6-1-2016

A decision support system for methods of measurement in construction projects

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"A DECISION SUPPORT SYSTEM FOR METHODS OF MEASUREMENT IN CONSTRUCTION PROJECTS"

A thesis submitted to the School of Sciences and Engineering in partial fulfillment of the requirements for the degree of

MASTERS OF SCIENCE IN CONSTRUCTION MANAGEMENT

To

CONSTRUCTION ENGINEERING DEPARTMENT

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MAY 2016

Acknowledgements

First of all, I thank God for everything and for enabling me to make successful choices and for facilitating my way throughout this research.

I would like to thank my advisor; Dr. Samer Ezeldin for his great help, guidance and support throughout this research and I really learned a lot from him. I would also like to thank all my colleagues in the Quantity Surveying field who helped me throughout this research specially Mr. Karim Mostafa; a Quantity Surveyor at Dar Al-Handasah (Shair and Partners) who gave me great help throughout this research and he provided me with the data needed.

I would also like to thank my family and friends for their great support especially my father and mother.

Abstract

The standard Methods of Measurement is an important topic when it comes to the process of the preparation of the Bill of Quantities of a construction project. This is because the Method of Measurement provides a set of guidance rules to prepare the bill that could have less discrepancies decreasing the risk of having problems during the cost control of the construction project during execution.

This paper is for developing a decision support system for choosing the suitable standard Method of Measurement for a construction project based on certain project parameters. Three popular international standard MOMs are researched which are the CESMM for civil projects, NRM for building projects and POMI for different project types and their usage in the Middle East is investigated. The literature review is explored to present main information about the characteristics and usage of the each method. Data about the method of measurements usage is then collected through a questionnaire distributed among a sample of quantity surveying professionals in the Middle East. An expert system in the form of a decision model is created that automates the process of the Method of Measurement selection for different projects in the Middle East based on five project parameters which are the project type, client and contractor's nationality compared to the country where the project is executed, project value and contract type. This model is then verified to check its logic and validated through case studies of real life projects and comparing the model choice of the suitable Method of Measurement for a certain project with the one actually used in that project and then the results are explained.

Finally, a conclusion is reached regarding the use of the three MOMs in the Middle East and that they are recognized with POMI and CESMM as the most recognized ones. Also, the model created may be suitable for choosing the suitable method of measurement for civil projects unlike building projects since NRM is still a new method which is still not used in projects. This conclusion is followed by a list of recommendations to improve the future research such as improving the model by adding more project parameters and also recommendations to serve the topic of standard Methods of Measurement within the professional field like making future researches to develop codes for some Middle Eastern companies as Egypt.

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1. Introduction

This chapter introduces the topic of the Methods of Measurements and how they are used to prepare the BOQ of a project which is considered an important contract document. It also involves the problem statement for which this research is made and the objectives that should be reached out of this research. It also highlights the methodology followed throughout this research in order to achieve the project objectives.

1.1. Background

Cost is one of the sides of the triangle of Construction Management that involves also quality and time. Cost in any project involves cost estimation for an item before execution and cost control during execution of the project. Cost estimation however, needs to be done in an accurate way as much as possible to decrease the possibility of errors that could be faced during the control process. Cost estimation process involves producing a Bill of Quantities (BOQ). This BOQ depends on defining certain items to be measured and quantified so that these quantities would be given a price that contributes to the whole price of the project. Ways of measuring quantities for items differ from one architect to another and from one project to another. These ways of measuring the items can be defined as a set of rules known as the Method of Measurement (MOM). This MOM describes the ways of measuring the quantities of items inside a project besides providing rules for the ways these items should be described in the BOQ. This Method of Measurement is what defines the items of a project and breaks them down to small items that needs to be measured so as to be given quantities that will be given prices afterwards. So the Method of Measurement (MOM) should be accurate in defining exactly what quantities need to be measured in order to avoid future problems in a project. Some associations however, produced certain standard MOMs for helping in the format of the BOQs they suggest to be used in the projects. For example, the RICS which is the Royal Institute for Chartered Surveyors produced some rules of measuring project quantities like the NRM, SMM7 and the POMI. Also, the ICE has shared in producing MOMs like the CESMM with its various editions. These are MOMs that involve an explanation of the main items of the project and how they should be broken down and quantified. But the question here is why are those MOMs important or why would a client want to use a standard MOM?

When the contractor is pricing a project, there should be a clear explanation of the items to be priced in the BOQ, otherwise, the contractor can either have a misunderstanding in the scope of the project or can include the price of a certain activity on two items of the project which means double counting the price which increases the cost to be incurred by the owner. Also, during the project lifecycle, there could arise some discrepancies of the items that can easily lead to variations and normally, the discrepancies are interpreted against the Owner's side since he is responsible for writing the BOQ. In addition, when pricing the project variations, the point of having a clear classified BOQ would be useful as it defines the items exactly that needs to have a change of price without changing the price of the included items that will be considered as extra costs incurred by the Owner.

With the increased construction revolution in the Middle East, is has become important to facilitate the process of project management for the projects. The large projects usually have high risks and it is hard to anticipate their unforeseen conditions which may cause huge losses of money in large projects. One of the ways of avoiding these risks is by trying to standardize the contract documents produced for the projects. An important contract document that needs to be standardized is the MOMs used in preparing the BOQs of the projects.

Some countries have believed in the importance of having a clear MOM for their governmental projects and so they decided to create a standard method of measurement that belongs to them such as Qatar and United Arabs of Emirates who now have standard formats for their contract documents including the MOM.

1.2. Problem Statement

From what has been discussed above, it is obvious that having a BOQ prepared by following a standard MOM is important to reduce project risks. However, the use of standard MOMs needs to be investigated more since these standard MOMs differ in their uses and also differ in their characteristics. Also, the standard MOMs can sometimes be not in favor of all the project parties specifically contractors who are forced to price a BOQ following a certain MOM that they might not be familiar with. It can also deprive the contractors from the luxury of compensating for their possible project losses through variations. But the

question of whether that is common for all MOMs or some MOMs are different from others needs to be researched which is the target of this research in order to be able to construct the decision model.

The question of whether these MOMs could be facilitating the BOQ production or help in avoiding the project risks could be answered by researching different MOMs to explore their characteristics and the implications of following any of the standard MOMs. The fact that these standard MOMs are usually produced by the international construction institutions makes it necessary to investigate the application of these MOMs in the Middle East. It is important to know how the construction industry in the Middle East could respond to the usage of these MOMs especially with the huge importance of the construction industry in the Middle Eastern countries. This will help figure out the basis upon which a standard MOM can be chosen for a certain project in the Middle East based on the project conditions to suit this project and to minimize the potential conflicts that can occur between the project parties.

1.3. Objectives

This research aims for satisfying some points regarding the MOMs and their usage in the Middle East for the different construction projects occurring there and these points are as follows:

a) Exploring the importance of the standard MOMs for the purpose of BOQ production
b) Exploring three different MOMs which are:
    i. CESMM for civil engineering projects
    ii. NRM for building works
    iii. POMI for most project works

    These MOMs are to be explained and compared from the perspective of their history, their purpose, their characteristics, their advantages and disadvantages.
c) Confirming the points researched about the usage of different MOMs through preparing a questionnaire to be distributed and filled by respondents who are experts in the field of quantity surveying.
d) Providing an expert system that could act as a decision model that helps to choose the most suitable MOM for a project in the Middle East.

e) Validating the model produced by having case studies for real life projects and comparing the MOM chosen by the model and the actual one being followed in the project.

1.4. Methodology

In order to achieve the desired objectives of this research, it was necessary to follow a certain approach that is summarized in figure 1-1 below:

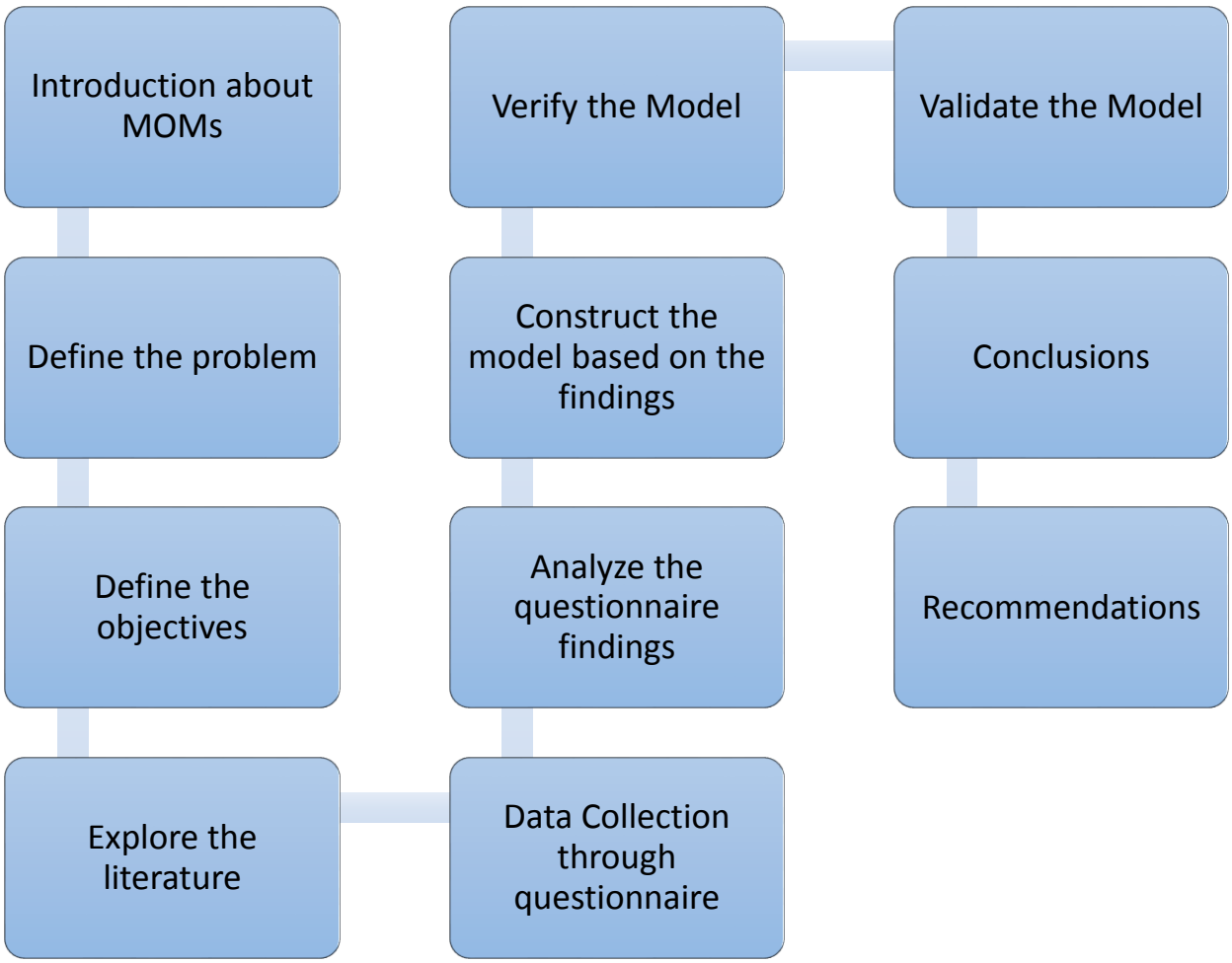

Figure 1-1 flow chart of the research methodology followed

As shown in figure 1-1, the first step is to introduce the topic of the MOMs and give a brief idea about their role in the BOQ preparation. Then a problem statement is mentioned defining exactly what is the problem for which this research is made. The next step is to define the exact objectives that needs to be reached at the end of this research. In order to achieve the desired objectives, the beginning should be through

exploring the literature to gather the information about each of the MOMs being investigated. The information gathered about the topic can help reach some conclusions which should be validated. The process of validation of these points would be done through preparing a questionnaire and distributing it on experts about the topic; mainly those involved with the field of quantity surveyors. The questionnaire would also include a part of its questions specialized for using its data collected from the answers to produce an expert system in the form of a user friendly model that requires some project parameters to be chosen in order to produce a result of which MOM is suitable for the desired project if it is to be constructed in the Middle East. After creating this model, it would need to be validated and this can be done through case studies of real life projects for which the model would be used to predict the most suitable MOM for preparing the project BOQ and the result would be compared against the MOM originally used for this project. There is also the verification part where the users would have to comment about their experience with the model and give recommendations on how to improve the model if it is needed. Finally, there would be conclusions describing the outcome of this research accompanied with future recommendations regarding the research on this topic.

1.5. Key Abbreviations

This is a list of abbreviations used throughout the research as shown in table 1-1 below:

Table 1-1 list of abbreviations used in this research

Abbreviation	Full Word
BOQ	Bill of Quantities
MOM	Method of Measurement
QCS	Qatar National Construction Standards
ADSSC	Abu Dhabi Sewerage Services Company
CEQ73	The Standard System of Measurement of Civil Engineering Quantities for South Africa and South West Africa
HKGSMM	Hong Kong Standard Method of Measurement
ICE	Institute of Civil Engineers
CESMM	Civil Engineering Standard Method of Measurement
RICS	Royal Institute of Chartered Surveyors
BCIS	Building Cost Information Service
NRM	New Rules of Measurement
SMM	Standard Method of Measurement
POMI	Principles of Measurement International
CSI	Construction Specifications Institute
IPMS	International Property Measurement Standards
VBA	Visual Basic for Applications

1.6. Thesis Content

This part lists the different chapters of this research and gives brief identification about the contents present in each chapter.

Chapter 1 – Introduction

This chapter contains a brief introduction to the topic through explaining the MOMs which are used to prepare these BOQs. It also mentions the common standard MOMs and the ones used for different countries. This chapter also includes the problem statement explaining what needs to be investigated followed by the objectives of this research which is what needs to be achieved at the end of this research. The methodology followed to achieve these objectives is then explained in the form of a flow chart. Finally, there is a table gathering all the key abbreviations used throughout this research.

Chapter 2 – Literature Review

This chapter includes the information that was gathered after checking the literature for the MOMs in general and specifically the three MOMs being investigated in this research. It involves a brief background about each one in addition to its characteristics and the use of each followed by the advantages and disadvantages of each MOM. At the end, there is a summary of this chapter comparing the three MOMs together. This chapter also includes an explanation of the techniques followed in this research methodology.

Chapter 3 – Data Collection and Analysis

This first section of this chapter includes an explanation of the method of data collection through the questionnaire. It involves a description of the reason of adding the specific questions in this questionnaire. The second section of this chapter contains an analysis of the responses to the questionnaire and the justification behind the answers.

Chapter 4 – Development of Model

This chapter explains how the model was prepared and the assumptions followed for preparing the model. There is also an explanation about the usage of this model and the data that should be entered.

Chapter 5 – Model Verification and Validation

The first section of this chapter explains how the model was verified to check its correctness and the second section involves the case studies of real life projects that were used to validate the model.

Chapter 6 – Conclusions and Recommendations

This chapter involves the final outcomes concluded from this research beside the recommendations that can be added to enhance the research outcomes.

2. Literature Review

This section includes the literature review that is the core of the topic and upon which the research is based. It involves a description of the history of each MOM and its contents in addition to the characteristics and usage of each MOM and the advantages and disadvantages behind using each MOM. It also involves a description of the research methods used in this research. And finally, there is a comparison between the three MOMs. The sequence of the topics discussed from the literature review is as follows:

1- What is a Bill of Quantities?

2- What is the Standard Method of Measurement (MOM) and its importance in the Construction Industry?

3- What are the common standard MOMs?

4- Researching the 3 MOMs in this research as follows

   a. Civil Engineering Standard Method of Measurement 3rd editions (CESMM 3)

   b. RICS Methods

      i. What is RICS

      ii. New Rules of Measurement (NRM)

      iii. Principles of Measurement International POM(I) or POMI

5- Some research techniques

6- Summary of literature review

2.1. Standard Method of Measurement

Bill of Quantities (BOQ) or (BQ)

For any construction project, there is a scope to achieve and this scope is defined by the works that need to be done in the building process in order to achieve that scope. These works should be broken down and divided into work items to be achieved and these works are identified in the Bill of Quantities (BOQ) of the project. According, to the Project Administration Handbook for Civil Engineering works (PAH), produced by the Chinese Government, the Bill of quantities is the list of items that give sort of an identification and measured quantities to the works to be done in the project to achieve its scope and it is also the document upon which the contractors' payments are determined (PAH, 2014). This BOQ is an important contract document that ensures that the tenderers would have a full understanding of the exact works that are required under this contract. Also, from the employer's perspective, the BOQ allows for full estimation of the cost of the project in addition to evaluating the variations that can occur in the project and have an impact on the contractual value. The BOQ allows for valuation of the work carried throughout the different stages of the contract (Watermeyer, 2008).

Standard Method of Measurement

The Bill of Quantities can be the basis of the success of a project if it has a high accuracy and clear description of works, but at the same time the BOQ can however, lead to a lot of disputes in a project if it is not clear and misleading. In his discussion to the reasons of contractual claims and disputes in the Construction Industry, Thomas mentioned that the courts have experienced a lot of cases that were linked to the inaccuracy of the Bill of Quantities and the items in it seemed to have a lot of inconsistencies in the interpretation of the items which affected the quantities mentioned in the BOQs. In most cases where there are inconsistencies, the court decision is usually taken in favor of the Contractor at the expense of the Owner and the Architect's part. So in the absence of a Standard Method of Measurement, a lot of claims occurred that involved discrepancies and misinterpretation to the items in the BOQ (Thomas, 2001). Accordingly, the BOQ should be written in a standard format that follows a certain trend and this trend should be guided by what is called "Standard Method of Measurement" (MOM) (Watermeyer, 2008).

According to the Chinese handbook, it is important to standardize the method of BOQ preparation and this standardizing process shall involve the formatting, the breakdown of items as well as the units of measurement of the items in the BOQ. This standardization is achieved through the Standard Method of Measurement (MOM). The purpose of the SMM is summarized in 6 points as follows:

- Providing a standardized layout and content of the BOQ
- Providing a uniform structure of the project items in the bill which will facilitate the description of the items
- Providing a logical system for the manual or computerized billing works
- Providing a simplification for measuring the project works which will help in contract administration
- Providing a uniform basis for quantifying and measuring the project works which will help avoid the disputes that can arise due to ambiguities and misleading content
- Providing assistance during cost control of the project works

(PAH, 2014)

Construction Industry in the Middle East

According to a survey made by Turner & Townsend in 2013, the Middle East showed an increase of the construction activity with projects with an estimated value of USD 1.3tn in the stages of planning and tendering. These projects involve different categories including but not limited to high-speed rails, industrial plants, football stadiums as well as residential projects. The majority of these projects are located in Dubai and Qatar (Turner & Townsend, 2013).

Examples of Standard Methods of Measurement:

There are some examples for the standard methods of measurement that are commonly used and the most important are the Civil Engineering Standard Method of Measurement “CESMM”, and the ones produced by the RICS “Royal Institute for Chartered Surveyors”; the New Rules of Measurement (NRM), the Principles of Measurement International “POMI”, and the Standard Method of Measurement “SMM7”. Other methods of measurement include the standard method of measurement for highways as well as

that for roads and bridges. Also there is the standard method of measurement for industrial engineering construction (Cartlidge, New Aspects of Quantity Surveying Practice, 2011).

Countries having Standard Methods of Measurements

Some countries are having a trend to standardize their contract documents and among these standardized contract documents is the Method of Measurement to be followed during the execution process of the construction project especially in the international projects. An example of these countries is Qatar who has a standard method of measurement titled “Standard Method of Measurement for Building Works” issued by the Engineering Services Department in the Ministry of Public Works in the state of Qatar as part of the Qatar National Construction Standards issued in 2010 (QCS, 2010). Also, the United Arab Emirates have some associations that adopted their own method of measurement such as the “Standard Method of Measurement for Construction Works for Use in the Preparation of Bills of Quantities” issued by the Abu Dhabi Sewerage Services Company (ADSSC, 2008). Oman also have adopted a standard structure for their contract documents with a standard method of measurement for the civil engineering projects’ works and they are in both English and Arabic Languages and the Arabic version was published in 1999 (Courtney, Tee, Hamilton, & Barton, 2013). Other countries have adopted their own method of measurement from some standard method of measurements like South Africa who has its standard method of measurement published in 1973 under the name “The Standard System of Measurement of Civil Engineering Quantities for South Africa and South West Africa (CEQ73)” and this standard method has been adopted from the CESMM (Civil Engineering Standard Method of Measurement) (Watermeyer, 2008). Hong Kong has also a standard method of measurement named Hong Kong Standard Method of Measurement “HKGSMM” that is based on the United Kingdom Department of Transportation Standard Method of Measurement for Roads and Bridges (Molloy, 2007).

Different Standard MOMs available

There are different standard MOMs available worldwide that can be used in construction projects according to their location and their project types as well as the project characteristics. Table 2-1 below shows a collection of the MOMs available worldwide and the origin of these MOMs

Table 2-1 Different MOMs and their origin

MOM	Origin
Civil Engineering Standard Method of Measurement (CESMM)	Issued by ICE for civil project works
New Rules of Measurement (NRM)	Issued by RICS for building project works
Principles of Measurement International (POMI)	Issued by an RICS subsidiary for general works of construction projects
Standard Method of Measurement (SMM)	Issued by RICS for building project works
International Property Measurement Standards (IPMS)	Issued by a group of professional and non-profit organizations from around the world calling themselves “International Property Measurement Standards Coalition IPMSC” and this MOM is used mainly for office buildings
Egyptian Code for Measurement	Used in Egypt for measuring construction works
Qatar Standard Method of Measurement for Building Works	Issued by Qatar as part of the standard construction documents used in Qatari projects (QCS)
Abu Dhabi Standard Method of Measurement for Construction Works for Use in the Preparation of Bills of Quantities (ADSSC)	Issued by Abu Dhabi Sewerage Services Company
The Standard System of Measurement of Civil Engineering Quantities for South Africa and South West Africa (CEQ73)	Issued by South Africa and adopted from CESMM

From table 2-1 above, it is obvious that there is a variety of MOMs available worldwide; however, the MOMs that can be used worldwide and not linked to specific countries are the NRM, POMI, CESMM, SMM and IPMS. However, in this research the focus will be on the NRM, POMI and CESMM since SMM is outdated and already replaced by NRM and IPMS is new and still being developed.

2.2. Civil Engineering Standard Method of Measurement (CESMM)

Origin of CESMM

The Civil Engineering Standard Method of Measurement known as CESMM was published by the Institute of Civil Engineers (ICE) in 1976. Its origin was when the ICE published a standard procedure suggested by an institute that deals with engineering quantities in 1933 to draft the bills of quantities in any civil engineering project which triggered the ICE to publish its Standard Method of Measurement of Civil Engineering Quantities in 1953. This method was modified and reissued in 1963 and then had its metric edition published in 1968. After that an association named the Construction Industry Research and Information Association (CIRIA) worked on a research to improve the contracting procedure and one of its suggestion was modifying the information provided in the BOQs. They came up with a conclusion that the BOQs of civil engineering projects should also involve control on the method and timing of the contractors' operations. This suggestion was considered by the ICE who in turn published the first edition of the Civil Engineering Standard Method of Measurement (CESMM) in 1976 and this method had greater standardization in its format as well as the introduction of different classifications that can help develop the items' description. It also had a coding arrangement and some expenses were introduced like the site expenses besides, there were lots of small modifications to help avoid discrepancies and misinterpretations (Watermeyer, 2008).

