey Klein, 2020).

Table 4.25: Frequency of Capable to do Measurement Without Using Measurement Software.

Definition		**Frequency**	**Percent (%)**
Able to do measurement without using measurement software	Not Capable	5	3.6
	Slightly Capable	21	15.2
	Moderately Capable	36	26.1
	Very Capable	50	36.2
	Extremely Capable	26	18.8
Total		**138**	

Table 4.25 shown that most of the respondents (36.2%) were very capable and 18.8% of respondents were extremely capable to do measurement without using measurement software. Since there were many respondents were experienced

quantity surveyors where they had at least 5 years working experience as shown in Table 4.1, so they were capable to do measurement without using measurement software. Then, 26.1% of respondents were moderately capable to measure without using measurement software. Because of relying on software may cause some mistake or wrong budget estimated (Olatunji, 2015). With the advance of measurement software, 15.2% of respondents were slightly capable while only 3.6% of respondents were not capable to carry out measurement without using measurement software. It means they have deficient in their measurement skill therefore the standard of measurement has decreased that noted by Keelagher Okey Klein, (2020).

4.7.4 Extra Negative Impacts of Using Measurement Software to the Quantity Surveyors Profession

This was an open-ended form of question and was not compulsory question where respondents may fill extra negative impact from their opinions. One of the respondents stated one of the negative impacts is that software may not 100% suit to the project due to lack of flexibility therefore in the market today, it still did not has one software which could suit everything.

Next, one respondent claimed that quantity surveyors would more and more rely on the software to work out the quantity and they may not know the method of measurement and the principle of measurement. Another respondent claimed that generally, quantity surveyors too dependent on software and could not even interpret simple measurement form actual construction drawings. The last respondent stated that if keep using measurement devices, actually quantity surveyors would no job.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusion

The three objectives as stated in Chapter 1 are:

i. To identify measurement software undertaken by quantity surveying consultancy.
ii. To determine the benefits of using measurement software.
iii. To identify the negative impacts of using measurement software.

From the data analysis and discussion, the conclusion of this research has identified and the three objectives of this research have been achieved.

5.1.1 Measurement Software Undertaken by Quantity Surveying Consultant Firms

With the improvement of technology, quantity surveyors have changed to use digital or software to do the measurement. By achieving the first objective, the measurement software that undertaken by quantity surveyors consultant firms were identified and ranked. There were 86.2% of the respondents (119/138) using measurement software. Overall, 49.3% of respondents were using Cubicost, 17.4% of respondents were using Binalink, 8% of respondents were using Buildsoft, 5.1% of respondents were using Revit, 4.3% of respondents were using Exactal, 2.9% of respondents were using AutoCAD and only 1.4% of respondents were using BuildSpace. However, 72.3% of respondents still used Excel to do their measurement software even though they have measurement software. Then, it had significant difference in using software such as Cubicost, Revit, Excel and AutoCAD based on the size of firm by using Kruskal-Wallis test .

There were 40% of respondents still using the traditional method which included scale ruler and hardcopy to do measurement. Then, 74.8% of the respondents already had software in their personal computer so this shown that the consultant firm is quite ready towards the digitalize to do measurement.

5.1.2 Benefits of Using Measurement Software

The benefits of using measurement software were being identified and analysed in Chapter 4. From the data analysis, there were top thee higher mean rank which were C4= *"can store data and information"* (mean rank=4.51), C9= *"Can reduce of measurement workload"* (mean rank=4.22) and C5= *"Reduce measurement mistakes"* (mean rank=4.20) compared with others 6 benefits of measurement software that identified from literature review. Besides, C4= "*Can store data and information"* had significant difference in gender where female (mean rank=75.51) rank significantly higher compared to male (mean rank=63.31). This is because measurement software can store all information in the model that allows quantity surveyors to estimate quantities and cost of the project while the traditional method cannot store information (Wong, Salleh and Rahim, 2014). C6= "*Improve cooperation and communication among quantity surveyors*" had significant difference on the age where the age group 36-45 years old thought the measurement software could improve more in cooperation and communication among quantity surveyors (mean rank=79.37) than the age group above 45 years old (mean rank=55.03).