A second edition was issued in 1985 titled "CESMM 2" that was to redefine some measurements that would accommodate the new construction technologies in some construction activities such as the site investigation and the geotechnical process. In 1991, the ICE published a third version named "CESMM 3" that was aligned with the sixth edition of the ICE's Conditions of Contract. CESMM 3 is the version that has been recently used over the past recent years to estimate items quantities and descriptions in civil projects. CESMM 3 dealt with the BOQ as the contract document giving brief identification and quantity estimation of the work to be accomplished in the contract and so it urged anyone responsible for pricing of the bill to examine also the scope of work through the drawings and the specifications as well as the contract data in order to reach the full image about the project items (Watermeyer, 2008). In 2012, the ICE decided to publish a fourth version of CESMM which is the CESMM4. This edition was issued in line

with the trending use of a standard form of contracts which is the NEC (New Engineering Contracts). The fourth edition retains the structure of CESMM3 and there are not much differences except that it is up to date with the new construction technologies which makes it a reliable guiding source for the BOQ preparation (CESMM4, 2012) and removed some redundant descriptions of the items that could sometimes cause confusion (Seeley & Murray, 2001).

Characteristics of CESMM

First of all, it is important to mention that the civil works for which CESMM is issued consists of a large amount of works that are grouped under a limited range of trades, unlike the building works that involve many trades of works (Cartlidge, 2011). CESMM is complex and hence it produces a detailed list of items for the project works (Twort & Rees, 2003). CESMM is used mainly for the civil engineering projects that are unlike building projects, would have less certainty during the bill preparation and would need flexibility in re-measuring the quantities of the works in the project, so an organized detailed method of measurement like CESMM would be necessary. The contractor working with CESMM would usually refer to the specifications and drawings much and the dependence on the bill is usually not considered enough (Seeley & Murray, 2001). A survey was made in 2013 showed that CESMM was preferred by 71% of the respondent quantity surveyors for the civil engineering projects (Eadie, Millar, & Harte, 2013) as shown in figure 2-1 below:

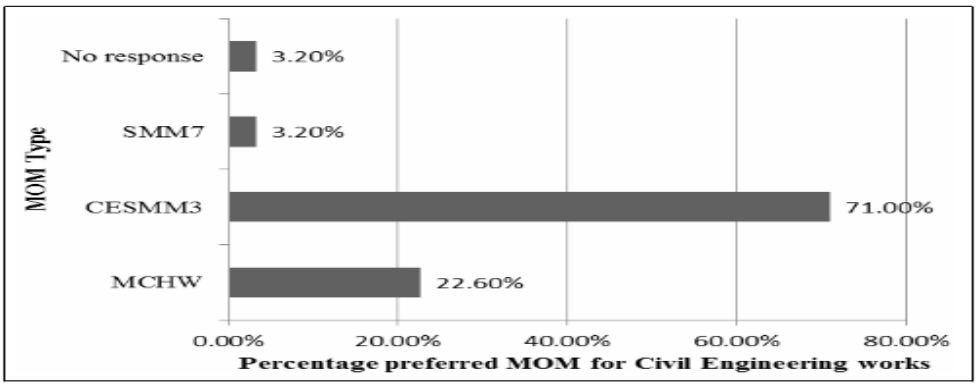

Figure 2-1 Preferred MOM for civil engineering works (Eadie, Millar, & Harte, 2013)

CESMM4 has the main characteristics of CESMM3 except that it involves updates that suit the new construction technologies in addition to an updated rail section (CESMM4, 2012). CESMM3 is characterized by focusing on the details of the items breakdown for civil projects, but still unlike other

standard methods of measurement like the New Rules of Measurement (NRM) or the Standard Method of Measurement (SMM7) and this is attributed to the nature of works of the civil engineering projects. CESMM has the inclusive approach for some of its trades which is grouping the works done in a certain activity like the excavation for example that is considered as a single item involving all activities to be done in the excavation; unlike SMM7 for example that will breakdown the excavation under a group of items like excavation, earthwork support and working space (Cartlidge, New Aspects of Quantity Surveying Practice, 2011). CESMM bills are characterized by providing additional cost significant information for the contractors to formulate their tender prices. CESMM allows for the contractor to include the cost of temporary works used to accomplish the task and these works that are not part of the final measured works. CESMM also provides flexibility for the contractors in pricing their temporary works that usually accompany the civil projects and choose their own methods of execution and price their value under the category of work-related charges (Seeley & Murray, 2001). In CESMM, different classes of work for a certain task shall be grouped in separate items such as different types of excavation shall be specified clearly and separately instead of grouping the whole works under a specific BOQ item. Also, similar tasks that are done in different locations shall be grouped under separate BOQ items (Spain, Taking off Quantities - Civil Engineering, 1995).

CESMM also, beside the civil works measurement, provides rules for measuring simple building works but doesn't deal for example with complex buildings that involve works like complex mechanical works. CESMM mainly depends on giving a general identification of the item and not writing the tasks to be accomplished by the contractor for a certain item. Also for the inclusive items, CESMM states that works not covered are deemed to be included if they are necessary to achieve the scope mentioned in the contract (CESMM3, 1991).

Structure of CESMM3

The CESMM3 consists of 8 main sections as shown in the following figure 2-2:

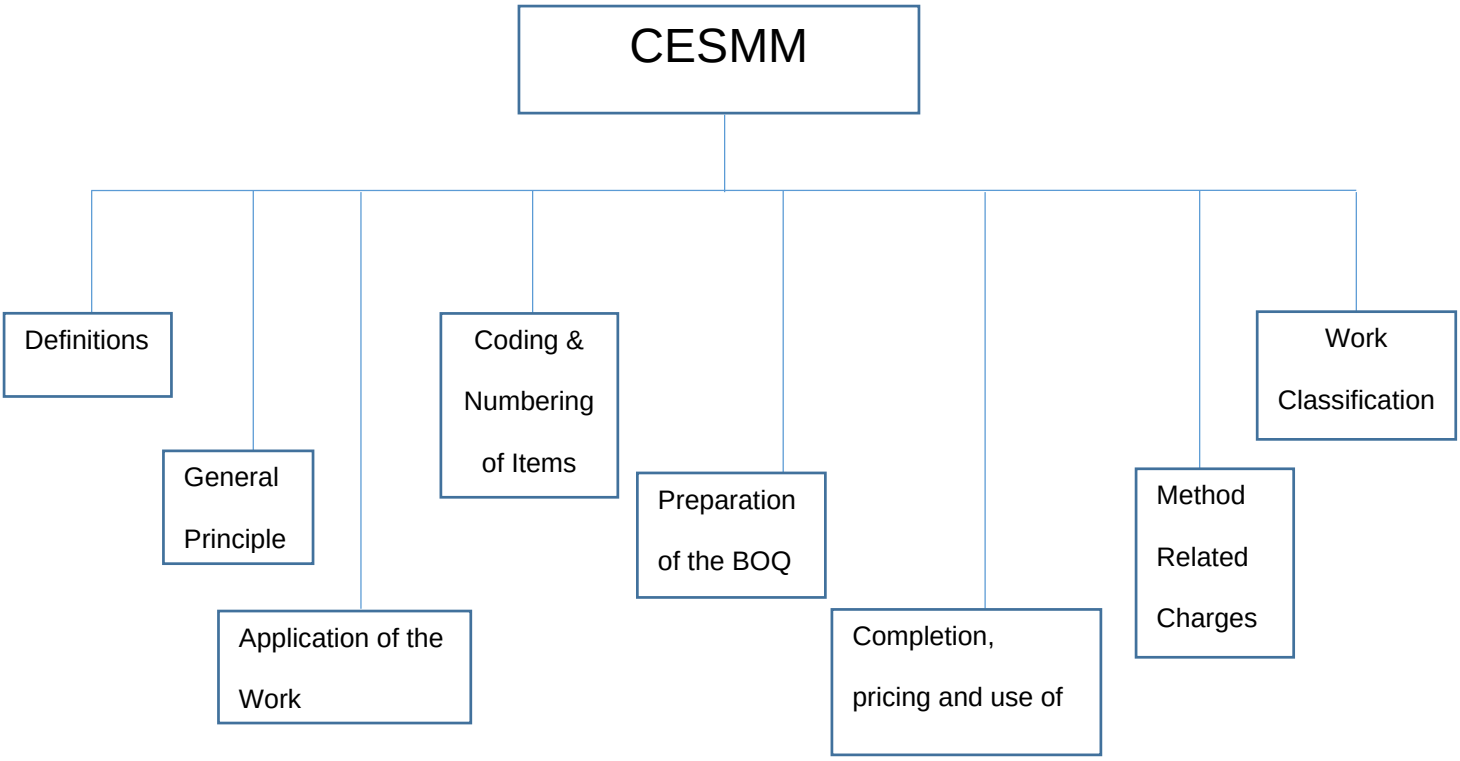

Figure 2-2 Structure of CESMM

The 8 sections of CESMM as shown in figure 2.2.2 above are definitions, general principles, application of the work classification, coding and numbering of items, preparation of the bill of quantities, completion and pricing and using bill of quantities, method-related charges and finally the 8th section which is the works section. This section is divided into 26 main work classes covering the works of civil engineering projects and it provides guidance on how to describe the items and what units shall be used for measuring a specific quantity of a certain item. Each of these working classes consists of 3 divisions that classify works into a successive level of details. For example, class H of the precast concrete is divided into three sections; the first shows the different types of precast concrete units while the second classifies different units of measuring their dimensions and the third section is for classifying these different types according to their mass. The coding system for CESMM items consists of a letter and 3 numbers which is linked to the three divisions and an example to demonstrate this is code H for precast concrete, 1 for being a beam, 3 for its length being in meters and 6 for its mass being in tons which gives a final code of

“H 1 3 6” and if an additional characteristic needs to be described for the item, and increment of 1 is added as “H 1 3 6 .1” (CESMM3, 1991).

The method of measuring the items in the CESMM is shown in the form of a table showing what to be recorded in the bill for each work section. An example to demonstrate that is by considering the section for Tunneling Works. At the beginning, there is a list of what items to exclude that may have been included in other work sections as shown in figure 2-3 below and there is a list for the classifications within the item itself which also determines the coding structure of the item as shown in figure 2-4 below:

CLASS T: TUNNELS

Includes: **Excavation, lining and securing of tunnels, shafts and other subterranean cavities**
Excludes: **Geotechnical processes carried out from the ground surface (included in class C)**
Filling within tunnels (included in class E)
Reinforcement in in situ lining (included in class G)
Pipe laying in headings, tunnels and shafts (included in classes I, J, K and L)
Cut and cover tunnels

Figure 2-3 List of items to be included and excluded in a class of works (CESMM3, 1991)

FIRST DIVISION	SECOND DIVISION		THIRD DIVISION	
1 Excavation	1 Tunnels in rock	m^3	1 Stated diameter:	not exceeding 2 m
	2 Tunnels in other stated material	m^3	2	2–3 m
	3 Shafts in rock	m^3	3	3–4 m
	4 Shafts in other stated material	m^3	4	4–5 m
	5 Other cavities in rock	m^3	5	5–6 m
	6 Other cavities in other stated material	m^3	6	6–7 m
			7	7–8 m
			8	exceeding 8 m
	7 Excavated surfaces in rock	m^2		
	8 Excavated surfaces in other stated material	m^2		

Figure 2-4 Classifications of an item in CESMM3 (CESMM3, 1991)

There is also a table for the rules to be considered when writing the bill describing a certain item and this table is divided into measurement rules that set the basic rules to be followed during the takeoff of an item and there is also the definition column that sets rules for defining the exact item to be measured. The coverage rules is also present and shows exactly what items to be deemed included in the priced item and finally there is the section of additional rules to be followed if there are any and this is shown in the following figure 2-5:

MEASUREMENT RULES	DEFINITION RULES	COVERAGE RULES	ADDITIONAL DESCRIPTION RULES
M5 The thickness of *in situ lining* shall be measured to the payment lines shown on the Drawings or, where no payment lines are shown, to the net dimensions of the volumes to be lined (see rule M2). **M6** The volume of in situ cast	**D3** Reinforcing materials added to the mix for *sprayed concrete* shall not be classed as reinforcement. **D4** The diameter of *lining* used for classification and stated in item descriptions shall be the internal diameter.	**C2** Items for *lining* shall be deemed to include joints and finishes. **C3** Items for *preformed lining* shall be deemed to include reinforcement and formwork.	**A7** Item descriptions for *lining* shall state whether tunnels and shafts are straight, curved or tapered. Item descriptions for *lining* shall state the gradient of tunnels sloping at a gradient of 1 in 25 or steeper and the inclination to the vertical of inclined shafts.

Figure 2-5 Measurement Rules for In-Situ Concrete (CESMM3, 1991)

Advantages of CESMM

CESMM is suitable for the nature of the works of the civil engineering projects due to the structure of the CESMM since it covers the civil works in a detailed and organized way which is useful considering the fact that civil works are hard to be fully gathered at the tendering stage of the project (Eadie, Millar, & Harte, 2013). It also gives flexibility for choosing the method of execution of the project works since the cost of the method and other temporary works would be allocated under the method related charges. It also allows the pricing of all the works that are temporary and don't form part of the final works but they are to be included in the BOQ (Seeley & Murray, 2001). The method related charges also give justification for the difference in prices between tenders since the basis on which each tenderer based the price of items is clearly defined through the method of execution defined in the BOQ (Barnes, 1992). Also, CESMM continues to update its versions to accommodate with the new technologies that appear in the world of civil engineering. The use of the coding system in identifying the items is helpful when integrating the CESMM in computerized software that deals with the bills. In addition, CESMM gives the opportunity to include extra work items not mentioned in a certain category by making coding iterations. Also, CESMM is considered flexible which is useful in the case of dealing with variations that result in a more frequent manner in civil engineering projects since the project works are very detailed so as to mark the exact items affected by the variations (Seeley, Ivor, Murray, 2001).

Disadvantages of CESMM

CESMM is sometimes considered to produce lengthy bills for some works that involves redundant work items that could have been included on other items (Twort & Rees, 2003). The fact that CESMM gives the engineer the responsibility to involve the conditions under which the works have been performed pointing out some site difficulties that the contractor may experience at site is considered by the engineers as a drawback since the engineer may skip mentioning some risks in the project which at that point would be a risk borne by the engineer if something is missed. CESMM does that out of the belief that an effective project BOQ shall involve all the work items that are necessary for the project, so that point would be a disadvantage for the engineers because some may prefer writing only the project works in the bill as the case of POMI, and leaving the anticipation of risks as a responsibility on the contractors instead of bearing them (Seeley & Murray, 2001). The section of the Method-Related Charges can be a source of problems sometimes. This is because the section states that the method-related charges specified by the contractor doesn't bind the contractor to use the same method specified in the works description. However, the method-related charges are not subjected to increase or decrease when the contractor chooses to use another method. This can result in conflicts in case the engineer issues a variation for the permanent works of an item since the contractor may claim that the temporary works associated with that item may no longer apply and the method-related charges are still fixed so there needs to be reevaluation of the rates specified. This can cause a debate between the consultant and the contractor (Twort & Rees, 2003). The fact that CESMM is a detailed method that has specific characteristics makes some firms not willing to use it since using it needs training of the staff, so most would prefer to stay in the safe side and use other familiar methods (Barnes, 1992).

2.3. New Rules of Measurement (NRM)

The New Rules of Measurement (NRM) is a set of rules initiated by the Quantity Surveying and Construction Professional Group of the Royal Institution of Chartered Surveyors RICS. These are rules that describe how the building works should be measured during the stages of the construction of the project involving the design and execution phases of the project (NRM2, 2012).

What is RICS?

The RICS is a professional institution that gives accreditation to the professionals working within construction sector worldwide. The RICS was founded in London by a group of 49 surveyors in 1868 who then received a Royal Charter in 1881 and finally became the Royal Institute of Chartered Surveyors in 1947. The RICS nowadays have a group of qualified and certified professionals all over the world who are experienced at the field of quantity surveying in the construction industry (NRM2, 2012).

The RICS has published a lot of journals regarding the topic of quantity surveying and the methods of measurements. The RICS classifies its documents as RICS practice statements which is mandatory since it provides members with mandatory requirements, RICS code of practice which can be mandatory or recommended since it defines some standards that provides user with recommendations for accepted good practice, RICS guidance note which is recommended since it provides recommendations for accepted good practice and RICS information paper that provides updates about the latest information or research. One of the most recognized publications of the RICS is the New Rules of Measurement (NRM) (NRM2, 2012).

The NRM is divided into three volumes; NRM 1, NRM 2 and NRM 3 (Towey, 2013). The NRM provides a codified framework for elemental cost planning that would help improve the involvement of a quantity surveyor in the cost management process of the project since its early phases (Matipa, Cunningham, & Naik, 2010).

NRM 1 named “Order of Cost Estimating and Cost Planning for Capital Building Works” provides guidance on how to quantify and divide the building works for cost management that involves preparing the cost estimate as well as the cost plans. It is made to be helpful for the client management level to give

advice and recommendation and also help in the cost control process. So NRM 1 would involve advice and suggestions on the logical preparation of the cost plan as well as rules on how to measure the works of the project. However, NRM1 wouldn't be of much help when preparing an approximate cost estimate for any project. NRM 1 is divided into four sections, the first includes a set of symbols and definitions to be used in accordance with the rules of the RIBA (Royal Institute of British Architects) that is concerned with improving buildings through architecture and also there is a focus on the rules of the OGC (Office of Government and Commerce) which is concerned with controlling the spending of governments to make it go in an efficient way and this part also contains symbols, abbreviations and definitions used within the rules. The second and third parts focus on the principles and rules to be followed when estimation the cost of the project and during cost planning. The fourth section would involve tables for the rules in the form of group of elements that will help cover the scope of work for any project (Towey, 2013).

NRM 2 named "Detailed Measurement for Building Works" provides some rules for how to quantify the works of any project and describe the works clearly in a way that explains the exact task to be done in each activity. This is used as guidance when preparing the Bill of Quantities (BOQ) for the works of the project. NRM 2 also provides a guidance on how to measure some items that can't be quantified such as the risks of the contractors (Towey, 2013). NRM 2 is considered as an RICS guidance note that provides its users with some recommendations for accepted good practice through providing guidance on how to classify and measure the items for the works of the building which means that they are non-binding to adhere to (NRM2, 2012); however, it is worth mentioning that courts would consider the availability of these guidance notes if conflicts arise afterwards (Campbell, 2013).

NRM 3 named "Order of Cost Estimating and Cost Planning for Building Maintenance Works" provides guidance on how to measure the maintenance works to prepare a cost estimate for the pre-contract stage as well as the post-construction stage when maintaining an asset for example. This volume also would involve some guidance on how to quantify the items that are not reflected in the measurable items like contractor's management and administration fees and also the consultancy fees associated with the maintenance works. It is important to mention that this volume also considers the time value of money since the maintenance costs are to be incurred throughout the life of the asset and the value of money

would change in that long term period. So when adding NRM 1 and NRM 3, they will both be useful to provide advice for the clients for the decision making towards a project (Earl, 2011).

NRM 2: Detailed Measurement for Building Works

The main volume here to be focused upon is the NRM 2 which will be considered in this research since it is the rules that explain the detailed measurement for the building works of the project. NRM 2 was published by the RICS as a first edition in 2012 and became operative on the 1st of January 2013. NRM 2 was a replacement for the Standard Method of Measurement (SMM) published first in 1922 and with the seventh edition (SMM7) as the last edition published in 1988 (NRM2, 2012). The first edition of the SMM was issued to act as a guide for the quantity surveyors so as to explain the strategies to be followed for quantifying the amount of works in a building project and describing the items of the project to be quantified which will form the bill of quantities referred to as BQ in the NRM 2 documentation wording and this original SMM was used mainly in the tender stages of a project and didn't provide specific guidance on how to measure the building works for the sake of producing cost estimates or cost plans (NRM1, 2009). The SMM afterwards had some modifications undergone for it; each introduced more details towards the route of measuring quantities that involved the introduction of metric measurements and these modifications were done gradually till the final version was reached in 1988 which is the SMM7. This SMM7 was published jointly between the RICS and the Building's Employers' Federation and it was modified and republished in 1998, but this time the edition involved coordination with the CAWS (Common Arrangement of Work Sections) which is an entity of the United Kingdom that is concerned with standardizing coordination between the BOQ and the product specifications. In other words, the BOQ items are cross-referenced each with a code that refers to the product specifications to help the contractors when pricing items for a tender (Towey, 2013).

Why was SMM7 replaced by the NRM 2 and how do they differ?

The NRM 2 was issued by the RICS instead of the SMM7 which they deemed outdated and caused confusion between parties involved in the project, so there should be a standard format that should be consistent when comparing costs (Earl, Managing costs consistently, 2012). The SMM appeared to have difficulties when trying to obtain meaningful cost data (Cartlidge, 2006). Also, the use of SMM appeared

to cause some inconsistencies in the measurements and descriptions of the project items and that made the cost estimates unclear since it was used to produce the cost estimates (not the purpose it was issued for) due to the absence of meaningful and consistent guidance notes on how to produce cost estimates for a project. This made the produce cost estimates inconsistent and it was hard for the clients and the project team to understand what was included in the cost estimate produced (Matipa, Cunningham, & Naik, 2010). To solve these problems associated with the use of the SMM, the RICS team has worked on producing the NRM with its three volumes; each for a specific purpose (NRM1, 2009). Unlike the SMM, the NRM produced is considered to be more detailed and the items are required to be dealt with carefully to ensure that all the work items are precisely described. When comparing the SMM7 to the NRM2 it is obvious that the SMM7 involves 22 work sections referenced in letters A, C, etc. for the building works while the NRM 2 has 41 divisions numbered from 1 to 41 which makes the NRM seem more focused and more detailed when categorizing the works of the project. An example to this division of items is the "Demolitions and Alterations" in SMM7 that was divided into two divisions in the NRM 2 to include "Demolitions" and "Alterations, Repairs and Conservation" with specific additions to each of those two divisions in the NRM 2 like for the demolitions, there is an addition of the recycling provisions. For the "Alterations, Repairs and Conservation", there was an increase in the rules covering the conservation and decontamination has been expanded (Lee, Trench, & Willis, 2014). The detailing of the NRM is not confusing compared to the SMM especially regarding the items of measuring labor that caused confusion within the SMM. These confusions have been prevented by making the laborious items "deemed included" within the NRM2 which made it more simple than the SMM, but at the same time more detailed than other standard methods of measurement (Davidson, 2012). It was also noted that the NRM 2 has dealt with the items that the SMM7 failed to quantify which are items associated with the project like the contractor's risks for example (NRM2, 2012).

Characteristics of NRM 2

The NRM 2 is considered as a guidance note from the RICS on how to quantify the works of a building and describing the items. The NRM 2 is written in a form that can be understood by all of the parties

involved in the project execution so as to help ease the coordination between the different team members of the project (NRM2, 2012).

According to the RICS, the NRM 2 objectives are summarized in 4 points:

- Providing a set of rules for measurement and for the procurement of building works that are easily understood by all parties involved in the project.
- Providing measurement rules that facilitate the preparation of the BOQ and the quantified works schedule of measurement for the preparation of bill of quantities and also provide a framework that facilitates the preparation of the bespoke and standard schedules of rates.
- Addressing all aspects of producing the BOQ that includes all information required by the employer and the consultant to prepare the BOQ and also quantifying the non-measurable items like the risks of the contractor as well as providing guidance for the format of the bill of quantities.
- Offering a guiding document that is mainly a result from the UK practice, but understandable and helpful by worldwide construction entities in any place.

(NRM2, 2012)

The NRM 2 accounts for cost estimation of the building throughout its different stages of execution that involves design, construction and the usage life. It is worth mentioning that the NRM 2 is expected to be used in accordance with the BIM (Building Information Modelling) which shows a 3D modelling for the construction of the building through its various stages of design, construction and usage. With the expected widespread of the BIM usage, the NRM 2 is expected also to be used for accurate estimation of the building costs since the different stages of construction will easily be presented and so it would be easy to identify clearly the works needed to achieve the scope and here comes the need for NRM 2 that will help estimate this cost and present it in a clear understandable way in the form of the Bill of Quantities (Towey, 2013). The NRM is considered to be thoroughly detailed regarding the items' breakdown; however, the most notably detailed section is that of the preliminaries placed in work section 1 and classified into main contract preliminaries and work package contract preliminaries. Each section of these is divided into part A for the information and requirements and part B for the pricing schedule (NRM2, 2012).

Structure of NRM 2

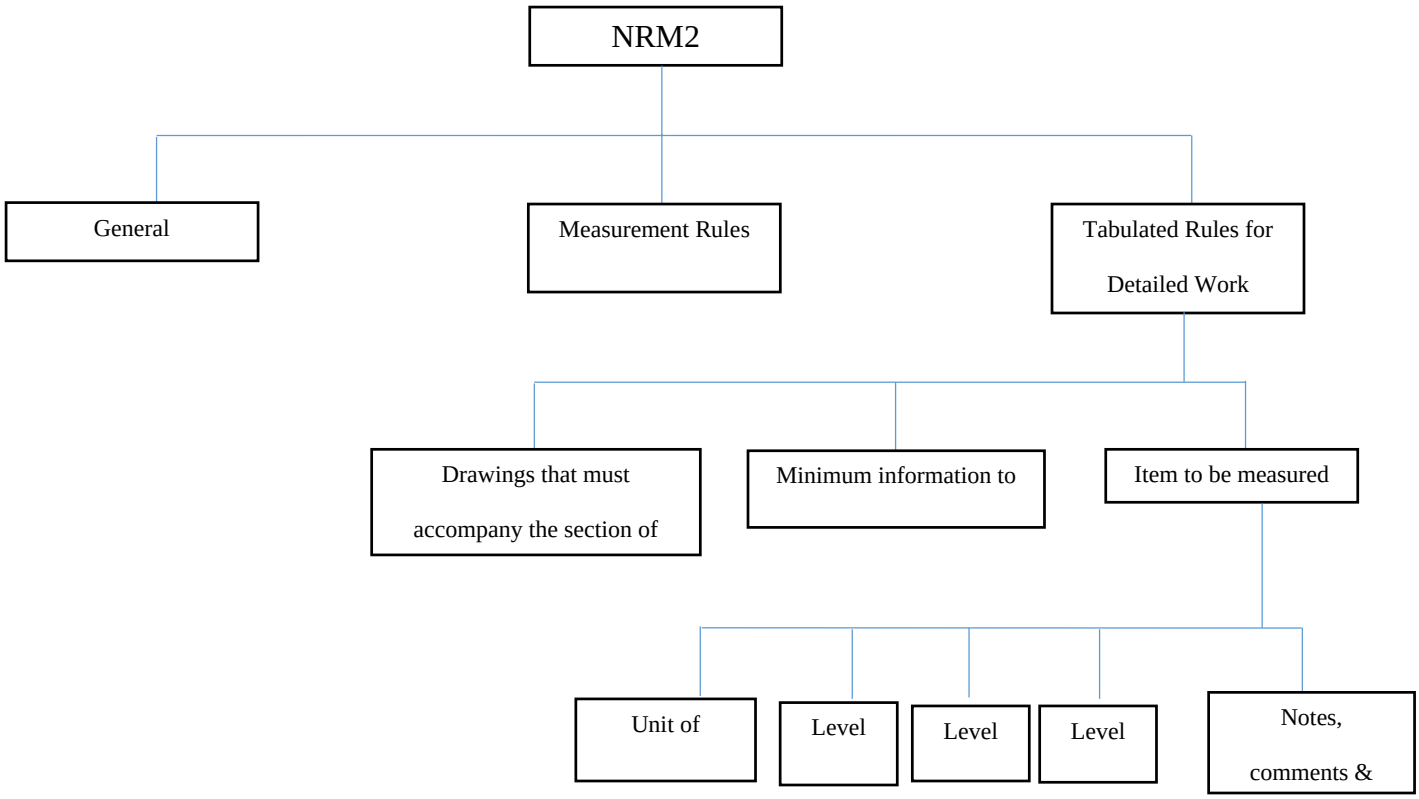

Figure 2-6 Structure of NRM2

NRM 2 document is divided into three parts as shown in figure 2-6; the first part is a general part that involves some definitions as well as the abbreviations beside an introduction about NRM 2 and states that the measurements done for BOQ are done in accordance with the RIBA Outline Plan of Work and the OGC (Towey, 2013). The RIBA plan of work is a framework explaining the strategy obeyed in managing and designing building projects as well as managing the contract into a number of key work stages. The work steps in this framework are divided into 11 sequential steps known as “RIBA Work Stages”. There is also the OGC Gateway Process which is used as an alternative for RIBA Plan of Work for managing and designing building projects. It depends on evaluating the project at key points of the lifecycle of the project to help the client take decisions towards the project before investing in it. The following figure 2-7 shows the implementation of the RICS cost estimating and cost planning process in the context of the RIBA Plan of Work and OGC Gateways that shows the process of producing formal cost estimate plans throughout

the stages of design development till the pre-tender estimates and finally producing a fully priced Bill of Quantities (NRM2, 2012).

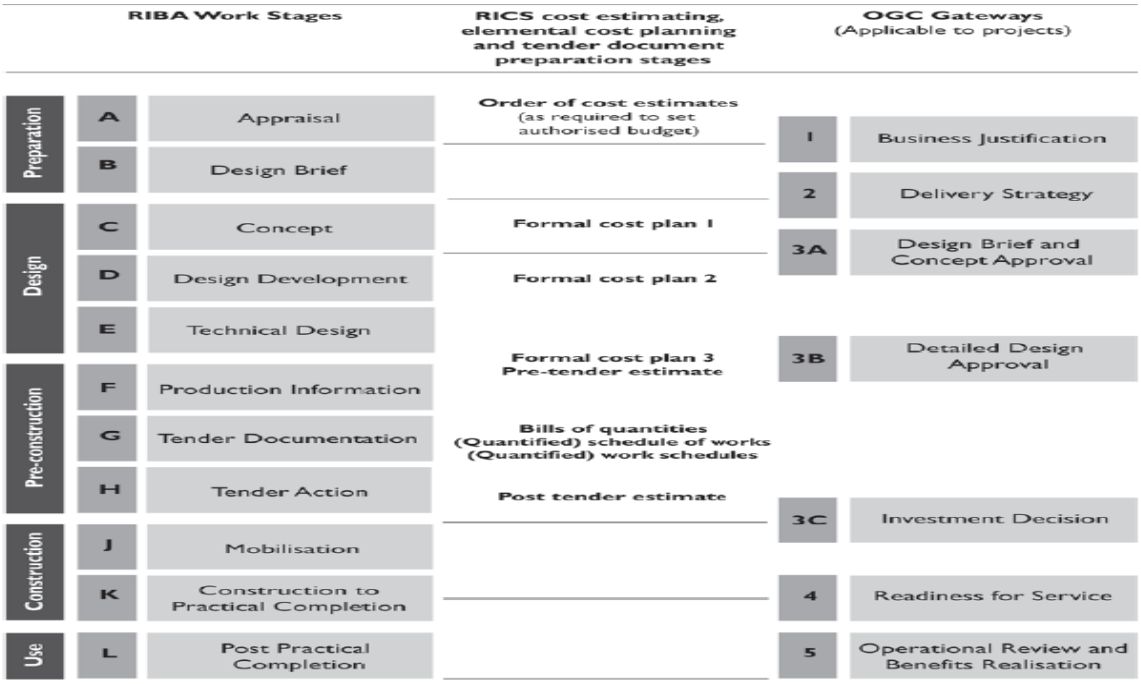

Figure 2-7 RICS Cost Estimation & Planning within Context of RIBA Plan and OGC Gateways (NRM2, 2012)

The second part of the NRM 2 is the measurement rules that highlights the benefits of the detailed measurements of NRM2 and explains what information should be present in order to prepare the BOQ. It also provides methods of preparing some contractors' items that are not easy to be dealt with such as the preliminaries, overheads, profit, design fees and risks. It also provides guidance on how to deal with difficult situations such as the price fluctuations, charges based on day work and value added tax. There is also a focus on the coding system of the items in the BOQ NRM2 besides the use of the BOQ for cost control and cost management (NRM2, 2012).

The third part of the NRM 2 provides the tabulated rules for measuring and describing the works of the building as well as the procurement works. The work items are divided into 41 work sections numbered from 1 to 41 (NRM2, 2012). This part represents the bulk of the document (Towey, 2013). This section contains the detailed information regarding each of the works section as shown in figure 2-6 above. The tables of the work sections involve a description of the drawings that mush accompany that section as

well as minimum information that should be shown on the drawings. The measurement table shown in figure 2-8 below would involve the description of the item to be measured and the units of quantifying the specified items in addition to a column named level one which is for the purpose of more explanation of the item and there are also levels two and three that specifies if any further details need to be mentioned regarding the items and the dimensions of the quantified materials and there is also a column for the notes or additional comments that should be noted when quantifying or describing the item or mentioning what works are deemed to be included for the item being measured.

Item or work to be measured	Unit	Level one	Level two	Level three	Notes, comments and glossary
2 Removing trees 3 Removing tree stumps	nr	1 Girth 500mm to 1,500mm. 2 Girth 1,500 to 3,000mm. 3 Girth over 3,000mm, stated in 1,500mm stages.	1 Filling material stated.		1 Removing trees is deemed to include removing the stump and roots unless otherwise stated. 2 Tree girths are measured at a height of 1.00m above original ground level.

Figure 2-8 Table of measurement of work items (NRM2, 2012)

For the preliminaries section, the requirements and information schedule shown in figure 2-9 below contains a column for the requirements and two columns for sub-heading 1 and sub-heading 2 that contain sub-items to be considered. There is also a column for the information required that states what information shall be included in the description of the item and finally a column for the supplementary information that involves additional comments to be included in the description if any is needed.

Sub-heading 1	Sub-heading 2	Information requirements	Supplementary information/notes
1 Project particulars	1 Name of project.	Short project title to be stated.	
	2 Nature of project.	Short description to be stated.	
	3 Location of project.	Full postal address to be stated.	
	4 Length of contract.	Period, in weeks, to be stated.	Where to be stated by the contractor, insert 'To be confirmed'.
	5 Names, addresses and points of contact of employer and consultants.	Function (e.g. architect), name of organisation, address, point of contact, telephone number and email address	

Figure 2-9 Information Table for Preliminaries section (NRM2, 2012)

For the pricing schedule of the preliminaries, it is divided into five columns as shown in figure 2-10 below; the first is the component column for defining the exact item to be priced and a column for the included items or notes on pricing that specifies what items should be deemed included. A third column is found for the units of measurement plus a fourth column for the pricing method; fixed charge or time related charge. There is also a fifth column which is the Excluded that describes the items to be excluded from the priced preliminaries item.

Component	Included/notes on pricing	Unit	Pricing method	Excluded
2 Furniture and equipment	Furniture and equipment for the employer and the employer's representatives where separate from main contractor's site accommodation. For example, desks, chairs, meeting table and chairs, cupboards, kettles, coffee maker, photocopier and consumables.			
	1 Bringing to site and installing.	item	Fixed charge.	
	2 Cleaning.	week	Time-related charge.	

Figure 2-10 pricing schedule for preliminaries (NRM2, 2012)

Advantages of NRM2

The BOQ produced by NRM2 is considered to be easy to understand since it breaks down the work items to the smallest details which gives clear information regarding all the items that contribute to the whole project works. NRM2 is flexible when there is a variation since it identifies clearly what items are affected by the variations. It is also an important feature of the NRM which is the focus on the ignored items of most projects like the preliminaries section. The NRM details the preliminaries of the project while most other standard methods would consider some preliminaries items to be included throughout the project works which may cause problems in variations since the contractor’s pricing of the variations would be a percentage of the cost of the item that originally includes the preliminaries; some of which may be not needed when applying that variation (Campbell, 2013). Also, the introduction of NRM has allowed the quantity surveyors to include composite descriptions for work items that consist of materials with different

types. The NRM2 also doesn't use a coding standard that refers to the specifications such as the CSI which makes it neutral and not only linked with a specific construction market (Davidson, 2012). Also NRM includes a list of risks that normally face the employer and transfers them to the contractor to be given a specific price in the BOQ (NRM2, 2012).

Disadvantages of NRM2

The fact that NRM is a very detailed method that goes into the smallest details of the project works is good and seems to have part in eliminating the ambiguities in any BOQ; however, these extreme details in the NRM2 can be a factor in rejecting working with it. This is because preparing a BOQ using the NRM2 would take much time since most of the items that were deemed to be included in the takeoff of any item would need to be priced and given a separate quantity in the BOQ which would take much time in the BOQ preparation. It may also increase the tender price since pricing smaller items might all sum up to a higher tender price. Some contractors also wouldn't be relieved with the idea of having to price the smallest details of a certain category of works especially the preliminaries section since most of its items were considered to be included and this was in favor of the contractors when any variation order is issued that involves time extension. There are also some disadvantages for the introduction of the NRM2 that involves the resistance to change within many of the construction firms in the market. This is because the NRM is a new detailed system that would need training in order to be able to use it and this training would require time to produce results and definitely would require cost which would make some firms think of sticking to their old systems that would give them immediate results even if they had less certainty than NRM (Campbell, 2013).

2.4. Principles of Measurement International (POMI)

The Principles of Measurement International for Works of Construction or what is known as “POMI” is a method published by the RICS Business Services Limited which is a wholly owned subsidiary of the RICS in June 1979 to standardize the method of measurement for building works and it was published in many languages like English, Arabic, German and French and its English version was modified and reissued in 2004. The RICS produced the POMI from its belief that the success of any BOQ depends mainly on its ability to be understood clearly by the parties who are participating in the contract and this is what requires a standard method of measurement to be available. The role of POMI comes whenever there is a design certainty and may be before the contractor is appointed so as to measure the project works at this stage to decrease the possibility of double counting an item (POMI, 1979).

Use of POMI

In 2011, the Building Cost Information Service (BCIS) which follows the RICS did an online survey for the use of POMI and invitations were sent to 4993 members of the Quantity Surveying & Construction Professional Group in 99 countries outside the United Kingdom who are only active members of the RICS Fellows. The results of the survey were produced in a report published in January 2012. The survey showed that around 45% of the respondents have experience with POMI and 44% of which are quantity surveyors, 12% contractors and 9% involved clients and 8% for the consultants. The results showed that the POMI is mainly used in the Middle East Countries. The projects that involved the use of POMI had different types that involved building projects and infrastructure projects also, but around 75% were building projects and most of the times it was linked with projects that had FIDIC contracts. While 74% of the respondents stated that POMI is generally fit for purpose, there were also 79% who mentioned that providing further guidance for POMI would be more useful (BCIS Report, 2012).

Figure 2-11 below shows the countries that are using POMI the most with UAE on the top of the list and figure 2-12 shows the projects where POMI is being used the most and it is obvious that POMI is being used for various project types, but building category is on the top of the list.

Region, Country, or administrative areas	Number of citations	% of responses (201) citing
United Arab Emirates	119	59.2
Qatar	34	16.9
Oman	31	15.4
Saudi Arabia	18	9.0
Bahrain	16	7.7
Mauritius	13	6.5
Egypt	10	5.0

Figure 2-11 Countries where POMI is mostly used (BCIS Report, 2012)

Project category	Nr	%	
Buildings	322	76.3	
Building maintenance	3	0.7	
Infrastructure	43	10.2	
Mining	1	0.2	
Mixed	49	11.6	
Petro-chem/Oil+Gas	3	0.7	
Unspecified	1	0.2	
Totals	442	100	

Figure 2-12 Project types using POMI (BCIS Report, 2012)

Structure of POMI

Most of the standard methods of measurement are produced to serve a certain category of projects, like the CESMM for civil works and the NRM for building works; however, POMI differs in the fact that it is able to serve a wide range of construction projects. The work sections of the POMI involve the building works beside site works and there are also a section for railway works as well as tunnel works. This can violate the criticism that POMI is being oversimplified because the point behind simplification is to make POMI able to serve various project types (Williams, 2016).

The POMI is divided into 15 work sections numbered from B to R in addition to the general requirements section plus a general principles section at the beginning that describes the general rules to be obeyed when preparing the BOQ such as what needs to be included and excluded and also the measurement

units to be used and the degree of accuracy to be used. The other work sections include most of the work items that are in any building project involving the site works also (POMI, 1979).

The POMI is a set of principles that are written with two main keywords which are “shall” and “may” and these keywords are what judge if the principle here is recommendation for better results or a guiding rule that without, there can be lots of misinterpretations (Williams, 2016).

The way an item is measured in POMI can be explained if an item like “Concrete” is taken as an example. In POMI, the concrete item is divided into 7 subdivisions including general principles about concrete, poured concrete, reinforcement, shuttering, precast concrete, pre-stressed concrete, sundries. Each of these subdivisions involves rules to be followed when preparing the bill of quantities for this item. For example, the pouring concrete involves rules on how to classify the concrete structures like concrete beams, columns, foundations, pile caps and diaphragm walls and there are rules about the measuring method itself and the representation of the item (POMI, 1979).

Advantages of POMI

POMI can be used for a wide range of construction projects with different types which makes it suitable for a project with variety of work types. Some of the responses to the BCIS survey mentioned that the simplicity of POMI is what makes it suitable and what makes many clients go for POMI in some projects. The simplicity of POMI can make it easy for the user to get familiar and experienced with this method of measurement and so can use the method easily in producing the bill of quantities (BCIS Report, 2012).

Disadvantages of POMI

The POMI is generally considered abstract compared to other standard methods of measurement and most of the respondents to the BCIS survey mentioned that POMI is abstract and the descriptions of the items are not detailed as they should be or as the case in the SMM and so more details of the item description is needed and so it can’t be used in complex projects as it can be misleading. Some responses specified the preliminaries section as the section that needs to be detailed. The replies also stated that the POMI needs more guidance to be added regarding how the BOQ should be prepared. Another sector of the replies mentioned that POMI doesn’t cover some items of the project works. Some

of the replies also stated that the POMI is not updated as it should be and it should consider the new construction techniques that are used in the present days and some respondents specified the MEP as the section that needs to be updated (BCIS Report, 2012). The POMI can be somehow ambiguous in describing the works of a certain part of the project since it doesn't separate the works of different nature who belong to the same task. The POMI also is not efficient as the NRM and SMM7 in dealing with some types of risks as the below ground risks since the POMI doesn't consider for example stating the ground water level or excavation in an instable ground (Williams, 2016).

POMI vs NRM2

Table 2-2 shows a comparison between how the NRM2 and POMI measure certain items and 2 examples are given and the difference is shown between the two items.

Table 2-2 Comparison between taking off items in POMI and NRM2

Item to be measured	**POMI**	**NRM2**
Masonry	• Item D in POMI and classified into 4 possible sub-items; Walls & Piers, Sills, Reinforcement and Sundries (POMI, 1979). • Concerning the cavity walls for example, POMI states that the cavity walls shall be measured as a composite item and the product is a quantified area of walls. POMI also suggests that the cavities may be quantified and the product is the area of the cavities and the cavity insulation	• Item number 15 and classified into 25 possible sub-items that can be measured like for example: walls, diaphragm walls, isolated piers, attached projections, arches, forming cavity, cavity insulation, fillets, joints, etc. (NRM2, 2012). • Concerning the cavity walls, unlike POMI, NRM2 divides the wall as an item into a wall that may contain a cavity and this cavity has a price for its formation and insulation. There is also an item for adjusting the bay and

	shall be deemed to be included (POMI, 1979).	installing lintel plus the gable ends and there is also the item of partition that is classified in details. It is obvious that the NRM2 is very detailed when pricing an item (Lee, Trench, & Willis, 2014).
Doors and Windows	• Item H in POMI and is classified into 6 possible categories; doors, windows, screens, ironmongery, glass and patent glazing (POMI, 1979). • For the doors, POMI states that doors shall be counted in numbers and the associated jambs, heads, sills, etc. shall be measured in length or in numbers (POMI, 1979). • For the windows, POMI states that windows, skylights and their like shall be counted in numbers including their frames or the frames shall be separately counted if they are from different materials other than the windows (POMI, 1979). • The ironmongery shall be counted in numbers for both doors and windows (POMI, 1979). • Glass shall be measured by area and the sealed factory glazed units shall be counted in numbers (POMI, 1979).	• Item 23 in NRM2 is titled Windows, screens and lights while item 24 is for doors, shutters and hatches (NRM2, 2012). • The windows section is classified into 10 possible takeoff items including for example, windows & window frames, window shutters, sunshields, glazing glass and ironmongery (NRM2, 2012). The takeoff of the windows shall involve details like dimensions of windows, radius of curved works, paint to windows, adjusting of wall construction if any, method of fixing or glazing, thickness of glass if any is found, method of fixing ironmongery and quality of the materials chosen (Lee, Trench, & Willis, 2014). • The doors section is divided into 16 possible takeoff items including for example door sets, doors, grilles, door frames, roller shutters, door stops, glazing and ironmongery (NRM2,

	• Screens are to be measured by area or counted in numbers and the doors and frames within the screens are to be measured in numbers (POMI, 1979).	2012). The takeoff of the doors shall involve details like dimensions of doors, fire resisting performance, method of fixing, thickness of glass if any is found, door paintings, method of fixing ironmongery and quality of materials used (Lee, Trench, & Willis, 2014).

Summary of comparison

As provided in the above table 2-2, POMI seems to be very simplified in comparison to NRM 2. For Example, Masonry in POMI are measured including cavity, fill of cavity, and cavity closing. On the other hand, Lee (2014) states that the takeoff list for the same item in NRM 2 involves the measurement of such items separately and the take-off list could include a range of 10 to 12 items as shown in figure 2-13 below:

Taking-off list

Cavity walls: block
facing brick
form cavity
Cavity insulation
Adjustment for bay: last four items
Lintel
Gable ends

Internal partitions
Blocks
Stud partition

Figure 2-13 NRM2 take-off list for Masonry (Lee, Trench, & Willis, 2014)

POMI Vs CESMM

Table 2-3 below shows a comparison between the POMI and CESMM from the strategy of the items' taking off.

Table 2-3 Comparison between taking off items in POMI and CESMM

Item to be measured	**POMI**	**CESMM**
Tunnels	• Tunneling activities are included within Section B of the site works and they are classified to three sub-items; tunnel excavation, tunnel linings and tunnel support and stabilization (POMI, 1979). • POMI states that tunnel excavation shall be measured by the volume of void to be occupied including the volume of the permanent linings and the tunnels should be classified as straight tunnels, straight shafts, curved tunnels, curved shafts, tapered tunnels, tapered shafts and other cavities that include transitions and breakaways (POMI, 1979). • POMI states that for the tunnel linings, poured concrete is to be measured by area stating whether the concrete is spray or cast and classified as either	• Tunneling activities are located in class T and divided into 3 main activities; excavation, lining and securing form of tunnels and shafts plus other subterranean cavities (CESMM3, 1991). • Tunnel excavation is classified with more details in CESMM since it is classified into excavation in rocks or other materials, tunnel shafts in rocks or other materials and other cavities in rocks or other materials. The measurement rules state that the earthworks, in-situ concrete and tunnel components shall be classified appropriately and the volume measured for excavation shall be that included in the payment only. It is worth mentioning that an isolated volume of rocks occurring in other materials shouldn't be dealt with

	lining or secondary lining and the segmental tunnel linings shall be measured in numbers (POMI, 1979). • POMI states that for the support of tunnels, there are 6 possible items which are the timber supports measured by volume, sprayed concrete supports measured by area, rock bolts measured by length, face packers measured by numbers, metal arch supports and injection of grout materials which are measured by weight (POMI, 1979).	separately unless its volume exceeds 0.25 m^3. The definition rules state that diameter used for classification is defined to be the external diameter of the excavation cross section of the measured item. The coverage rules state that the disposal of excavated materials should be deemed included on the price. There are also some additional rules that mention specific details about the measured items (Spain, 2003). • For the tunnel linings, it is classified into in-situ linings and performed segmental linings for tunnels, shafts and other cavities. They are further classified into either sprayed concrete or casted concrete or precast concrete bolted rings or cast iron rings, etc. and their diameter should be stated. The measurement rules mention some details of how the thickness of the lining should be measured as well as the volume of in-situ cast concrete. There are also some definition rules defining in details the items to be measured. The coverage rules state that the items shall be deemed to

		include the price of reinforcement. There are also some additional rules for the description of the items to be measured (CESMM3, 1991). • For the support and stabilization, there are 4 possible items which are the rock bolts, internal support, pressure grouting, and forward probing. Each item is further divided according to its type and the units of measurement is determined based upon this. There are some measurement rules that determine exactly how the support items shall be measured and these rules are accompanied by definition rules that define exactly the item measured and the coverage rules. There are also additional rules for the description of the items like the rock bolts which states that the size, type and the maximum length should be stated in the description (CESMM3, 1991).
Excavation	• Excavation is placed as a sub-item of the site works section B in POMI and its classification is considered to be very broad. The excavation is measured by the volume of the void	• Excavation is placed as Class E works and classified into excavation for cutting or by dredging or excavation for foundations or general excavation. The classification involves also the type of

	created and this is somehow confusing since it doesn't specify the different excavation types in the same soil, but instead gives the final total volume forming the void (Williams, 2016).	materials and the maximum depth. There are measurement rules to explain how the measurements shall be made and how each type of material should be dealt with in the bill. There are also definition rules that define each excavation type and what each description in the bill would represent. The coverage rules mention what items to be deemed included such as holding sides of excavation and the disposal of excavated materials. There are also some additional description rules that define specific cases of excavation like excavation under water (CESMM3, 1991).