5.1.3 Negative Impacts of Using Measurement Software

The negative impacts of using measurement software were being identified and analysed in Chapter 4. From the data analysis, there were top thee higher mean rank which were D1= *"It is cost wasting because it has higher installation cost"* (mean rank=3.78), D8= *"Quantity surveyors become more rely on it"* (mean rank=3.60) and D7= *"The implementation of measurement software will reduce number of employment"* (mean rank=3.54). Most of the respondents (70.3%) agreed and strongly agree that it had high installation cost as compared with the traditional method.

Besides, D3= *"Attend measurement software training is wasting of time",* D7= *"The implementation of measurement software will reduce number of employment"* and D9= *"Able to do measurement without using measurement software"* had significant difference between ages. The older respondents in the opinion that attended measurement software training was wasting of time (mean rank=85.12) compared with the younger respondents who less thought

that training was wasting of time (mean rank=58.18). In addition, older respondents were highly agreed that implementation of measurement software would reduce the number of employment (mean rank=82.79) compared with the younger respondents (56.37). Furthermore, the experience respondents were more capable to do measurement without using measurement software (mean rank=78.18) compared to the younger respondents (mean rank=51,56).

D7= *"The implementation of measurement software will reduce number of employment"* and D9= *"Able to do measurement without using measurement software"* had significant difference between working experience. There were 57.2% of more experience respondents highly agreed that implementation of measurement software will reduce number of employment (mean rank=85.33) than fresh graduated respondents (mean rank=59.38). Wong, Salleh and Rahim (2014) claimed that with the advance of measurement software which can help quantity surveyors to automatically quantification in hours. 3.6% of respondents were not capable to measure without using measurement software while 81.1% of respondents were moderately capable, very capable and extremely capable to measure without using measurement software. Then, one of the respondents claimed if keep using measurement software would reduce number of employment. Besides, the respondents who were working experience more than 1 year (more than 10 years' mean rank=85.33, 1year, <= 5 year's mean rank= 76.04, 5 years, <=10 years's mean rank=74.39) were more capable to do measurement without using measurement software compared with fresh graduated respondents which were less than or equal to 1 year working experience (mean rank=53.27).

5.2 Research Limitation

Although this research had achieved the objectives, there are few limitations faced during conducting this research. By conducting this research the questionnaire had distributed to the respondents within 5 weeks then are still some of the respondents refuse to participate to answer the survey. Then, convenience sampling and snowball sampling are used as the sampling techniques to select sample as another limitation in this research.

The next limitation is using quantitative method. Quantitative data collection has a limitation such as it only provides numeral descriptions rather than detail and accurate results that can be collected during qualitative method.

5.3 Recommendation for Future Research

The research title on the impact of measurement software is still under study. Based on this research, there are few recommendations for future research. Future researchers will refer these recommendations that may be beneficial to the quantity surveyor firms:

- Stratified random sampling is recommended as the sampling technique because it is more accurate representative sample groups that are more appropriate to the research.
- Use qualitative method, by interviewing with the knowledgeable and experienced quantity surveyors who can provide detail and accurate results through their working experience.
- A study on the alternative ways to encourage quantity surveyors to use measurement software to improve the efficiency of the quantity surveyors in the quantity surveying consultant firms.
- A study on the impact of measurement software that is undertaken by quantity surveyors who are working in the development firms and contractor firms.
- A study on how the local government can encourage the quantity surveying consultant firms to install measurement software.

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APPENDICES

APPENDIX A: Questionnaires

The Impact of Using Measurement Software in Quantity Surveying Consultancy

Dear Sir/Madam,

Good day, my name is Lim Meow Ying, an undergraduate student of Bachelor of Science (Hons) Quantity Surveying from Department of Surveying, Lee Kong Chian Faculty of Engineering and Science (LKC FES) University Tunku Abdul Rahman (UTAR). Currently, I am conducting a survey on "The Impact of Using Measurement Software in Quantity Surveying Consultancy" for my final year project.

The research objectives are:

i) To identify measurement software undertaken by quantity surveying consultancy.
ii) To determine the benefits of using measurement software.
iii) To identify the negative impacts of using measurement software.

My target respondents are consultant quantity surveyors. I would like to invite you to participate in this research by completing a set of questionnaire and this questionnaire will just take a few minutes to complete. This survey consists of four (4) sections including Respondent's profile, Types of measurement software undertaken by quantity surveying consultant firm, Benefits of using measurement software and Negative impacts of using measurement software.