Summary of comparison

As provided in the above table 2-3, POMI seems to be very simplified in comparison to CESMM. For Example, excavation in POMI is a sub-item under site works and is measured as the volume of the void to be permanently occupied which is somehow mysterious regarding to the nature of the void and the steps followed to make the void. On the other hand, CESMM includes the excavation under the earthworks category which is a more focused category than site works. Regarding the works description, CESMM is more focused than the POMI in the point that it specifies the different types of excavations that occur in the soil to make the void and these types are recorded in separate items. The specifications involve the various depths for excavation under the ground level.

2.5. Research Methodology

Survey as an approach for data collection

The survey approach is one of the techniques for data collection for the field work research. It is one of three possible techniques besides the case study approach and the problem solving approach. Surveys are important for collecting data within a limited time from respondents who are experienced with the topic giving a generalized result regarding a particular population. There are two types for surveys which are the descriptive survey and the analytical survey. The descriptive survey aims at finding answers to some questions while the analytical survey aims at defining relationships between the factors being investigated in the research (Naoum, 2007).

Techniques of data collection

The survey is made through the common type which is the questionnaire. The purpose of the survey should be explained in the questionnaire in a brief scheme. It is beneficial in case of finding answers to questions or forming conclusions about relationships between variables. Most of the questions in a questionnaire should be closed ended requiring one specific response or requesting a rank from the respondents for some factors (Naoum, 2007).

Steps for constructing a questionnaire

The process of constructing a questionnaire is shown in figure 2-14 below:

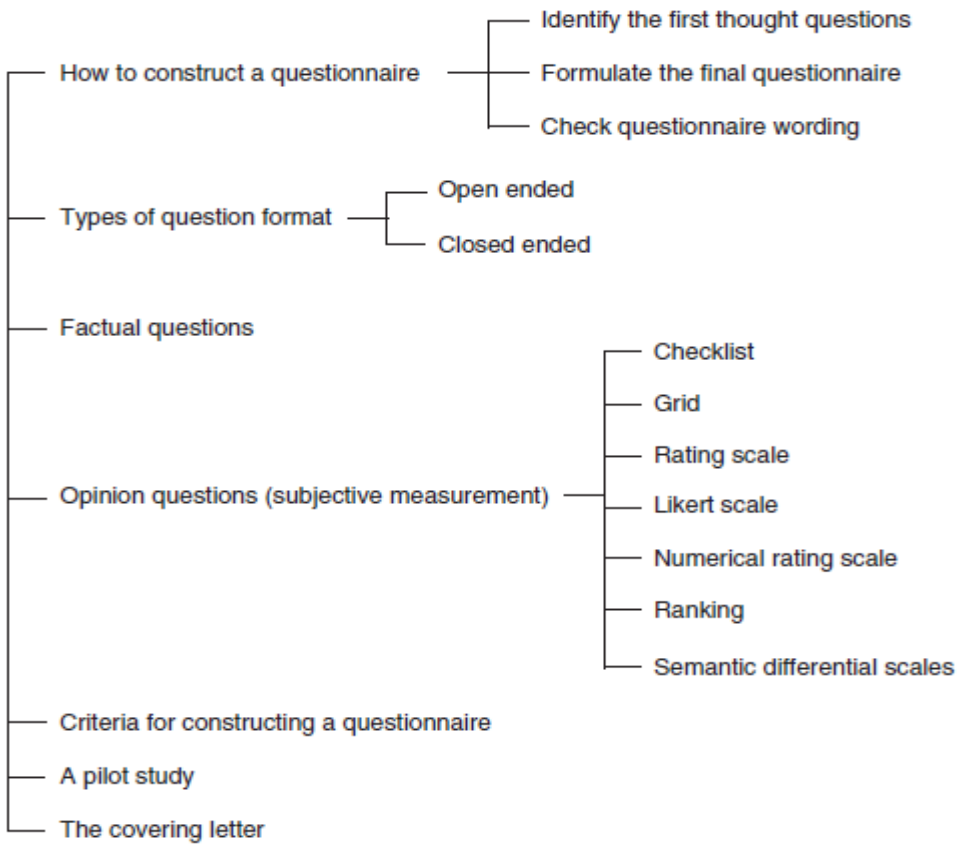

Figure 2-14 Process of constructing a questionnaire (Naoum, 2007)

The first step of producing a questionnaire is to identify first thought questions based on the information from the literature review or from personal concerns. Then comes the part of formulating the questionnaire and this is done by trying to categorize the questions and dividing them into sections to see which questions should be asked and which questions are already covered in other questions and their presence might cause confusion in order to remove them. After that comes the part of checking the wording of the questionnaire in order to see if it is clear or some questions might be misleading and need to be rephrased.

In the questionnaire itself, the questions can either be open ended or closed ended. The open ended requires the respondent to type answers while the closed ended only need choices or short responses and it is advised to try to decrease the open ended questions. There are also some factual questions which are used to investigate the respondents knowledge about certain facts which can help define how accurate are the responses of the respondent. Other question types involve the opinion questions which

should be the core of the questionnaire and they are needed to reach conclusions about the topic being investigated in the questionnaire.

There are some criteria to be followed when preparing a questionnaire such as to make it short and simple and also to check if the answers required would truly be beneficial for the topic being investigated. Besides, the questionnaire should be attractive in appearance as much as possible.

Before distributing the questionnaire on the population required, it is advisable to distribute the questionnaire on a selected sample of people to answer it and then ask for their comments regarding the questionnaire and the recommendations that need to be done to make it better. And finally, there should be an attractive cover letter at the beginning of the questionnaire introducing the topic and explaining purpose of the questionnaire and asking for a reply from the respondents (Naoum, 2007).

Advantages and disadvantages of the questionnaire

The advantages of questionnaires include being fast since the response is received in a relatively speedy way. Also they are considered to produce results with high validity since the questionnaire is sent to a population of various kinds of people. However, there are some drawbacks for the questionnaire approach that include the point that they need to be simple and short. Also, it is hard to guarantee the accuracy of the results since the respondents may answer the questions randomly. In addition, it is hard to know the basis on which any of the respondents answered a certain question if it is clearly not logical answer.

2.6. Summary

Table 2-4 Summary of comparison between NRM2, CESMM & POMI

Point	NRM2	CESMM	POMI
History	• Issued by RICS in 2012	• Issued by ICE in 1976 • Latest version is CESMM4 issued in 2012	• Published by the RICS Business Services Limited which is a wholly owned subsidiary of the RICS in 1979
Type of works measured	• Measures building works	• Measures civil engineering project works and has a provision for simple buildings	• Measures both buildings and civil works
Structure	• Consists of 3 sections as follows: ○ General ○ Measurement Rules ○ Tabulated Rules for detailed work sections	• Consists of 8 sections as follows: ○ Definitions ○ General Principles ○ Application of the work classification ○ Coding & numbering of items ○ Preparation of BOQ ○ Completion & pricing & using BOQ ○ Method related charges ○ Works Classification	• Consists of a general principle section in addition to the works sections that include a general requirements section at the beginning.

Works Breakdown	• Has 41 divisions for the works.	• 26 main work classes covering civil engineering works.	• Has 15 work sections.
Advantages	• BOQs produced by NRM2 are clear since it breaks down the work items to the smallest details. • NRM2 is flexible when there is a variation. • Focus on the ignored items of most projects especially the preliminaries section that when considered included may cause problems when there is a variation. • Allowed the quantity surveyors to include composite descriptions for work items that consist of materials with different types. • Doesn't use a coding standard that refers to the specifications such as the CSI which makes it neutral and not only linked with a	• CESMM is suitable for the nature of civil works that are hard to takeoff their quantities in the tendering process. • Gives flexibility for choosing the method of execution of the project works since the cost of the method and other temporary works would be allocated under the method related charges. • Allows the pricing of all the works that are temporary and don't form part of the final works but they are to be included in the BOQ. • Gives justification for the difference in prices between tenders • Updates its versions to accommodate with the new technologies that	• Preferred by users for being simple to work with. • Covers a wide range of works in construction projects. • Being issued long time ago made working with it familiar and so some firms prefer it.

	specific construction market. • Includes a list of risks that normally face the employer and transfers them to the contractor to be given a specific price in the BOQ.	appear in the world of civil engineering. • Clear explanation since it groups different tasks belonging to a certain category of works in one location under separate tasks • Clear explanation since it groups items of similar nature but different locations under separate tasks • The coding system allows CESMM to be easily implemented in computerized software that deals with the bills. • Flexible when dealing with variations	
Disadvantages	• Preparing a BOQ using the NRM2 would take much time since most of the items that were deemed to be included in the takeoff of any item would need to be priced	• Sometimes considered to produce length bills with redundant work items that could have been included on other items. • Throws risk on engineer as the engineer should	• Abstract and the descriptions of the items are not detailed. • Doesn't separate the items belonging to the same work location but with

	and given a separate quantity in the BOQ. • May increase the tender price since pricing smaller items might all sum up to a higher tender price. • Not in favor of contractors regarding to the detailed level of pricing especially the preliminaries section because it helps them collect money in case of a variation. • Resistance to change to the NRM since it is new and would need training and results are not guaranteed.	anticipate the possible difficulties on site and the engineer is not experienced as the contractor with the project or site conditions. • The complicated system makes firms unwilling to use them since they need to train their staff for the use of CESMM. • The method-related charges section can cause conflicts between the contractor and engineer in case of variations.	different nature so it is somehow ambiguous. • Not efficient in dealing with some types of risks. • Preliminaries section is too abstract. • Needs more guidance to be added regarding how the BOQ should be prepared. • POMI is not updated as it should be and it should consider the new construction techniques that are used in the present days.

3. Data Collection and Analysis

3.1. Data Collection

The data collection process was done by preparing a questionnaire to be filled by specialists in the field of quantity surveying.

The purpose of the questionnaire prepared was to:

- Investigate the knowledge of the quantity surveying field professionals in the Middle East regarding the different MOMs.
- Investigate the advantages and disadvantages of the detailed and brief BOQs and when each of them could be necessary.
- Serve the purpose of creating the model through determining the factors upon which the MOM could be chosen to prepare the BOQ of a certain project.

Steps for constructing the Questionnaire

The questionnaire approach is a means of data collection for the fieldwork research and it was used in this research in order to establish relationships between the different factors investigated in this research. The preparation of the questionnaire involved several steps; the first of which was preparing a questionnaire having a lot of questions about the topic and a pilot study was made by distributing this questionnaire on selected sample of people who gave responses about some things that needs to be clarified and other questions that can be rephrased for better understanding of the questionnaire by the respondents. Also, there were suggestions to add some questions that could enhance the data collection and help within the process of constructing the model.

The final draft of the questionnaire was prepared by categorizing the questions into 3 sections; the first of which is a trying to define the population being investigated in this research. The data required in this section involved mentioning the name of the respondent and his/her job title and the company for which the respondent is working. The type of the firms for which the respondents should be working for was grouped into 3 main categories; the first of which was the client who requires the project to be executed

and this client can be a developer for example. The second category were the consultants who are involved in the construction projects since they should have experience with the cost management and the quantity surveying fields and can be responsible for BOQ preparation and also in the supervision process during execution of the project. The third category were the contractors who are responsible for the project execution and they are considered an important category since they deal with the BOQs during tender preparation and throughout the project execution.

The second section of the questionnaire involved a first part for questions about the type of MOMs that the respondents had experience with in preparing the BOQs; whether non-standard MOMs or standard MOMs or both. In addition, there was a part of this section that involved classifying the respondents based on their years of experience with the BOQ preparation and this was important to show the trend of the use of MOMs for the BOQ preparation throughout the years. Also, in this part of the section, there was a question about the experience with the three specific MOMs being investigated in this research by asking the respondents if they had experience with the NRM, POMI and CESMM or other methods.

The second part of section 2 was trying to investigate certain points that were figured out from the literature review in chapter 2 regarding the detailed and brief BOQs. For the detailed BOQs (the ones prepared by NRM and CESMM in this research), it was important to investigate certain points that were implied during exploring the literature such as whether these detailed BOQs can enhance the pricing accuracy by breaking down the project items into the smallest details. Also, another characteristic being investigated is whether the preparation of these BOQs would require a lot of time so that it would be useless or not worth the effort exerted in preparing for small sized projects. In addition, it was important to check whether these BOQs would be clear for the contractors when understanding the works to be executed to achieve the project scope. The effect of these BOQs on quantifying the variations needed to be validated since it is inferred that these BOQs would involve small items so that when a claim of variation arises, it would be easy to accurately quantify the items being affected by that variation without including the price of redundant items that would mistakenly increase the price of the variation. There was also a need to investigate the point that the detailed types of BOQs could mistakenly result in an increase in the tender price due to the assumption that the large number of items to be priced can sometimes

result in double count of prices especially with the assumed inexperience of the contractors in the Middle East with using these types of BOQs.

The brief BOQ properties were also investigated in this part of the section through a question asking if this type of BOQs can be important when there is no plenty of time to spend on preparing a detailed BOQ, so brief BOQs can be a possible solution that helps in the quick issuance of the tender documents. Also, it was important to investigate if those brief BOQs are subjected to neglecting necessary details that can lead to misinterpretation of the requirements of the project works. Another characteristic of the brief BOQ that was to be investigated was if those types of BOQs were subjected to misinterpretations by the contractors when pricing like for example not understanding the full works to be priced for a certain item which can lead to the contractor giving the item an over or low pricing according to the wrong description that was inferred from the item description. It was also required to investigate if the brief BOQs can be unclear in the point of quantifying the variations that occur for a certain project item since these BOQs use the inclusive approach which makes it difficult to know the exact price of a variation if the item varied includes other priced items that are not affected by that variation and this would lead to conflicts between the contractors and the consultants. In addition, there was a question regarding the point that brief BOQs can cause a tender to be mistakenly priced whether higher than its original value or lower since these BOQs can lead the contractors to whether miss some important items when pricing or double count the prices of items which can increase the tender price.

The last part of section 2 in the questionnaire was for the purpose of creating the model. It was assumed that there are five factors or parameters that can affect the process of choosing the most suitable MOM for a certain project which are:

- Project Type: the type of project may favor some MOMs over other MOMs; for example simple building works may have less problems so POMI may be favored while complex projects might need detailed BOQs.
- Client's Nationality: whether the client is local and belongs to the same country of the project or the client is international who is requesting a project to be done in a foreign country. An assumption was that local clients may go for a brief MOM since they have experience with the

contractors and the market of their countries. On the other hand, international clients might prefer the detailed type of BOQs so as to save themselves risks arising from the BOQs.

- Contractor's Nationality: whether the contractor is local and belongs to the same country of the project or the contractor is international meaning that the contractor is working in a country other than his origin. An assumption was that international contractors might be more experienced in dealing with the detailed MOMs such as CESMM and NRM which could be preferable to avoid project risks that can cause a lot of problems in huge projects. On the other hand, local contractors might be assumed that they could have no experience with MOMs like the NRM and CESMM and so might prefer to work with POMI to produce a brief BOQ.
- Project's Contract Value: whether the project is a large project that has a high contractual value in terms of price or the project is a small sized project that has low contractual price. An assumption is that large projects can experience more problems and it is important to try to avoid these risks and reduce their probability so an MOM like NRM or CESMM can produce a detailed BOQ with the project risks accounted for in pricing. On the other hand, small sized projects can include simple construction works that could be done in small time duration, so a brief BOQ produced by an MOM like POMI could be enough for such projects.
- Contract Type: whether the contract is a unit price or a lump sum contract. An assumption is that unit price contracts rely mainly on the BOQs as the BOQ has a great priority compared to other contract documents of the project and so using an MOM like NRM or CESMM can be more accurate in preparing a detailed BOQ which can decrease the project risks. On the other hand, lump sum contracts have a fixed price for the project's value and the BOQ doesn't have a high priority among the project's contract documents and the BOQ are less likely to be needed except in some cases such as pricing of potential variations. In this case using POMI to produce a brief BOQ can be enough for the project requirements.

So all of these points about the 5 project parameters to be involved in the model were assumptions based on the points mentioned in chapter 2 discussing the literature review and the validation of these assumptions would be thorough the responses to this question. These responses would be used to

produce a percentage preference for each of the two choices corresponding to each of the 5 project parameters.

Another question in this part involved asking the responses to give percentages on the weights of each of the 5 parameters in the decision making process of which MOM is chosen for a certain project. These percentage preferences along with the weights given to each parameter would then be used to create the decision model of choosing the most suitable MOM for a project which would be discussed in details in chapter 4.

The final section of this questionnaire labelled section 3 was for choosing the most suitable MOM to prepare the BOQs for the different types of projects. This question was intended to be added to the decision making process as another parameter of the choice of the most suitable MOM. The projects were classified into 7 categories:

- Residential Buildings
- Office Buildings
- Hospitals
- Hotels
- Water and Waste Water
- Roads and Highways
- Tunnels and Bridges

The respondents had to choose the most suitable MOM for each of these project categories and it was assumed that the first four project types representing the category of building projects would have MOM choices between POMI producing brief BOQs and NRM producing detailed BOQs. For the last 3 project categories who belong to the category of civil projects, it was expected that each should have an MOM choice between the CESMM producing detailed BOQs or the POMI producing brief BOQs. It was also decided to provide the option of the non-standard MOMs for the respondents who chose that they dealt only with non-standard MOMs in section 2.

3.2. Data Analysis

The questionnaire was distributed on 140 professionals in the field of quantity surveying. The assumptions made were that the quantity surveying field in the Middle East may involve a population of 1000 professionals who might have experience with the standard MOMs in BOQ preparation so it was required to collect around 10% of that number, the desired sample calculated was 100 responses. So based on this, the questionnaire was distributed on 140 professionals; however, the responses arrived were 15 from each of the three sectors for which the questionnaire was sent who are Client, Consultant and Contractor and this forms a percentage response of 32.15%.

These responses were from various entities who belong to the Middle East from countries like Egypt, Saudi Arabia, United Arab Emirates, etc.… The entities for which the respondents represent are reputable consultants, contractors as well as clients and all of those have projects in the Middle East region and even some have projects worldwide. The factor of choosing respondents from reputable construction entities was important for the credibility of the responses to ensure as much as possible that the respondents could have had a real experience or information about the proposed methods of measurement being investigated in this study.

Analysis of questionnaire responses

This is an analysis of the responses for the different questions that were asked throughout the questionnaire:

a) Section 2 results:

1. Types of MOMs used by the respondents in preparing the BOQs

The distribution of the responses shown in Figure 3-1 below shows that among the three options given, about 27% have used only standard forms of BOQ preparation against 13% who have used only non-standard forms while the respondents who used both types had a percentage of 60% and this gives a good indication that the respondents are aware of the standard forms of MOMs used in BOQ preparation since a total of 87% have used the standard forms. It is also worth mentioning that most of the percentage of those who used only non-standard forms came from contractors

which may give an indication that contractors are more likely to be unaware of the standard forms compared to clients and consultants.

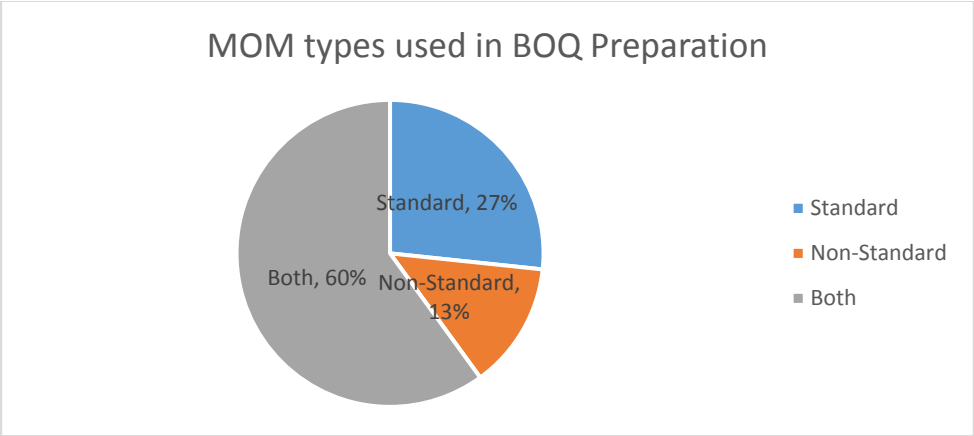

Figure 3-1 MOM types used in BOQ preparation

2. The years of experience in preparing the BOQs

The number of years of experience for the respondents in the BOQ preparation is shown in figure 3-2 below and the majority of the respondents had a 0-4 years of experience and these formed around 40% while there are 33% for the 5-10 years of experience and 16% and 11% for the 11-15 years and the above 15 years category. What may be inferred from the fact that the majority of respondents who returned the questionnaire were of recent experience is that the idea of MOMs is getting to be known by the new generations in construction especially with the emerging trend to develop the field of construction management through the Middle East in the recent years.

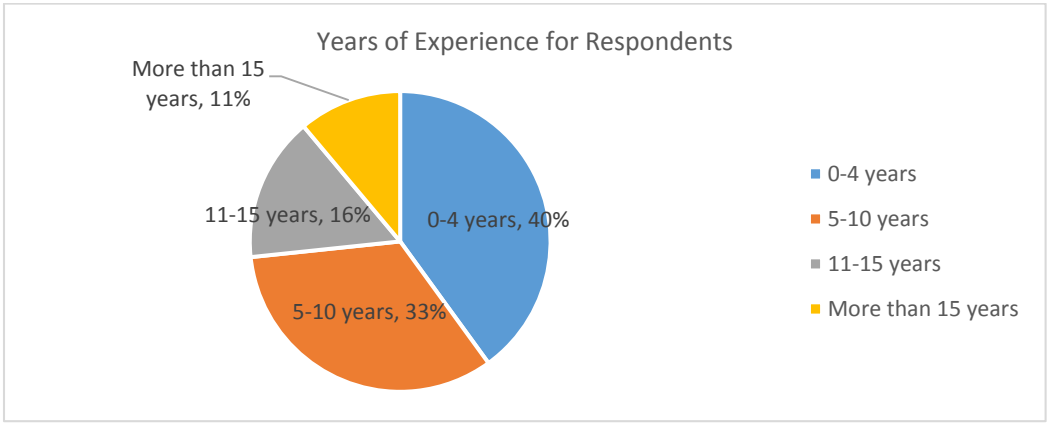

Figure 3-2 Number of years of experience of respondents in BOQ preparation

3. Using a standard MOM can decrease the probability of having variations and claims during construction

The answer to that question came with 44% seeing that using a standard MOM will definitely decrease the probability of having variations and claims that can arise from the BOQ during the execution of the project and around 53% seeing that the standard MOM might save the risks of having a lot of variations and claims during execution of the project. So, it is clear that the majority which form around 98% of the respondents believe that the standard MOM is important to decrease the probability of having conflicts that result from variations during construction, but they differ in the estimation of the extent to which the conflicts can be avoided through using standard MOMs. The results are shown in figure 3-3 below

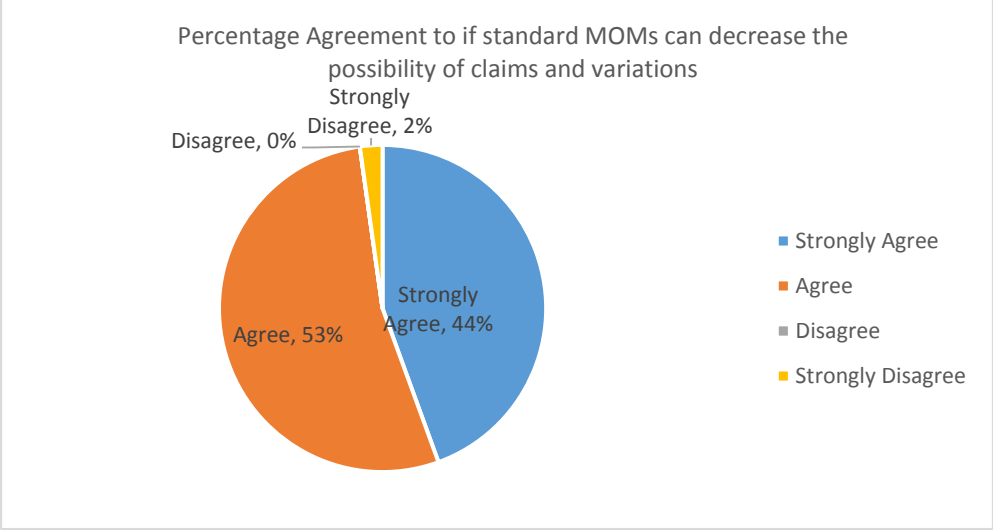

Figure 3-3 Percentage Agreement to if standard MOMs can decrease the possibility of claims and variations

4. Methods that have been used by respondents or whom they have experience with

The responses that came expressing the different types of MOMs that the respondents may have used or had experience with were as shown in figure 3-4 below:

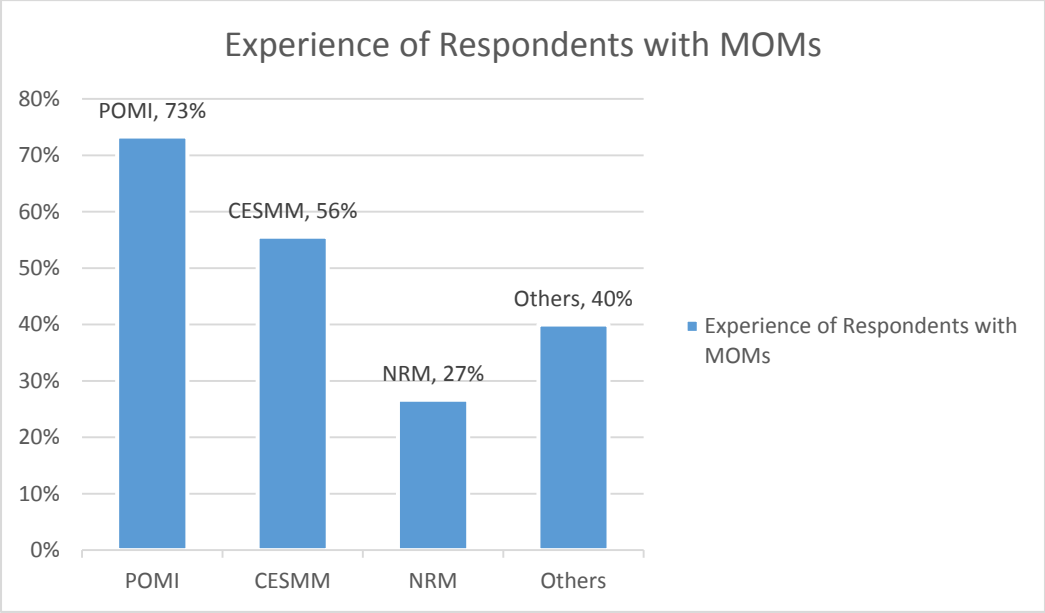

Figure3-4 Experience of Respondents with different MOMs

It is obvious that the method that most of the respondents had experience with is the POMI as 73% have expressed that they have used POMI for preparing bills in previous projects or have experience with using POMI. This confirms what was mentioned in section 2 for the literature review that states that the POMI is the most common method out of the three investigated that is used in the Middle East for projects especially building projects.

For the CESMM, 56% of the respondents have expressed that they have experience with CESMM and may have used it in different projects for the BOQ preparation. This number is not considered very high and gives an indication that POMI is still preferred over CESMM or to be precise, it is more known for the people involved in the construction industry in the Middle East. It is also noticeable that the 56% is still not low compared to what was expected and this may be attributed to the fact that CESMM was introduced to the market long time ago and some firms have accommodated to using CESMM for civil projects and at some points it can be considered in competition with POMI when choosing an MOM for civil projects in the Middle East, but still POMI is considered the first choice till now.

For the NRM, the respondents gave the lowest percentage among the three methods. The percentage of respondents was 27% which would be reasonable to assume that these responses

were of people who have experience with NRM, but may have still not used it since it is hard to assume that the NRM which is a recent method have been used in many real projects in the Middle East. Also, it is noticeable that the percentage of the people who marked NRM as a method whom they have experience with belong mainly to the category of people who have been involved in the BOQ preparation since a recent time. This supports the argument stated before that the project management is developing and so there is an attempt to improve its aspects and one of the ways is to get aware of the new MOMs that are being issued and NRM is one of the most recognizable example of these methods nowadays.

Other respondents have stated using other standard methods different from the three methods being investigated in this research and those responses formed around 40% of the total responses received. The different methods mentioned had some examples as the SMM7 which was mentioned in section 2 of the literature review as being the precedent of the NRM. Also, many have stated using methods that are standard for their companies that involved some modifications by introducing the CSI (Construction Specifications Institute) as a reference to the materials mentioned in the BOQ. Other mentioned methods of measurement involved example like the FIDIC MOM, the NEC3 MOM as well as the IPMS (International Property Measurement Standards) that is a method specified for office buildings. Also, other responses involved the methods that are standard for certain countries such as QCS for Qatar.

5. Detailed BOQs in terms of items' breakdown

    a) Detailed BOQs in terms of items' breakdown enhance items pricing

The results of this question came as shown in figure 3-5 below

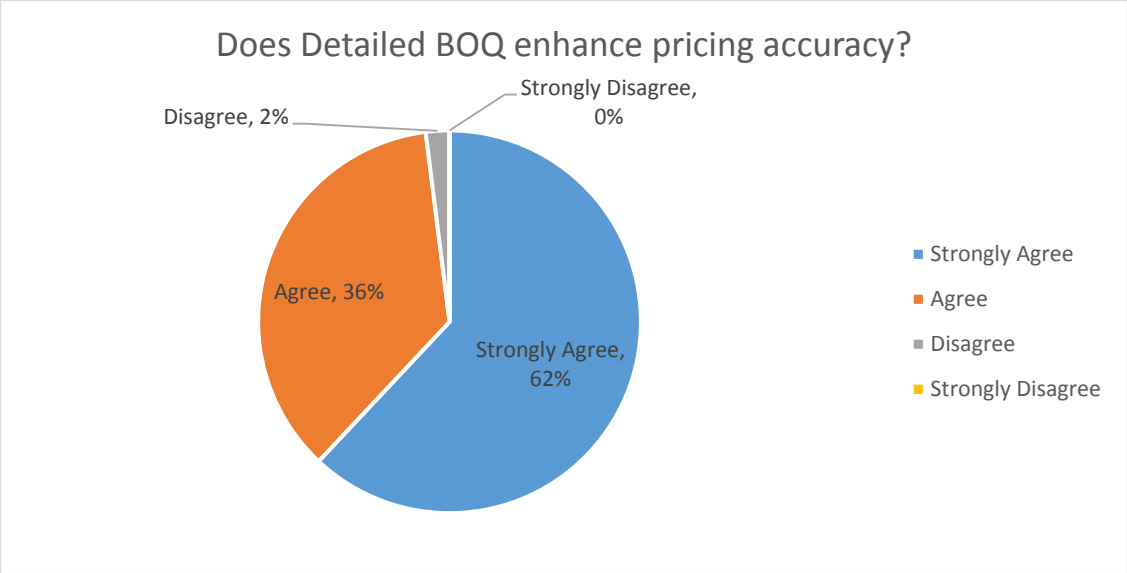

Figure 3-5 Does Detailed BOQs enhance pricing accuracy of items?

It is obvious that the respondents agreed with this point since 62% had opinions that the BOQ prepared using a detailed MOM with respect to the breakdown of items would definitely enhance the accuracy of the items priced and the other 36% had opinions that the pricing accuracy might be improved when using detailed BOQ having the smallest items of the project to be priced separately. Overall, the majority of the respondents were supporting that point which seems logical since breaking down an item to its very smallest components would be easy to find the price of the separate items instead of having a bulk item that needs its components to be priced under a single item which may cause an unreasonable price if there is an error in estimating one of the item's included components and it would be hard to track the error. The responses confirm the related part of the literature regarding the NRM2 and CESMM that are considered to have high accuracy in pricing than the POMI which is abstract and relies more on the inclusive approach where small items' prices are to be included within the price of the major item.

b) Wastes time in case of small projects

The results of this question came as shown in figure 3-6 below

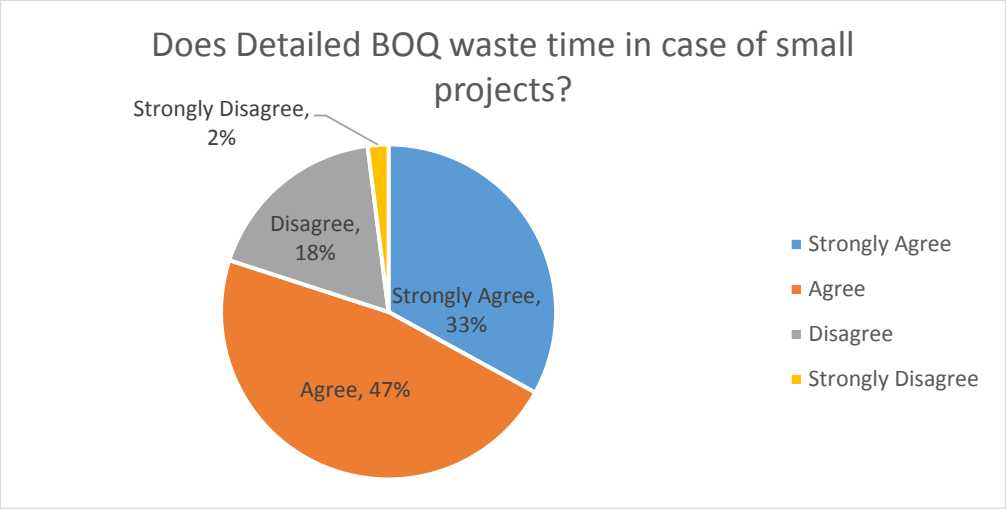

Figure 3-6 Does Detailed BOQs waste time in case of small projects?

It is obvious 33% of the respondents were strongly supporting that detailed BOQs would not be needed in case of small sized projects as they would waste time and another 47% of the respondents think that detailed BOQs might not be needed when working in a small sized project so both sides would form around 80% supporting that point regardless of the degree of agreement. On the other hand, there is around 20% who don't support that opinion and they think that the need of detailed BOQs is a must and it is preferred regardless of the project size.

Trying to justify the responses, it would be logical to think that producing a detailed BOQ would mean having to breakdown all the project items into very small items which would mean that the takeoff process would involve quantifying these small items which would definitely take much time than if those items were to be grouped together in addition to increased costs incurred for preparing a detailed BOQ. For small sized projects, the projects' budget is considered relatively small plus the project duration is usually short. So for these reasons, many may find it as unrealistic to exert a lot of effort in producing a detailed BOQ for such types of projects.

Considering the opposing side who supports producing a detailed BOQ for any project size, this side may have an opinion that the project size doesn't mean not to handle the project items with care since any mistake may cause the small sized project to be delayed and its price may increase causing a lot of problems. The responses who had that argument represented 20%;

89% of which are on the side of consultants and clients which may give an indication that they are biased towards detailed BOQs.

c) Easily understood by contractors decreasing mistakes in pricing

The results of this question came as shown in figure 3-7 below

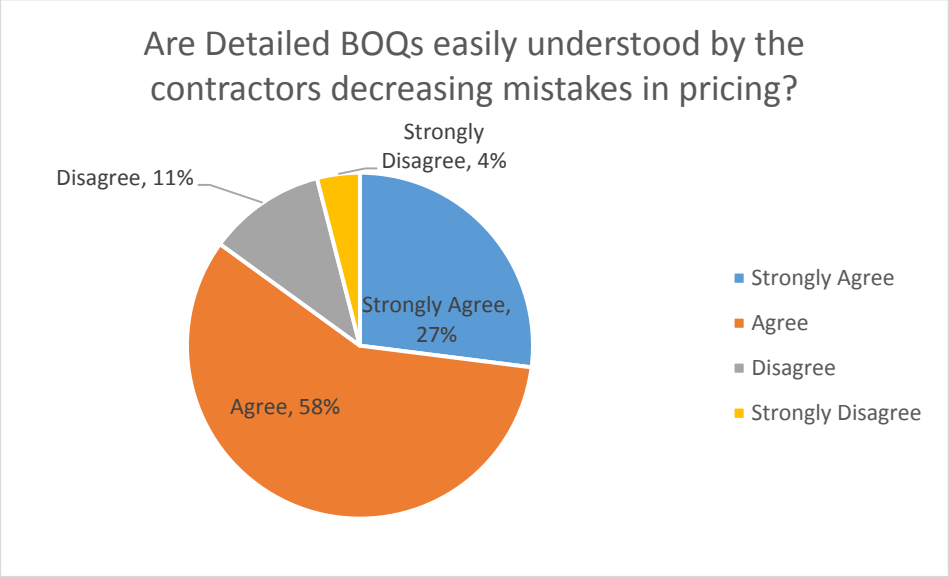

Figure 3-7 Are Detailed BOQs easily understood by contractors decreasing mistakes in pricing?

It is obvious that around 27% of the respondents were strongly supporting the point that detailed BOQs make it easier for the contractor to understand the project scope and price the exact items needed to reach the final cost of the project. In addition, there was another 58% of the respondents who may be willing to support that idea that detailed BOQs can be helpful in decreasing the errors in the pricing of the BOQ.

On the other hand, another sector forming around 15% were not supporting that idea and they didn't agree that pricing a detailed BOQ would affect the understanding of the project items. The 15% who are not supporting that point had around 72% of them as contractors who might think that pricing errors or the misunderstanding of the project scope can occur regardless of the BOQ being detailed or brief. They might have a belief that a brief BOQ can still be understood by the contractors if it is written clearly describing all the project scope. However, it seems logical that a detailed BOQ which would have the smallest details regarding the project items would make it

clear for the contractor to know which items exactly are required to reach the final project scope. Unlike a brief BOQ that follows the inclusive approach which makes it most likely for the contractor to forget to include a certain item and price it which would cause conflicts during the project execution and may result in claims that can evolve to disputes.

d) Enhance quantification of variation orders

The results of this question came as shown in figure 3-8 below

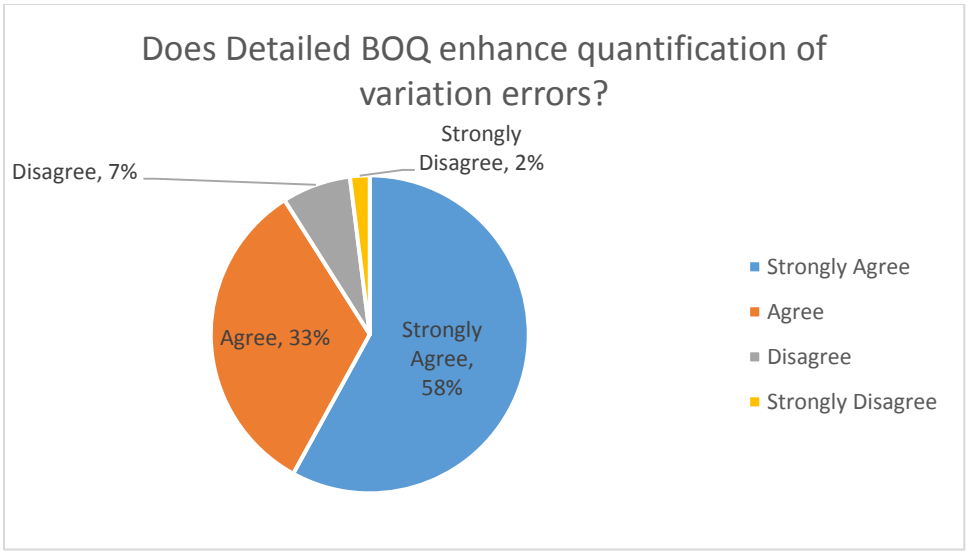

Figure 3-8 Does Detailed BOQ enhance quantification of variation orders?

It is obvious that 58% of the respondents strongly support the fact that producing a detailed BOQ would definitely help in the process of quantification of the amount of variation orders that may arise in a project during execution. Also, 33% of the responses agree that quantification of variations might be easier when having a detailed BOQ for the project items, so the total agreeing percentage is about 91% of the responses. It seems logical to adopt that opinion since having a detailed BOQ would mean a lot of small items in a project grouped in the BOQ. If a variation occurs in a project, it would be easier to spot which items are directly affected by that variation which would make it very easy to measure those items again in the context of the applied variation. This is unlike the brief BOQs produced by brief MOMs where the inclusive approach is applied in a frequent manner and on the condition of variations, this might cause a lot of

problems. The problems can occur from the fact that the item affected by variation would most likely include another small items that are not affected by that variation, so when a contractor submits the price of the whole item affected by the variation, the consultant would debate the price of the included items. A consequent step would be the consultant requesting a breakdown of the original cost of the items which would then be debated when the contractor submits it and there would be claims occurring that might evolve into disputes.

e) Increase price of tender due to pricing of small items

The results of this question came as shown in figure 3-9 below

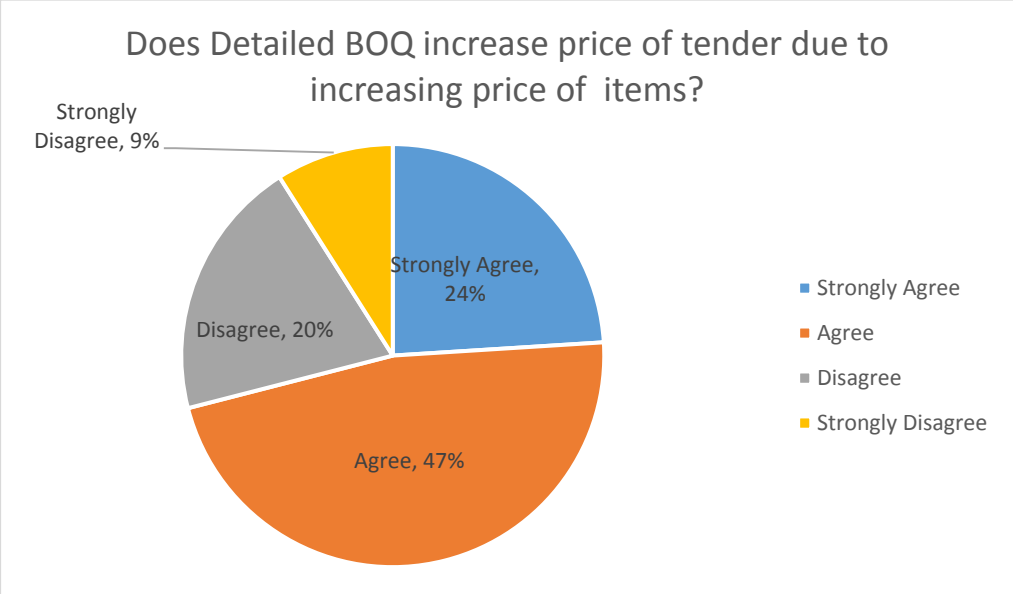

Figure 3-9 Does detailed BOQ increase tender price due to increasing price of items?

It is obvious that 24% of the responses consider the detailed BOQ to be strongly increasing the price of the tender through increasing the price of the items. While 47% consider that detailed BOQs might be causing an effect on increasing the tender price. The point of view in this argument seems to be that increasing the number of items in a bill to be priced by breaking down the project to the smallest components would by default force each contractor pricing the BOQ to judge each of the small items separately and deal with each item as a means to increase the profit earned. When all of these many priced items are grouped together, it is more likely that the total price of the project would be higher than if the items were priced with the inclusive approach.

On the other hand, there is an opposing opinion which formed around 29% which is a significant percentage of respondents who believe that a detailed BOQ won't have an effect on the increase of the tender price. They might believe that the price of an item should be the same as the price of its sub-components if this item was to be broken down. This point seems debatable, but with the presence of a higher supporting percentage, it would seem fair to adopt the point of view that detailed BOQs can be a reason for the increase in the tender price through pricing small items.

6. Brief BOQs

   a) Help in quick issuance of tender documents

The answers to this question came as shown in figure 3-10 below

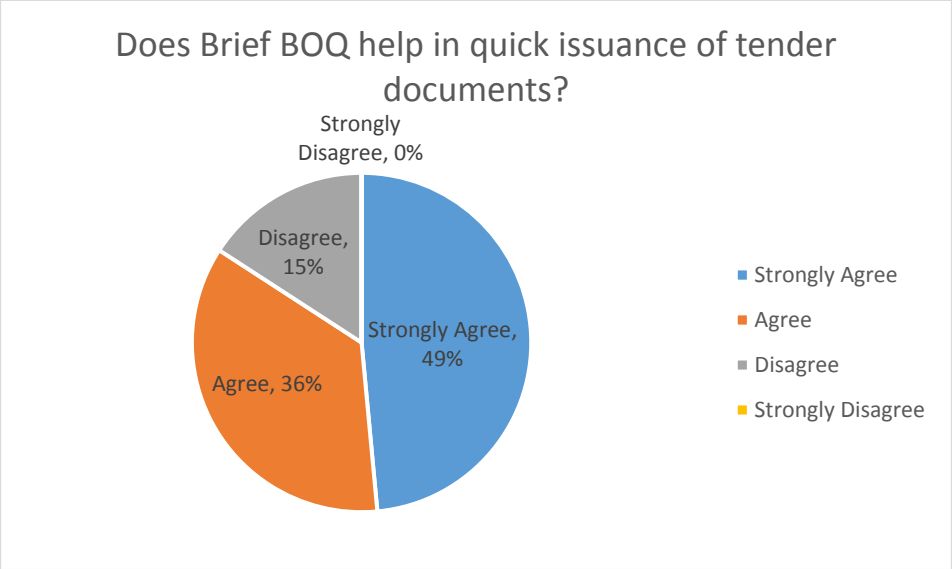

Figure 3-10 Does brief BOQ help in quick issuance of tender documents?

It is obvious that around 49% were strongly supporting the point that producing a brief BOQ would be a factor in the quick issuance of the tender documents for a certain project and around 36% consider that brief BOQs may be suitable for producing the tender documents quickly. The overall agreeing percentage is around 85% of the responses. While on the other hand, there is a 15% of the responses who consider that brief BOQs are not an important factor in the quick issuance of the tender documents.