All collected responses and comments will be kept confidential and used solely for academic purpose. Please do not hesitate to contact me if you have any further enquiries.

Thanks & Warmest Regards

Name: Lim Meow Ying
Email address: meow63323903@1utar.my
Student ID: 15UEB07066

* Required

Section A: Respondent's Profile

Please fill in all the fields in the appropriate box.

1. Are you working in a quantity surveying consultancy firm? *

- ◯ Yes
- ◯ No (sorry, you may leave this survey thank you)

2. Are you a quantity surveyor related professional? *

- ◯ Yes
- ◯ No (sorry, you may leave this survey thank you)

3. Gender *

- ◯ Female
- ◯ Male

4. How old are you? *

_____

5. Years of working experience in construction industry*

For example: 10 months, 1 year or 5 years

_____

6. How many quantity surveyors professionals in your company? *

_____

Section B1:General Questions About Measurement Software Undertaken By Quantity Surveying Consultant Firms

There are some measurement software used in Malaysia such as Cubicost, Revit, Buidsoft, Masterbill, Binalink and Exactal. Excel is a spreadsheet and it is not considered as the measurement software.

7. Which software does your company use? (You may choose more than one answer) *

- ◯ Cubicost
- ◯ Buildsoft
- ◯ Masterbill
- ◯ Binalink
- ◯ Exactal
- ◯ Revit
- ◯ Excel
- ◯ My company does not use measurement software
- ◯ Other: _____

8. Do you still use traditional method which includes scale ruler, printed drawings and Excel to do measurement? *

- ◯ Yes (go to question 9)
- ◯ No (go to question 11)

Section B2: General Questions About Measurement Software Undertaken By Quantity Surveying Consultant Firms

There are some measurement software used in Malaysia such as Cubicost, Revit, Buidsoft, Masterbill, Binalink and Exactal. Excel is a spreadsheet and it is not considered as the measurement software.

9. Which items do you measure by using the traditional method? (You may choose more than one answer)

- ☐ All elements
- ☐ Excavation and earthwork
- ☐ Piling
- ☐ Foundation
- ☐ Ground beam
- ☐ Column
- ☐ Floor beam
- ☐ Floor slab
- ☐ Roof slab
- ☐ Roof finishes
- ☐ Roof covering and rainwater drainage
- ☐ Staircase
- ☐ Staircase finishes and railing
- ☐ External walls
- ☐ Internal walls and partitions
- ☐ Windows
- ☐ Door
- ☐ Builder's work in connection with services and sundries
- ☐ Ironmongery
- ☐ Internal wall finishes
- ☐ Internal floor finishes
- ☐ Internal ceiling finishes
- ☐ External wall finishes
- ☐ Sanitary wares and fittings
- ☐ Ramp

- ◯ Road marking
- ◯ Road kerb
- ◯ Roadworks
- ◯ Surface water drainage
- ◯ Sewerage work
- ◯ Retaining wall
- ◯ Boundary wall fencing
- ◯ Hard landscaping works
- ◯ Water reticulation
- ◯ Cold water plumbing system
- ◯ Sanitary plumbing system
- ◯ Miscellaneous
- ◯ Other: _____

10. Why you are using the traditional method for dong measurement but not the measurement software?

- ◯ Because my company does not use measurement software.
- ◯ Because measurement software is a new tool and I am not familiar with it.
- ◯ Because measurement software has many procesures when calculating the items.
- ◯ Because I am familiar with using scale ruler for doing measurement
- ◯ Because my company does not equip with measurement software to every computer and I think it is time-consuming for me to wait other quantity surveyors to complete the task by using measurement software
- ◯ Other: _____

Section B3: General Questions About Measurement Software Undertaken By Quantity Surveying Consultant Firms

There are some measurement software used in Malaysia such as Cubicost, Revit, Buidsoft, Masterbill, Binalink and Exactal. Excel is a spreadsheet and it is not considered as the measurement software.

11. Do you use measurement software to measure all the elements in a project?*

- ◯ Yes, I am using the measurement software to measure all the elements in a project.
- ◯ No, I only use the measurement software to measure certain elements in a project.
- ◯ No, my company does not have measurement software (go to question 16)
- ◯ Other: _____

Section B4: General Questions About Measurement Software Undertaken By Quantity Surveying Consultant Firms

There are some measurement software used in Malaysia such as Cubicost, Revit, Buidsoft, Masterbill, Binalink and Exactal. Excel is a spreadsheet and it is not considered as the measurement software.