When investigating the responses, it is logical to think that producing a brief BOQ means that the items which are priced follow the inclusive approach which might mean less items to be taken off so the taking off would take less time (considering manual take-off) and for the set of rules present, it will be general rules for measuring the items and writing the bill. All of this seem to be factors that aid the fast preparation of the BOQs which are part of the tender documents or at least avoid having the BOQs as the source of delay in producing the BOQs.

b) Neglects necessary details

The answers to this question came as shown in figure 3-11 below

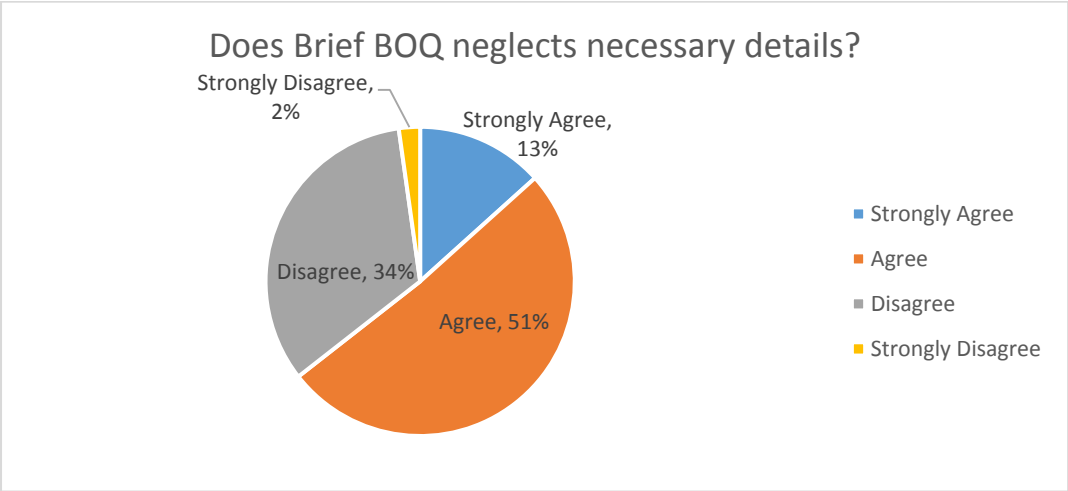

Figure 3-11 Does Brief BOQ neglect necessary details

It is obvious that 13% of the respondents strongly support the idea that a brief BOQ might neglect necessary details that could have facilitated the interpretation of the BOQ when executing the project. Another 51% of the respondents consider that idea about brief BOQs that it may be neglecting necessary details which could have facilitated the execution in a better way. This opinion can be based on the fact that using MOMs that produce brief BOQs would most of the time follow the inclusive approach which could focus on the bigger picture of the items and neglect some items that should have been taken into consideration. Those MOMs also would most likely give general rules of pricing and defining the items and this is most likely to ignore some important points that could have mentioned regarding the items. In addition, MOMs

producing brief BOQs are most likely to be missing some helpful guiding notes regarding some points such as dealing with the project risks.

On the other hand, there is a significant percentage of respondents who are against that argument who form around 34% and another 2% who totally oppose that idea. Adding these two groups would result in a total of 36% rejecting the idea the Brief BOQs neglect necessary details. This is a significant percentage that needs to be investigated. The percentage of rejections came mainly from the contractors who formed around 75% out of the total rejecting votes and 26% out of the total responses which means most of the contractors were against the accusation that Brief BOQs neglect necessary details. This might be because contractors might be biased towards using a MOM that produces brief BOQs and this type of BOQs is easier for a contractor to price its items during the tendering process. In addition, during execution if a discrepancy appeared in the BOQ, the contractor would submit a claim for variation or compensation and this would help if the contractor is losing money in the project. Also, for the category disagreeing other than the contractors, there is a belief that some Brief BOQs following POMI for example are sometimes modified by referring to the CSI code which could make it a custom POMI and this may improve the POMI making its descriptions for the items less general.

c) Cannot be understood by contractors causing mistakes in pricing

The results for this question came as shown in figure 3-12 below

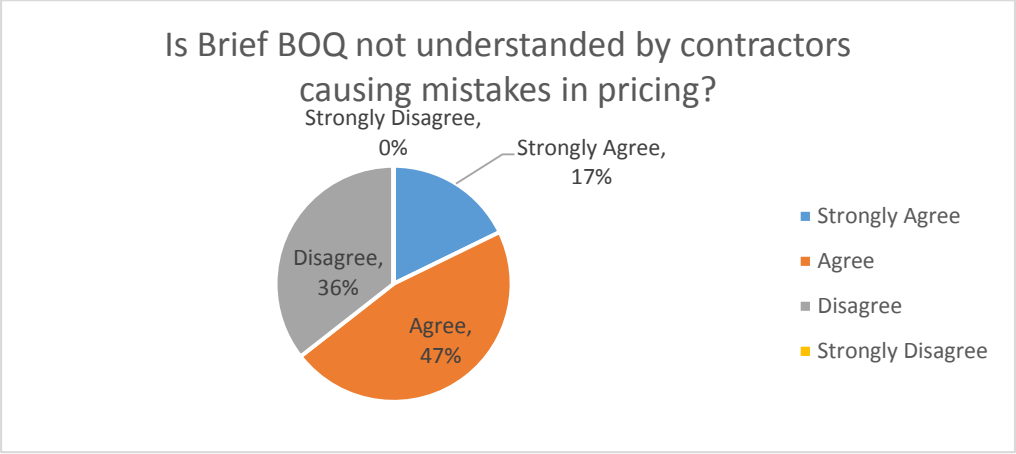

Figure 3-12 Is brief BOQ not understood by contractors causing mistakes in pricing?

It is obvious that 17% of the respondents strongly agree with the idea that a brief BOQ be misleading for the contractors which is more likely to cause problems during project execution as a result of inaccuracy of pricing. Also, there are 47% of the respondents who might be supporting that idea. A logical reason for this agreement with the investigated idea is that the brief MOMs may contain general information on how to describe the items to be priced by the contractors. This types of BOQs also follow the inclusive approach which increases the probability of misunderstandings from the side of the contractor towards the required scope by sometimes forgetting to take into consideration all the items required to achieve the scope.

On the other hand 36% of the respondents disagree with that argument and they don't see that brief BOQs are misleading for contractors when pricing. This 36% is a significant percentage which needs investigation to be able to judge. The percentage of the contractors disagreeing forms around 56% of the disagreeing population and this may be justified considering that contractors might be in favor of the brief BOQs which help them price the items with less effort and at the same time might be in their favor in case of variations so that they can submit claims to increase their prices of the items as discussed in the previous question. For the rest of the disagreeing percentage, this involves consultants and clients and this may be justified considering that some consultants believe that the brief MOMs can be modified by adding some references like the CSI that would make the contractor liable to refer to the specifications of the project which may decrease the possibility of misunderstandings by the contractor.

d) Brief BOQs obstacle the quantification of variations

The results for this question came as shown in figure 3-13 below

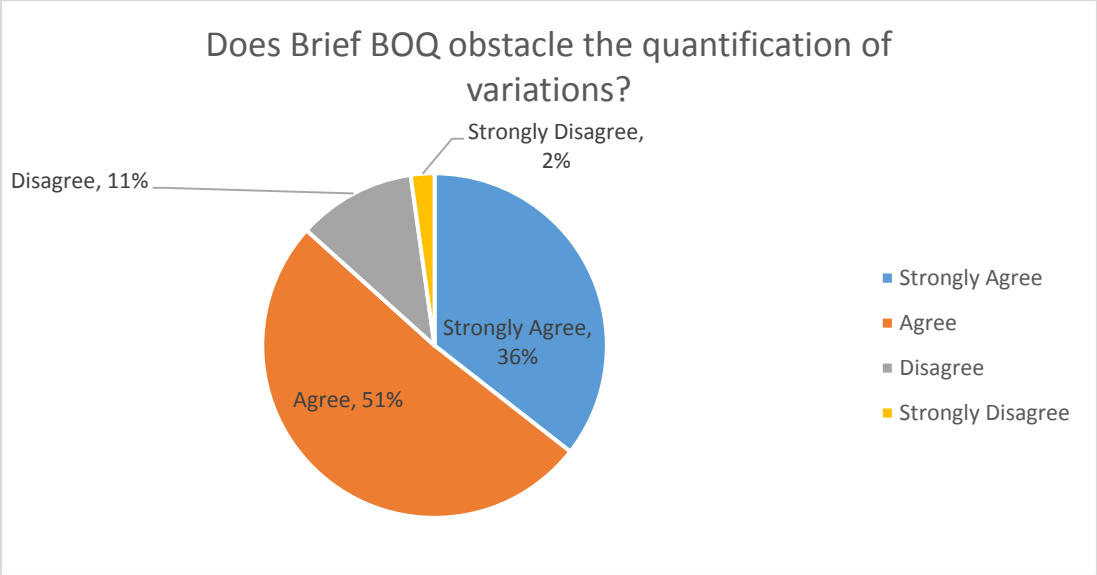

Figure 3-13 Does Brief BOQ obstacle the quantification of variations?

It is obvious that around 36% of the respondents strongly support the idea that brief BOQs make it hard to quantify the compensation amount for a variation that occurs during the project execution. In addition around 51% of the respondents are willing to agree that brief BOQs might be an obstacle in quantifying the project variations. This seems logical taking into consideration that MOMs which are used to produce brief BOQs don't breakdown an item to its smallest details so when a variation occurs, it would be hard to analyze the price of the items that are affected by that variations and this would cause debatable discussions between the contractor and the consultant and these discussions may evolve to disputes.

On the other hand, around 13% disagreed with the idea that the brief BOQs are not a problem when quantifying the items affected by a variation. However, it seems logical to adopt the opinion that brief BOQs are not preferred in quantifying the variations.

e) Brief BOQ is more likely to cause inaccuracy of pricing by decreasing or increasing the tender price

The results for this question came as shown in figure 3-14 below

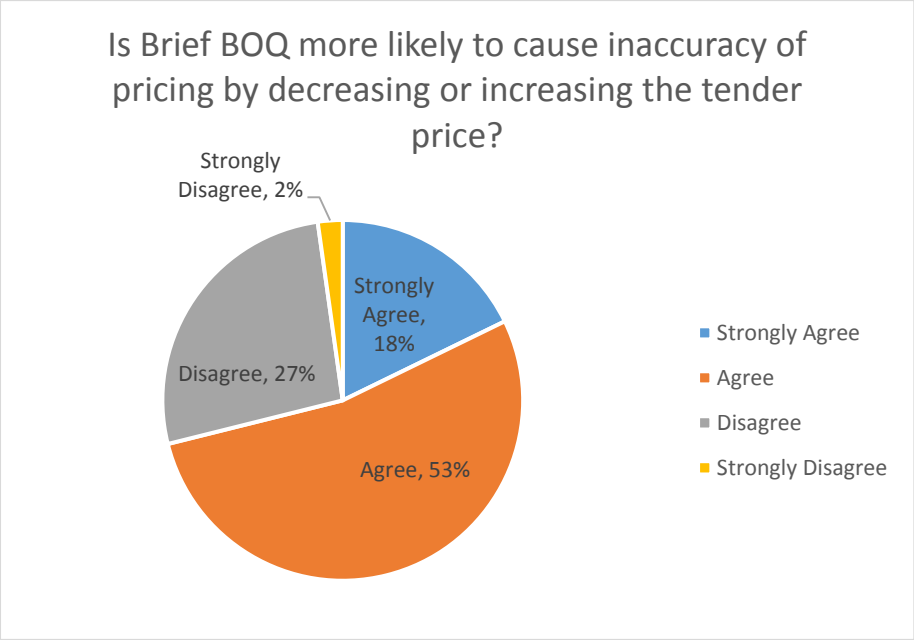

Figure 3-14 Is Brief BOQ more likely to cause inaccuracy of pricing by decreasing or increasing the tender price?

It is obvious that around 18% of the respondents strongly support the idea that a brief BOQ may result in inaccuracies regarding estimation of the tender prices and around 53% of the respondents see that these inaccuracies might be possible. A justification for these responses may be that brief BOQs deal with the project items as bulk items that consist of small items included within this bulk item. This might increase the probability of a contractor to make errors that may involve ignoring some of the small items and forgetting to include them in the estimation which would mistakenly decrease the tender price. Or in some cases, the contractor might price a small item and at the same time include its price by mistake on another bulk item which may result in double counting of the prices and by default would increase the price of the tender items.

On the other hand, 29% of the respondents didn't agree with that idea. They may seem to be convinced that a brief BOQ can decrease the items to be priced which may decrease the possibility of double counting of items. Also brief BOQs might not be an issue that decreases the price of the items in case the contractor is experienced and the BOQ clearly defines the item which might be the case if for example, CSI was included as a reference in POMI.

This point seems debatable and may be subjected to judgements since 29% of the responses is a significant value that should be taken into consideration before adopting certain trend.

7. What type of BOQ is preferred for the following project characteristics?

   a) Project performed for a local client

   The choices for this project parameter came as shown in figure 3-15 below

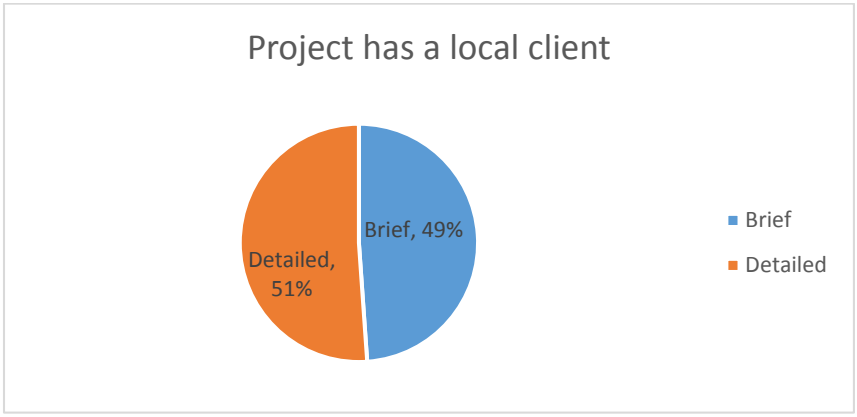

Figure3-15 BOQ type preferred if the project had a local client

It is obvious that around 51% of the respondents preferred a detailed BOQ type for the projects who have a local client against 49% who preferred a brief BOQ if the client requesting a project was local. The point of those choosing brief BOQ for a local client maybe relying on the fact that a client who belongs to the same country of the project is most likely to be aware of the country's situation and the conditions under which the projects are executed. This awareness of the client with the mentioned circumstances could possibly make the client tending to prefer to work with a brief BOQ that would be less likely to cause problems since the client would have more chances to avoid the problems that were possibly faced in previous projects. This brief BOQ could also be preferred due to its advantages such as easy prepared and so would decrease the time needed for BOQ preparation in the tendering process.

On the other hand, the sector who thinks that a detailed BOQ would be a preferred choice for a local client believes that detailed BOQs should be preferred regardless of the client's type.

This is because the client might be highly concerned about finishing the project with the least possible problems that could occur and so would choose to use a detailed BOQ regardless of the project conditions in order to decrease the risk of facing future problems resulting from the BOQs. As a result, it seems that the fact that the client is local is not a highly determining factor to which BOQ type would the client be biased towards.

b)Project performed by an international client

The choices for this project parameter came as shown in figure 3-16 below

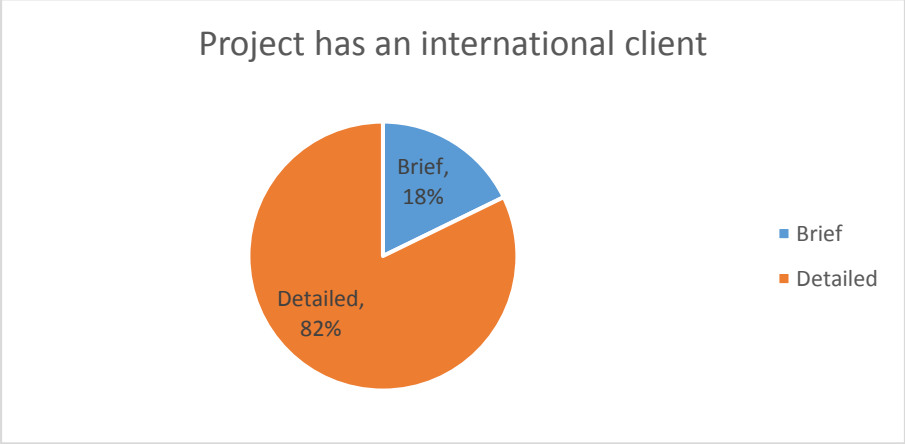

Figure 3-16 BOQ type preferred if the project had an international client

It is obvious that around 82% support the choice of the detailed BOQs to be prepared for projects who have an international client while only18% think that a brief BOQ would be chosen by an international client for its projects. The majority choosing a detailed BOQ for projects requested by an international client may be justified in the point that international clients would always be concerned about finishing the projects with less problems occurring from the BOQ during execution. The detailed BOQs as discussed in this research would make everything clear for the contractors and also the MOMs used in preparing these BOQs are most likely to provide guidelines on how to account for the risks when preparing the BOQs in addition to the clear description of the items needed to achieve the project scope.

On the other hand, the opposing sector who choose a brief BOQ for projects with an international client may be relying on the idea that a client may prefer to work with a brief

BOQ since it saves time when being prepared during the tender stage and would also save some of the costs incurred on preparing the BOQ. However, the highest sector of respondents believe that detailed BOQs are preferred for the projects with international clients.

Overall, it seems from the responses of the surveys for the two previous points that there is a high tendency to support the idea that any client would prefer a detailed BOQ regardless of the client's nationality if it is local in the county where the project is executed or the client is from a foreign country.

c) Project executed by local contractor

The choices for this project parameter came as shown in figure 3-17 below

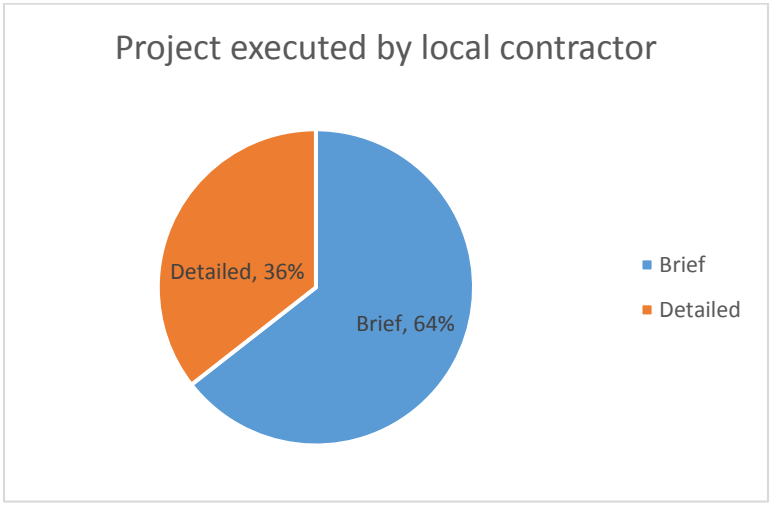

Figure 3-17 preferred type of BOQ if project is to be executed by local contractor

It is obvious that around 64% of the responses preferred a brief BOQ for projects which are executed by local contractors against a 36% who preferred a detailed BOQ for projects which are executed by local contractors. 93% of the contractors responded by choosing a brief BOQ. Analyzing these responses in the context of the questionnaire and the literature, it seems that most contractors are biased towards the brief BOQs prepared by brief MOMs. This can be explained by the fact that brief BOQs are most likely to cause problems during the execution of the project and these problems would result in variations which would in

most of the cases be in favor of the contractors. These variations can help the contractor compensate for the money losses if there are any. Other parties like consultants and clients would support the idea of brief BOQ for local contractors depending on the idea that local contractors are most probably unaware of how to use MOMs that produce detailed BOQs and so this can cause pricing problems such as double counting of items. Also, local clients maybe involved in other projects with the local contractors and may have history of projects between them. So if there is a problem that occurs in a project as a result of variation for example, maybe solved by friendly negotiations. So in this case exerting much effort and spending more money for preparing a detailed BOQ might be an exaggeration.

For the other sector choosing a detailed BOQ, this maybe as a belief that contractors are most likely to depend on variations in compensating for their losses or underestimation of items, so it would be wise to avoid variation problems and so produce a detailed BOQ that would have clear breakdown of the items so as to minimize the variation problems.

d)Project executed by international contractor

The choices for this project parameter came as shown in figure 3-18 below

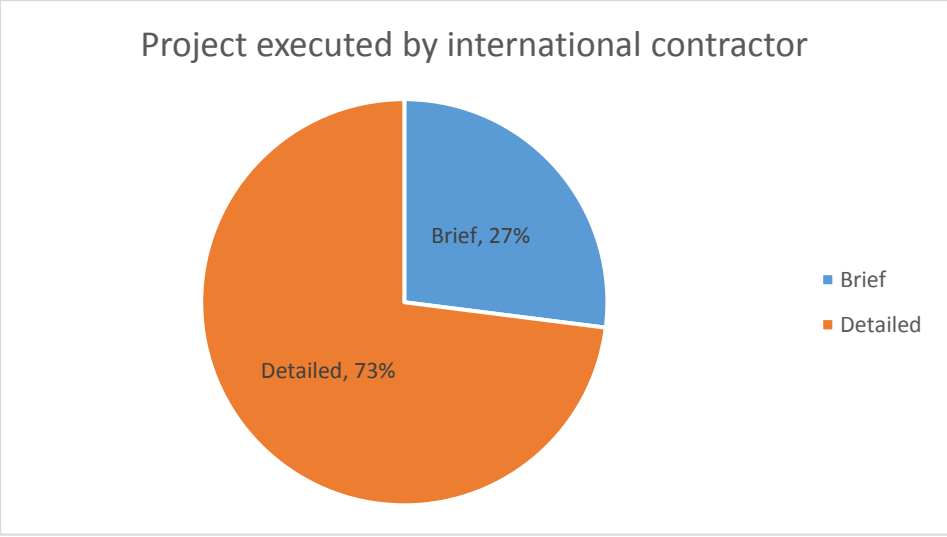

Figure 3-18 Preferred type of BOQ if project is to be executed by international contractor

It is obvious that around 73% of the responses prefer a detailed BOQ for the project is it was to be executed by an international contractor against 27% who prefer a brief BOQ for an international contractor. The difference between the two percentages is low which gives an indication that an international contractor is not a factor that is highly determining the type of BOQ chosen for the project. For the responses supporting the detailed BOQ, this can be justified in the point that detailed BOQs depend on MOMs that can be helpful in reducing the project problems through identifying the items clearly and also breaks down the project works into the smallest detailed items which can help in case of variations. Also, BOQs which are written following a detailed MOMs can have the risks anticipated and accounted for in pricing through some MOM rules. So an international contractor may prefer a detailed BOQ to help save problems which can occur in a foreign country where rules and laws might not be in the favor of the contractor. Also, international contractors are probably most likely to be aware of the different MOMs used and so pricing a BOQ following a detailed MOM would be a universal language in pricing which can decrease the probability of having misinterpretation for the project scope.

On the other hand, the responses supporting a brief BOQ could possibly be depending on the point that contractors no matter their nationalities would always be biased to the advantage provided to them by brief BOQs that can help them cover for their losses from the variations that can occur due to the BOQ discrepancies. Also, brief BOQs are easy in pricing and takes less effort and time than detailed BOQs and this is why a contractor regardless of its nationality may always be likely to prefer working with a brief BOQ.