12. Which elements that you will use the measurement software to perform? (You may choose more than one answer)

- ◯ All elements
- ◯ Excavation and earthwork
- ◯ Piling
- ◯ Foundation
- ◯ Ground beam
- ◯ Column
- ◯ Floor beam
- ◯ Floor slab
- ◯ Roof slab
- ◯ Roof finishes

- ◯ Roof covering and rainwater drainage
- ◯ Staircase
- ◯ Staircase finishes and railing
- ◯ External walls
- ◯ Internal walls and partitions
- ◯ Windows
- ◯ Door
- ◯ Builder's work in connection with services and sundries
- ◯ Ironmongery
- ◯ Internal wall finishes
- ◯ Internal floor finishes
- ◯ Internal ceiling finishes
- ◯ External wall finishes
- ◯ Sanitary wares and fittings
- ◯ Ramp
- ◯ Road marking
- ◯ Road kerb
- ◯ Roadworks
- ◯ Surface water drainage
- ◯ Sewerage work
- ◯ Retaining wall
- ◯ Boundary wall fencing
- ◯ Hard landscaping works
- ◯ Water reticulation
- ◯ Cold water plumbing system
- ◯ Sanitary plumbing system
- ◯ Miscellaneous
- ◯ Other: _____

13. Does your company provide measurement software training to the quantity surveyor?

- ◯ Yes
- ◯ No

14. Does every computer used by the quantity surveyor in your company equipped with measurement software? (eg: Cubicost, Revit, Buildsoft, Masterbll, Binalink and Exactal)

- Yes
- No, only a few computers have the software

15. How frequently are you using measurement software to do measurement?

- Never(0% of your projects)
- Seldom (30% of your projects)
- Sometimes (50% of your projects)
- Always (70% of your projects)
- Every Project

Section B5: General Questions About Measurement Software Undertaken By Quantity Surveying Consultant Firms

There are some measurement software used in Malaysia such as Cubicost, Revit, Buidsoft, Masterbill, Binalink and Exactal. Excel is a spreadsheet and it is not considered as the measurement software.

16. Based on your opinion, does measurement software provide benefits to quantity surveyor? *

- Yes
- No

Section C: Benefits of Using Measurement Software

Please answer each of the following questions as below the best describes your opinion.

17. Do you agree the measurement software will provide following benefits to quantity surveyor profession? *

Definition	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Save time	◯	◯	◯	◯	◯
Get accurate cost estimate	◯	◯	◯	◯	◯
Quantify automatically for BQ preparation	◯	◯	◯	◯	◯
Can store data and information	◯	◯	◯	◯	◯
Reduce measurement mistakes	◯	◯	◯	◯	◯
Improve cooperation and communication among quantity surveyors	◯	◯	◯	◯	◯
Able to identify overlapping or clashing elements in 3D model	◯	◯	◯	◯	◯
Flexible to edit the measurement	◯	◯	◯	◯	◯
Can reduce of measurement workload	◯	◯	◯	◯	◯

18. Is there any other benefits to the quantity surveyor profession? If yes please answer it.

Section D: Negative Impacts of Using Measurement Sofiware

Please answer each of the following questions as below the best describes your opinion.

19. Do you agree that measurement software is cost wasting because it has high installation cost? *

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

20. Do you agree measurement software is a low return investment? *

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

21. Do you agree that attending measurement software training is wasting of time? *

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

22. Do you agree that measurement software is difficult to understand and has many steps to remember? *

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

23. Do you agree that by using measurement software, it will lower down your measurement skills? *

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

24. Do you agree that by using measurement software it has security problem?*

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

25. Do you agree that the implementation of measurement software will reduce the number of employment? *

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

26. Do you agree that by using measurement software quantity surveyor become more rely on it? *

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

27. Do you still able to carry out your measurement without using measuremenet software? *

	1	2	3	4	5	
Strongly Disagree	◯	◯	◯	◯	◯	Strongly Agree

28. Is there any other negative impact to the quantity surveyor profession? If yes please answer it.

_____