Overall, it seems from the responses of the surveys for the two previous points that there is a high tendency to support the idea that any contractor would prefer a brief BOQ regardless of the contractor’s nationality if it is local in the county where the project is executed or the contractor is from a foreign country.

e)Project with high contract value

The choices for this project parameter came as shown in figure 3-19 below

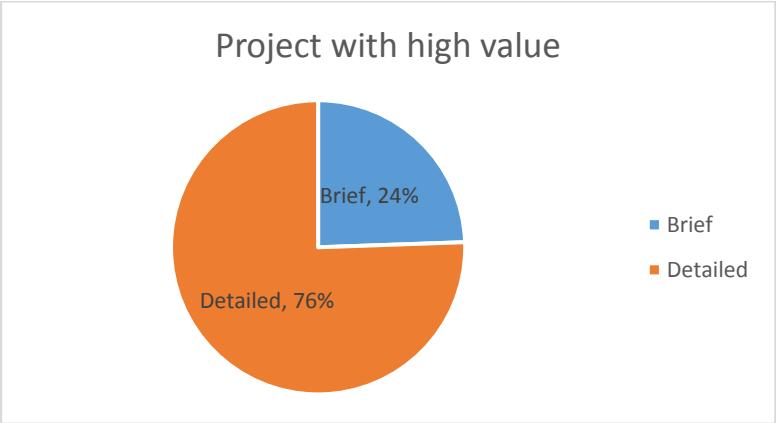

Figure 3-19 Preferred BOQ type for a project with high contract value

It is obvious that around 76% of the respondents preferred a detailed BOQ for a project with high contract value against 24% choosing a brief BOQ for a project with high contract value. The high percentage choosing a detailed BOQ may be justified considering that detailed BOQs decrease the probability of misinterpretations by the contractors to the project scope in addition to the fact that their MOMs provide clear guidelines on how to breakdown the project items so that all project works are covered. Also the MOMs provide basis on dealing with the project risks and quantifying them which makes the estimated price of a project most likely to be near the actual price when executing the project. Also, if variations occur, it is easy to quantify them in a way to avoid claims and disputes which is an important factor that would probably help decrease the probability of a project to be delayed as a result of conflicts since these delays would probably affect the large projects with high contract value.

On the other hand, a significant percentage chose a brief BOQ to be produced for projects with high contract value. The point behind this choice maybe depending on the fact that these projects might contain large amount of works that are difficult to quantify and so using an MOM like NRM or CESMM would require much effort and time in preparing the BOQ which might delay the project start. However, the majority of the responses chose a detailed BOQ.

f) Project with low contract value

The choices for this project parameter came as shown in figure 3-20 below

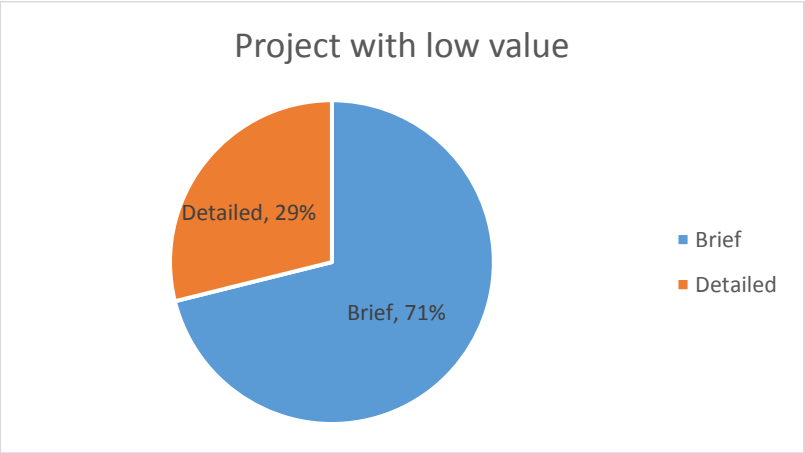

Figure 3-20 preferred BOQ type for projects with low contract value

It is obvious that around 71% of the respondents chose a brief BOQ for projects with low contractual value against 29% who chose a detailed BOQ for projects with low contractual value. The justification behind the majority choosing a brief BOQ may be attributed to the fact that low value projects would probably have less probability in facing problems during execution and the possibility of having variations might be very low, so a suitable BOQ choice may be the brief type. This is because brief BOQs need less effort in pricing and would take less time.

On the other hand, the side choosing a detailed BOQ despite the low project value of the project may depend on the point that a detailed BOQ is always needed regardless of the project value. This is because applying the detailed MOM rules to prepare the detailed BOQs would need less effort to be applied in case of low value projects that are expected to have less work items. This effort might be extra, but it could be important to avoid problems that can face the project and these problems might increase the price of the project and cause problems which would turn a simple project into an annoying one. As a result detailed BOQs may be needed to avoid complicating simple projects. However, the majority responded by choosing a brief BOQ for a project with low contractual value.

g)Project with lump sum contract

The choices for this project parameter came as shown in figure 3-21 below

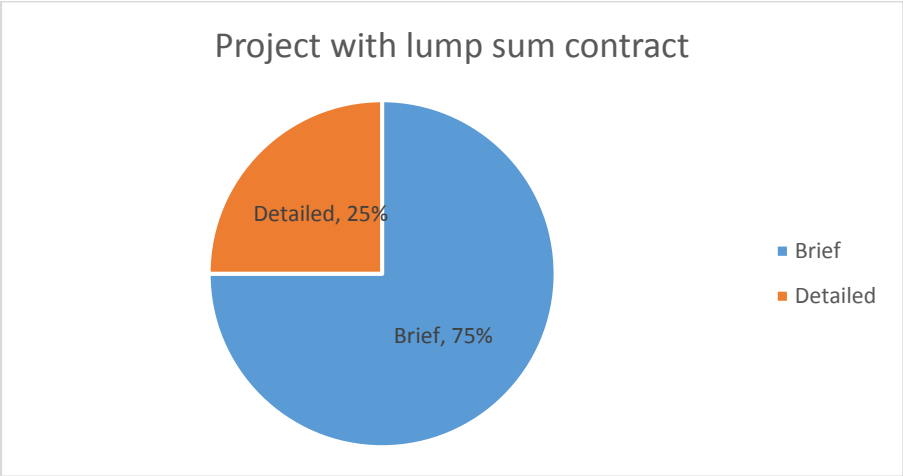

Figure 3-21 Preferred type of BOQ for a project with lump sum contract

It is obvious that around 75% of the respondents chose a brief BOQ for projects with lump sum contracts against 25% who chose a detailed BOQ for a lump sum contract project. The majority choosing a brief BOQ can be justified considering that in a lump sum contract, the BOQ does not have a great priority during the project execution since the value of the project is stated in the contract. The BOQ in case of a lump sum contract is only used when there is a variation to a certain item of the scope where the BOQ can give an indication of the amount that needs to be either added or omitted. For this purpose, it might be preferred to use a brief type of BOQs so as not to exert extra effort and time that wouldn't be needed.

On the other hand, for the opposing sector who chose a detailed type of BOQ, their point may still be stressing on the importance of the detailed BOQ regardless of some project parameters since detailed BOQs solve most of the project problems during execution. Analyzing the opposing percentage, it is obvious that 76% of these respondents belong to the sector of the owners and consultants who, unlike contractors would prefer to avoid project problems by using a detailed BOQ.

h)Project with unit price contract

The choices for this project parameter came as shown in figure 3-22 below

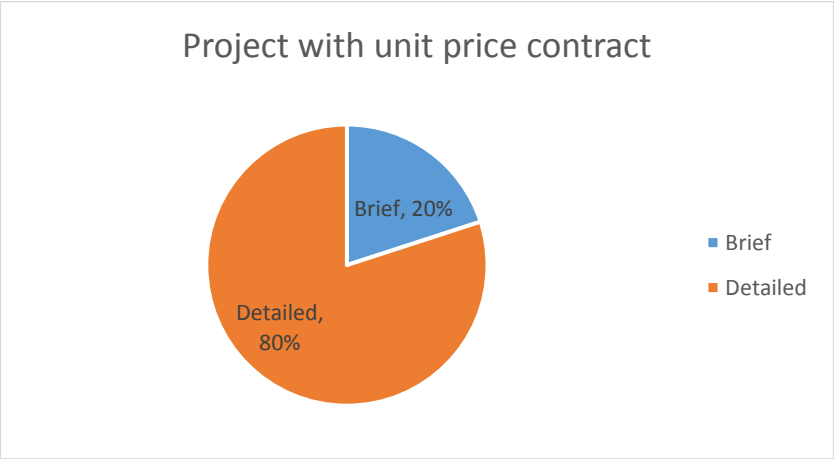

Figure 3-22 Preferred BOQ type for projects with unit price contracts

It is obvious that 80% of the respondents chose the detailed type of BOQs for a project with unit price contract while only 20% chose the brief type of BOQs for a project with unit price contract. This can be explained in the idea that MOMs used to prepare detailed BOQs breakdown the project items to the smallest possible detailed item in the project and this can give a clear price of each item separately. So when there is a variation in a unit price contract which is something that occurs with high rate in this type of contracts, the detailed BOQ would provide the clear indication of the exact change in the price of the items. So, as explained before, MOMs used for brief projects usually use the inclusive approach of including small items on larger items. This would cause a lot of conflicts between the consultant and the contractor in case there is a variation since the contractor would have to provide a clear breakdown for the original price of the item affected by the variation in order to justify the request of the compensation and this breakdown would be debatable by the consultant in most cases. So as a result, to save this trouble, the detailed BOQs may be the best types for unit price projects and this is supported by the responses to this question.

8. For the percentage weight of the 5 parameters affecting the decision making process in the choice of MOM, the result was as shown in table 3-1 below:

Table 3-1 Weights for project parameters affecting MOM choice

Project Parameter	Average Percentage Weight
Project Type	23%
Client's Nationality	26%
Contractor's Nationality	12%
Contract Value	21%
Contract Type	18%

Table 3.2.1 shows for the average rating of the weights of the project parameters in the MOM decision making process, the highest weight is for the client's nationality with 26% effectiveness in the decision making process and this is may be reasonable because the client has the upper hand in the project and so clients are likely to choose the MOM that suits them. The second ranking was for the project type followed by the contract value and the contract type while the lowest weight was given to the contractor's nationality.

b) Section 3 results

What is the preferred MOM for a BOQ preparation of the following types of projects if it was to be executed in the Middle East?

<u>Building Projects</u>

1. For Residential Building Projects

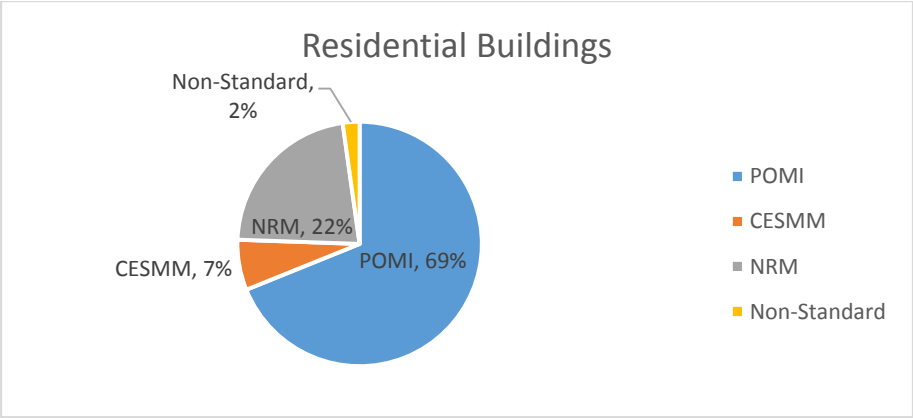

Figure 3-23 Preferred type of MOM for a residential building project

As shown in figure 3-23 above, the majority of the respondents forming 69% chose the POMI as the most preferred MOM for a residential buildings project if it was to be performed in the Middle East. The NRM came as a second choice with a percentage of 24% plus a 7% for CESMM and a 2% for non-standard MOMs. In this type of projects the choice is usually between NRM and POMI since NRM is specialized for building works and POMI is suitable to most types of projects. The majority choosing the POMI can be justified considering that POMI is commonly known in the Middle East and have been used in many projects unlike NRM that is a new method issued in 2012 and became effective in 2013 so most of the construction firms are still not aware of NRM or not accepting to change their practices in pricing. The small sector choosing CESMM may have depended on the point that the residential project may be in the form of residential complex that involves external work which is described better in CESMM. Also CESMM have a provision for simple buildings which may be the case in the building project.

2. For Office Building Projects

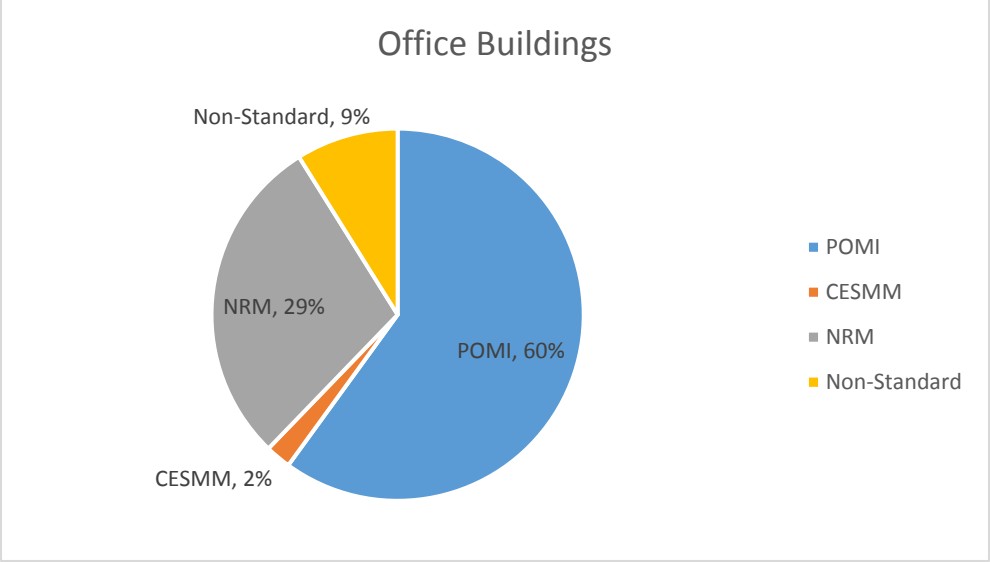

Figure 3-24 Preferred type of MOM for an office building project

As shown in figure 3-24 above, the majority of the choices of MOMs for the office buildings were in favor of POMI with a percentage of 60% and 29% chose the NRM. The choices for

CESMM formed 2% and 9% for non-standard MOMs. Again, the choice here should be mainly between the NRM and the POMI, and the same justification of preferring POMI over NRM can be applied except that NRM here is chosen with a higher percentage that in residential buildings. This can be an indication that the respondents would prefer the detailed NRM for complex projects that are not as simple as residential buildings. POMI is well known in the Middle East unlike NRM and also office buildings have a large amount of works in the finishes so using NRM would require a lot of effort in preparing the BOQ and in pricing it. So that is why many can prefer using the POMI in office building projects in the Middle East.

3. For Hospital Projects

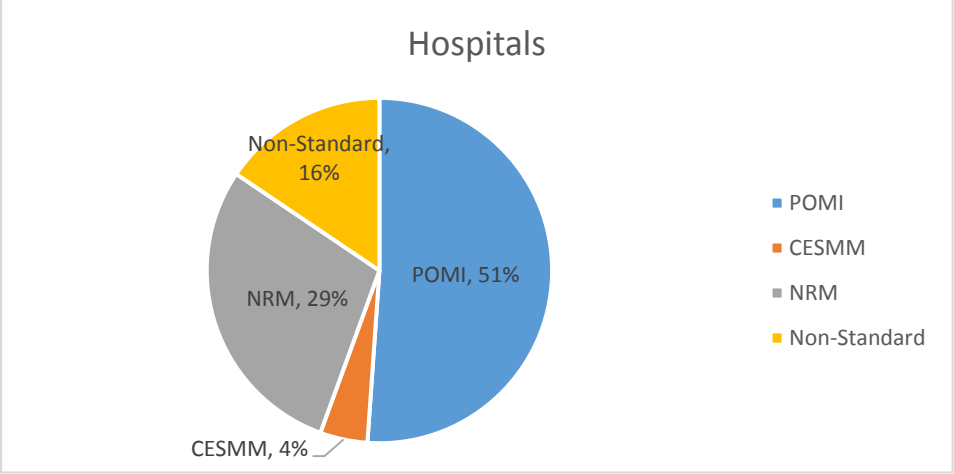

Figure 3-25 Preferred type of MOM for a hospital project

As shown in figure 3-25 above, the majority of respondents chose the POMI for hospital projects in the Middle East with a percentage of 51% while 29% chose POMI. Again, for a building project type, POMI is chosen with a percentage higher than NRM. Like the office buildings, the percentage choosing NRM is more than that choosing it for residential projects and the reason was discussed in the previous point; however, in hospital projects, a significant percentage forming around 16% chose non-standard MOMs and this can be justified considering that hospitals are non-conventional building projects that should require a lot of MEP works as well as finishes and also other complicated systems that need a specialized description in the BOQ and that is why a non-standard MOM could be chosen for the unconventional works of the hospitals.

4. For Hotel Projects

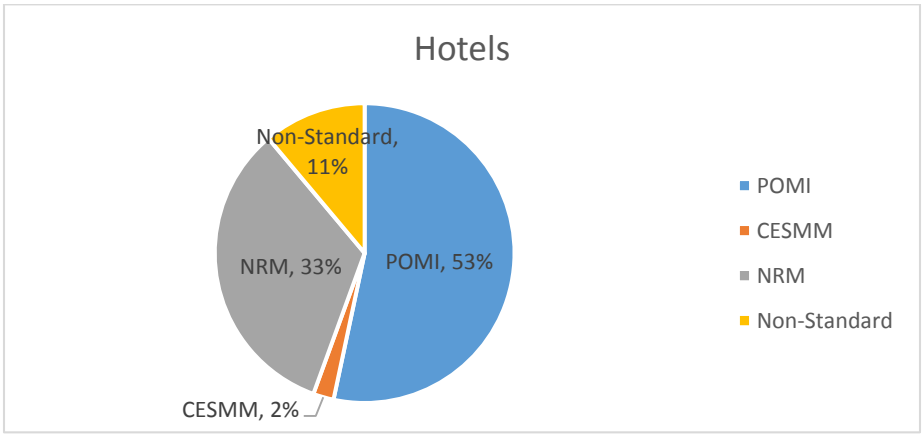

Figure 3-26 Preferred type of MOM for a hotel project

As shown in figure 3-26 above, the majority of responses again chose POMI with a percentage of 53% while 33% for NRM. This can be due to the large complicated hotel works that have a different kinds of finishes besides the complicated MEP works which would take a lot of time in preparing the BOQs, so this is why POMI may be chosen as a simple choice for the hotel projects. NRM on the other hand would mean too much details mentioned in the BOQ and would require more effort in the BOQ preparation, but at the same time would mean avoiding a lot of project risks that can occur with a high probability in complex building projects like the hotels, hospitals and office buildings.

Civil Projects

5. For Water and Waste Water Projects

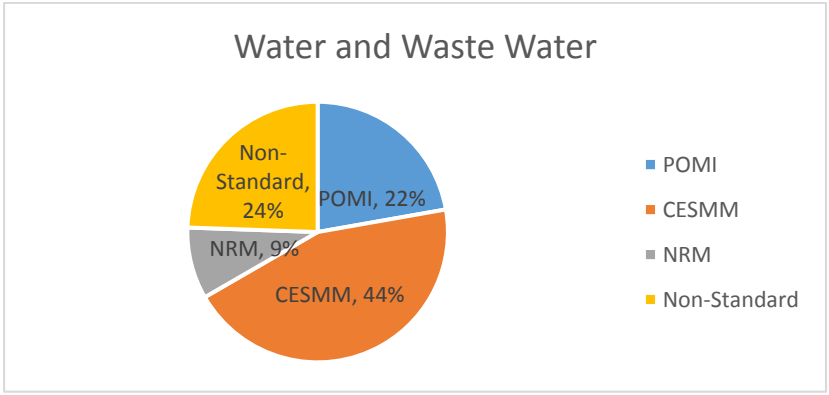

Figure 3-27 Preferred type of MOM for a water and waste water project

As shown in figure 3-27 above, the majority chose CESMM for this water and waste water projects with a percentage of 44% followed by 22% choosing POMI and 24% choosing non-standard MOMs. The justification behind the results may be in the point that water and waste water projects are non-conventional projects that can't be handled well by POMI so CESMM may be a specialized choice in handling these types of BOQs so this is why CESMM may be preferred. A significant percentage chose non-standard MOMs and this may be related to the point that water and waste water projects need special works that are hardly covered in details in standard MOMs so non-standard MOMs can be used that are prepared with care to satisfy the project requirements. There are also a small percentage choosing NRM for water and waste water projects and this can be attributed to the point that not everyone is aware of the NRM exact usage and that it is made for only building projects and can't handle BOQs for heavy civil projects like the water and waste water projects. So, the percentage choosing NRM may be only depending of the point that NRM is too detailed, but not aware of the fact that it is only for building works.

6. For Roads and Highways Project

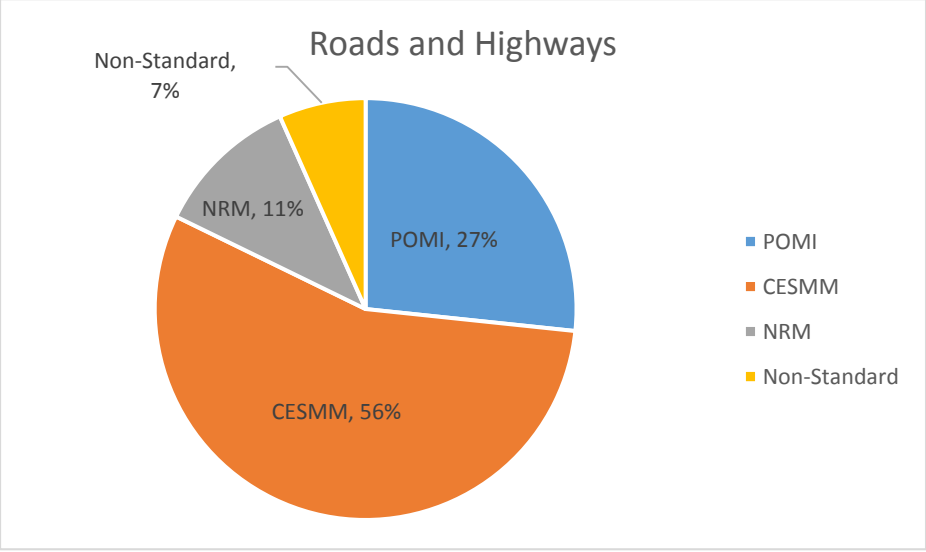

Figure 3-28 Preferred type of MOM for roads and highways projects

As shown in figure 3-28 above, the majority of the responses preferred CESMM for the roads and highway projects with a percentage of 56% and 27% preferred POMI which is a close difference for the percentage preference. This may be explained in the point that the sector choosing CESMM prefers using the detailed BOQs in dealing with roads and highway projects that involve high risks and have difficulty in quantifying the works during the tender stages so CESMM may be a better choice. The sector choosing POMI may depend on the point that it is well known in the Middle East and so it is always a valid choice in most project types due to being familiar and simple when preparing BOQs.

There is also a significant percentage of respondents who prefer NRM and they form around 11% of the responses who prefer using NRM for road and highway projects. Again, this shows unawareness about the true nature of the NRM and its unique purpose which is for preparing the BOQs for building works projects and they are not suitable for civil projects.

7. For Tunnels and Bridges Project

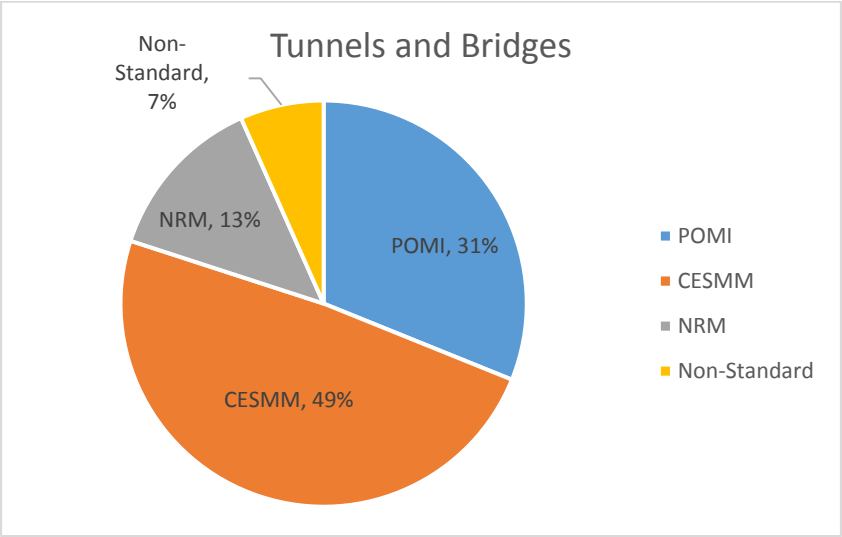

Figure 3-29 Preferred type of MOM for tunnels and bridges projects

As shown in figure 3-29 above, the majority of respondents chose CESMM for tunnels and bridges type of projects with a percentage of 49% and POMI was chosen with a closer percentage preference of 31%. CESMM is preferred with a high percentage for those who prefer to avoid risks of such civil projects and it is a specialized type of MOM that follows clear

detailed rules for producing the BOQs for this type of projects. POMI also has rules for measuring these types of projects and since POMI is familiar and simple, so it will always be present as a valid choice in dealing with tunnels and bridges projects.

Again, there is a noticeable percentage of respondents choosing the NRM which means that there is a lack of complete awareness to the purpose of NRM and that it is made for building works and can't handle BOQs for heavy civil projects.

3.3. Findings of analysis

Population

From the choices of the population section, it seems that most of those who returned the questionnaire have years of experience ranging from 0-10 years which means that MOMs is getting known recently in the new generations involved in the field of quantity surveying in the Middle East. Regarding the different types of MOMs that the respondents expressed experience with, it is obvious that most of the respondents showed experience with POMI which is compatible with the literature review points that POMI is the oldest MOM of the three investigated which made the Middle East start using it long time ago. This is in addition to the point that POMI is simple and so it is easily understood by parties involved in the project cost plan more than any other MOM. For CESMM, it showed a good percentage of recognition by the respondents since CESMM was introduced also from a long time and so it has been used with a good rate in civil projects, but not as high as the POMI in the Middle East. The high usage of CESMM shows that the parties may recognize that civil projects are of difficult nature and so a standard MOM should be used to prepare the BOQs for such projects. For the NRM, the results showed that NRM has the lowest recognition among the three methods and this is may be due the fact that it is a recently introduced MOM and its complexity makes it still not familiar to the firms involved in the construction industry.

Detailed BOQs

For the nature of the detailed BOQs prepared by detailed MOMs such as NRM and CESMM, it seems that most of the responses agree that detailed BOQs enhance the accuracy of pricing and easily understood by contractors in addition to aiding the quantification of variations. However, they may be a waste of time in case of small sized projects and can increase the price of tender items in case of double counting. In general, it is possible from the responses to assume that the category of the clients and consultants are somehow biased or prefer the detailed BOQs prepared by MOMs such as NRM and CESMM since they help avoid many project risks and can help decrease the problems faced during execution as a result of misinterpretation of the BOQ items or the project scope. On the other hand, contractors usually don't prefer dealing with these types of BOQs since they prevent them from claiming lots of variations that can compensate for a contractor's loss and also their complexity takes a lot of effort in pricing since they depend on pricing small items. These types of BOQs also involve detailed breakdown of items that most of the contractors are not familiar with pricing which is the case in the preliminaries section in the NRM2.

Brief BOQs

On the other hand, brief BOQs prepared by brief MOMs like POMI are considered familiar and simple in preparing BOQs beside the point that they help issuing tender documents faster. However, brief MOMs are not considered to give highly accurate prices and they can also cause misinterpretations by the contractors when pricing the BOQs. These misinterpretations can cause an inaccurate pricing for the project and these types of BOQs can sometimes neglect necessary details of the project beside the point that they are not very clear when there is a claim of variation that needs to be quantified. This is because of the inclusive approach followed by the brief MOMs which depends on including the price of small items or works within the total price of a major item in the BOQ. Despite that, it is preferred the most in the Middle Eastern projects due to their simplicity and familiarity. It would be logical from the results to conclude that these types of MOMs produce BOQs that are preferred by the contractors sector who are somehow biased towards the POMI since it saves time in pricing and can be a good document to support

their claims of variations due to misinterpretation of the BOQ items. Also brief MOMs are helpful to contractors in quantifying these variations since the breakdown of the item affected by variation to separate the items directly affected from those included would always be debatable and there is a high probability for the contractor to compensate for part of the project losses through claims resulting from variation orders.

Project parameters

- For the client nationality:

  It is obvious that most clients would prefer to use an MOM that prepares a detailed BOQ for its projects especially if the client was an international client from a foreign country who would like a detailed universal language for the projects to avoid risks. For local clients, some would prefer to use a brief MOM for the BOQ preparation since they are most likely aware by the contractors and there are relationships between some clients and some contractors which can facilitate solving any problem that can arise during the project execution as a result from the BOQ. But overall, clients normally prefer a detailed BOQ type.

- For the contractor's nationality:

  It is obvious that local contractors would prefer working with a brief MOM to prepare the BOQs since they are most likely to be familiar with these types of MOMs rather than the detailed ones. Also brief BOQs provide contractors with a lot of advantages that include easy understanding of the BOQ and require less effort in pricing the BOQs. This is besides the fact that they can the contractors compensate for some of the project losses through claims of variations. On the other hand, international contractors are most likely to prefer working with a detailed MOM that produces a detailed BOQ since it would save a lot of trouble that can result from misinterpretation of the project items in the BOQ and this is because foreign contractors don't usually prefer to be involved in disputes with clients of the native country since they might not be familiar with the laws in the project country. So overall, contractors prefer brief BOQs, but international contractors are more likely to go for a detailed one.

- For the Project value:

  Projects with high values are most likely to involve a lot of works and a high possibility of risks which would need a detailed BOQ to avoid problems that can obstacle the projects' progress so the effort done in preparing a detailed BOQ for a high value project is worth it to decrease the probability of undesirable consequences. On the other hand, for low value projects, most would prefer preparing a brief BOQ with less details since it would require less effort that may be suitable for the size of the project executed. Also, low value projects are expected to have conventional works that are simple and familiar to the project parties.

- For the contract type:

  In lump sum contracts, the BOQ doesn't have a huge priority compared to other contract documents since it may be mainly used as an indication of the value of possible project variations and so a brief BOQ would be a better choice. On the other hand, the BOQ in the unit price contracts has a huge importance and is relied on heavily during the project execution and so it is preferred to use an MOM that prepares a detailed BOQ.

Preferred MOMs for different project types constructed in the Middle East

- Building Projects

Regarding the building projects, it is obvious that POMI is preferred mostly over NRM when it comes to pricing of building projects in the Middle East due to the nature of works in the building projects which is simpler than most other project types. NRM is preferred by a relatively significant percentage for some building types that may need to have their BOQs handled with care, but still the complexity of NRM and the fact that NRM is still a new method that hasn't emerged yet in the Middle East makes it unlikely to be chosen by construction firms for projects. CESMM was marked by a very small category of the respondents which may indicate a lack of full awareness regarding the CESMM and the types of projects for which CESMM is used.

- Civil Projects

Regarding the civil projects, it is obvious that CESMM is also preferred as a choice for civil projects in the Middle East and the choice of POMI is competing with CESMM in civil projects. This is attributed to the fact that CESMM has been recognized in the Middle East since a long time ago as well as POMI so some clients would prefer using CESMM to decrease the risks of a project when being executed. However, POMI is still used at a competitive rate due to its familiarity and simplicity and so many clients would still rely on POMI regarding the civil projects.

NRM was also marked by some choices for civil projects which proves that there should be more awareness towards the purpose of the NRM that it is only for building projects and can't handle BOQs for civil projects.

4. Model

This section shows the process of creating the model based on the responses received throughout the questionnaire in addition to the user interface for the model. After the survey responses were analyzed, the next step was to produce a decision model so as to help automate the process of MOM selection based on the responses received throughout the questionnaire for question 7.

4.1. Model Construction

In the second section of the questionnaire, the questions were divided into separate parts; the first was to validate the literature review points and the second was for the purpose of creating the model which is specifically questions 7 and 8 regarding the choices of a detailed or brief BOQ. Section 3 also was designed for the purpose of aiding the decision model through letting the respondents choose the most suitable MOM for the different project types shown to them which would help give a percentage preference for the MOM according to the project type.

Question 7 results were analyzed and the percentages were shown in pie charts in the analysis section in chapter 3.2 and they showed the different preferences of the BOQ type according to each project parameter. However, section 3 results showed some discrepancies which were represented in the idea that a significant percentage of the respondents selected unsuitable MOMs for some kinds of projects. For example, some chose the CESMM for the category of building projects and others chose the NRM for the category of the heavy civil projects. Accordingly, when using the results of section 3 for the model, the discrepant results were removed and the percentage preference was recalculated after removing these results from the total sample. It was decided that the model would produce the most suitable MOM to be chosen for each project according to the choices of the type of BOQ by the respondents in question 7 of the questionnaire. The sector choosing a detailed BOQ would mean an MOM choice of either NRM or CESMM, so if the project belongs to the building projects category, the MOM chosen would be automatically NRM and CESMM for civil projects. Similarly, in section 3, the MOM chosen for each project type is considered in the decision making process of the model. If the project belonged to the civil projects category and the BOQ type chosen was detailed, then the MOM choice would automatically be CESMM.

For the choice of the brief BOQs, this would automatically mean the POMI is the chosen MOM regardless of the project type since POMI is suitable for both categories of the project.

The project parameters affecting the choice of the MOM in the model are as follows:

- Project Type
- Client Nationality
- Contractor Nationality
- Project Value
- Contract Type

The approach that would be followed to create the model would be through calculating a weighted average of the percentage preferences for all the 5 project parameters combined. In this project, the 5 parameters each had a percentage preference for its 2 possible options calculated from the responses in the questionnaire as shown in table 4-1 below:

Table 4-1 Percentage preference for each project parameter

Project Parameter	Percentage Preference	
	Brief	Detailed
Residential Buildings	74%	26%
Office Buildings	68%	32%
Hospitals	55%	45%
Hotels	54%	46%
Water & Waste Water	33%	67%
Roads & Highways	32%	68%
Tunnels & Bridges	39%	61%
Local client	49%	51%
International client	18%	82%
Local contractor	64%	36%
International contractor	27%	73%
High contract value	24%	76%
Low contract value	71%	29%
Lump sum contract	75%	25%
Unit price contract	20%	80%

The five project parameters that were deemed to be effective in the decision making process of the most suitable MOM for the project are explained as follows:

- For the Project Type

  The choice is for one of the first 7 rows in table 4-1 above, and each project type has its own percentage preference of detailed and brief BOQs based on the choices made by the questionnaire respondents in section 3 of the questionnaire. If the choices were for NRM or CESMM, this would be equivalent to detailed BOQs and if POMI, it would be equivalent to brief BOQs.

- For the client nationality

  The client can either be local or international. A local client means that the client belongs to the same country where the project is being constructed while an international client means that the client is requesting a project in a foreign country.

- For the contractor's nationality

  Same as the client's nationality; a local contractor would mean that the contractor belongs to the same country where the project is being executed. While an international contractor means that the contractor belongs to a foreign country other from that where the project is being executed.

- For the project value

  The range of values that define a high contract value were values above $100,000,000 and the low project values are those below this number. The currency was unified to be in US dollars.

- For the contract type

  The project type is either lump sum which is a fixed price contract or a unit price/re-measured contracts.

For the factors of the weights of the parameters affecting the decision model investigated in question 8 of the questionnaire, they were to be multiplied by the choices and calculate a weighted average as shown in table 4-2 below:

Table 4-2 Weights for the parameters affecting the decision making of the choice MOM

Project Parameter	Percentage Preference		Weight
	Brief	Detailed	
Residential Buildings	74%	26%	23%
Office Buildings	68%	32%	23%
Hospitals	55%	45%	23%
Hotels	54%	46%	23%
Water & Waste Water	33%	67%	23%
Roads & Highways	32%	68%	23%
Tunnels & Bridges	39%	61%	23%
local client	49%	51%	26%
international client	18%	82%	26%
local contractor	64%	36%	12%
international contractor	27%	73%	12%
high contract value	24%	76%	21%
low contract value	71%	29%	21%
lump sum contract	75%	25%	18%
unit price contract	20%	80%	18%

From the responses to question 8, it was obvious that the client nationality had an average weight of 26% which means that the client nationality is the most effective in decision making followed by the project type, contract value and the contract type and the least effective parameter is the contractor's nationality.

The choice mechanism is made by multiplying the weight of the project parameter by the corresponding preference percentage of the detailed and brief BOQs for each parameter and then getting the sum of this multiplication if each of the 2 columns for the detailed and brief BOQs. The highest percentage preference between the brief and detailed would guide the choice to which MOM type. The explanation is summarized in figure 4-1 below

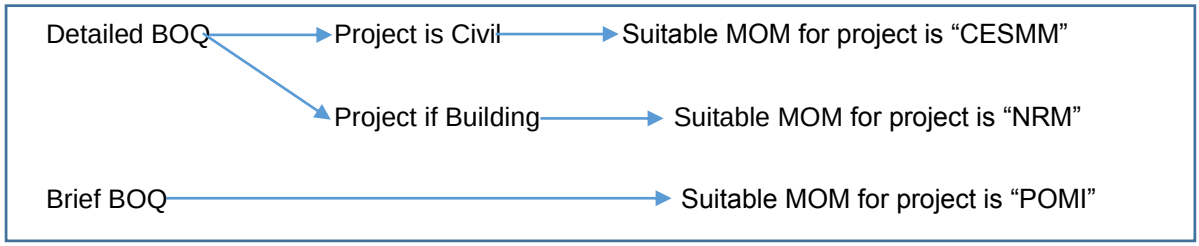

Figure 4-1 Flow chart for the decision making process of the suitable MOM for the model

As a simple testing of the extreme choices by combining the list of the parameters that have the highest percentage preference for brief BOQ which are the local client, local contractor, low contract value and lump sum contracts as shown in figure 4-2 below for an office building project:

Project Parameter	Value	Brief	Detailed
Project Type	Office Building	15.64%	7.36%
Client's Nationality	Local	12.71%	13.29%
Contractor's Nationality	Local	7.73%	4.27%
Project Value	10,000,000	14.93%	6.07%
Contract Type	Lump Sum	13.50%	4.50%
Result		**65%**	**35%**
Most Suitable MOM	POMI		

Figure 4-2 Combination giving a brief MOM

These values are expected to give a definite result of brief MOM and it resulted in POMI since the project belong to the building category, but the percentage preference is determined as shown in table 4-3 below:

Table 4-3 Preference percentage for brief MOM parameters

Project Parameter	Percentage Preference		Weight
	Brief	Detailed	
Office Building	68%	32%	23%
Local client	49%	51%	26%
Local contractor	64%	36%	12%
Low contract value	71%	29%	21%
Lump sum contract	75%	25%	18%
Result	65%	35%	

The results show a percentage preference of 65% towards the brief BOQ type and 35% towards the detailed BOQ type which is as expected. These percentage preferences were calculated by summing the product of multiplication of the weight by the percentage preference for each of the five factors.

On the other hand, trying a combination of parameters that have the highest percentage preference for detailed BOQs which are international client, international contractor, high contract value, and unit price contract for an office building project as shown in figure 4-2 below:

Project Parameter	Value	Brief	Detailed
Project Type	Office Building	15.64%	7.36%
Client's Nationality	International	4.62%	21.38%
Contractor's Nationality	International	3.20%	8.80%
Project Value	10,000,000,000	5.04%	15.96%
Contract Type	Unit Price	3.60%	14.40%
Result		**32%**	**68%**
Most Suitable MOM	NRM		

Figure 4-3 Highest combination giving a derailed MOM

These values are expected to give a definite result of detailed MOM and it resulted in NRM since the project belong to the building category, but the percentage preference is determined as shown in table 4-4 below:

Table 4-4 Process of calculating the percentage preference of the BOQ type depending on the weights of the project parameters

Project Parameter	Percentage Preference		Weight
	Brief	Detailed	
Office Building			
International Client	18%	82%	29%
International Contractor	27%	73%	20%
High Contract Value	24%	76%	26%
Unit Price Contract	20%	80%	25%
Result	32%	68%	

The results show a percentage preference of 68% towards the detailed BOQ type and 32% towards the brief BOQ type which is as expected.

4.2. User Interface for the Model

The next step is to show the final interface for the model and this is done using the VBA programming language which is the “Visual Basic for Applications” for producing the input and output screen to be shown for the users for the sake of inputting the project parameters and the final result would be shown to them.

The command screen is shown in figure 4-3 below

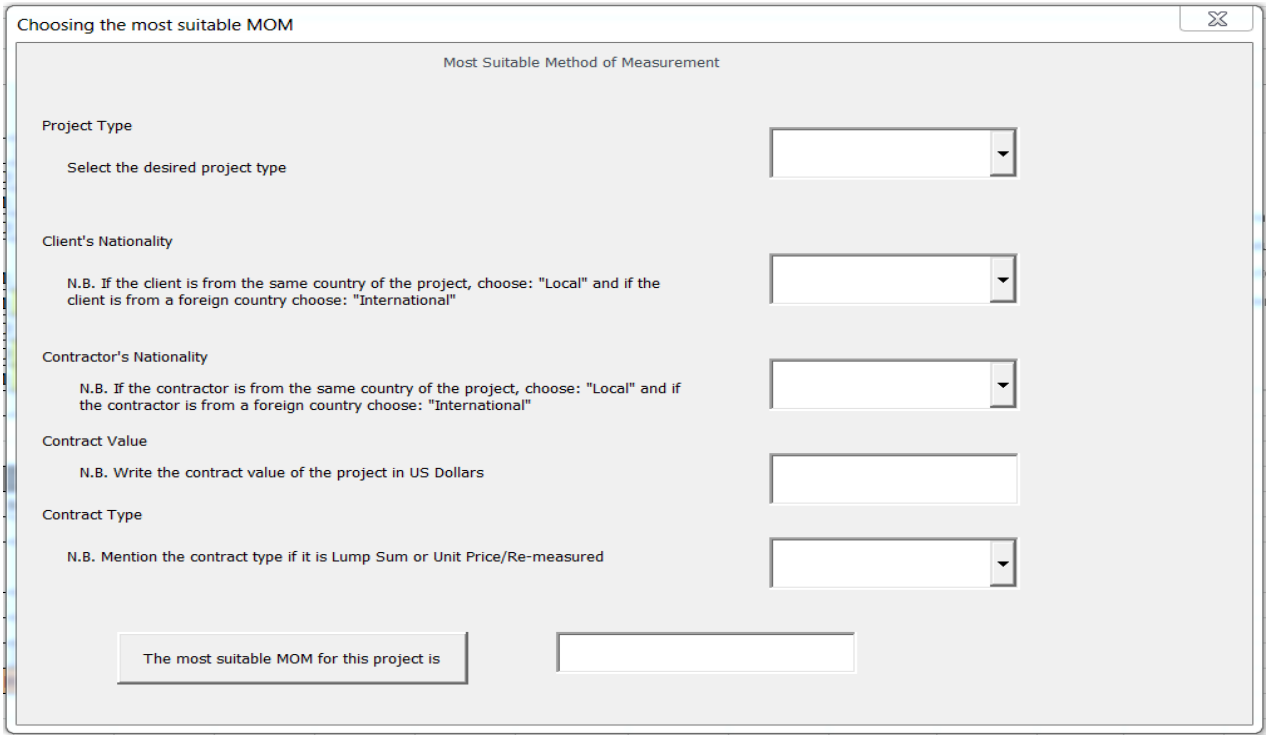

Figure 4-4 User Interface of the model for choosing the most suitable MOM

As shown in figure 4.2.1, the model requires an input for 5 items; the project type, the client’s nationality, the contractor’s nationality, the contract value and the contract type. Under each requirement label, there is an explanation of the options provided for the user to make his choices. For example, there is an explanation of the difference between the local and international choices in the case of the client and contractor’s nationalities. Also, there is an explanation of the project value to be entered and its currency to be in US dollars. Finally, the user would have to click on the button titled” The most suitable MOM for

this project is" in order for the program to provide which MOM is suitable based on the equations applied in the excel model shown in the model construction section 4.1. Model Construction.

In this model, the user is provided with a dropdown list showing the different possible types of projects which are Residential Building, Office Building, Hospital, Hotel, Water & Waste Water, Roads & Highways, and Tunnels & Bridges. The user selects the type of project and then for each of the project parameters there is a dropdown list showing the different possible options. For the Client and Contractor's Nationality it is either "Local" or "International", and for the Contract Type it is either "Unit Price" or "Lump Sum". The project value is the only number, the user would have to type. The user selects the desired combination of the project parameters and then the most suitable MOM is determined based on the score of preference percentage of BOQ types shown in section 4.1. Model Construction.

An example to demonstrate the inputs and output is shown in figure 4-4 below:

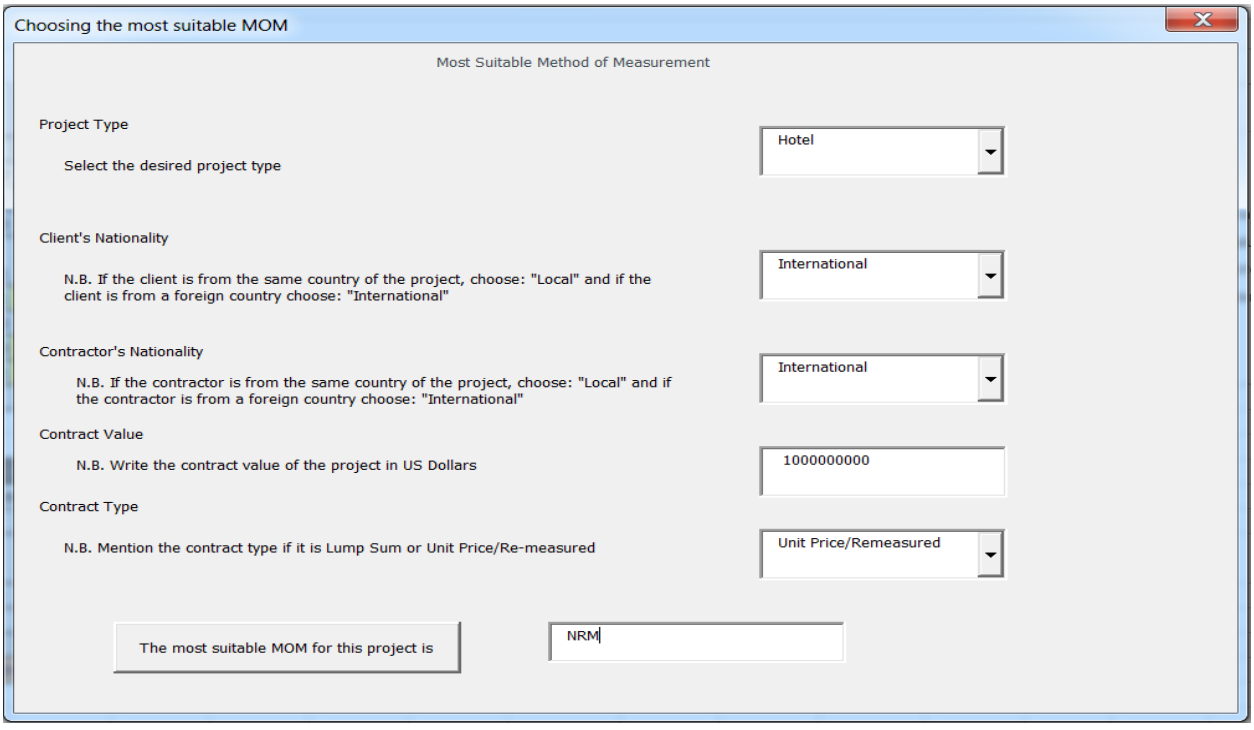

Figure 4-5 Example for the inputs and output of the model

In this example, the user chooses a project type of a hotel done for an international client by an international contractor with a value of $10,000,000,000 by a unit price/re-measured contract. The output would be the NRM as the most suitable MOM to be chosen for these project parameters.

5. Model Verification and Validation

This section discusses the steps made for the verification of the model and the validation through using case studies from real life projects.

5.1. Model Verification

The model verification is to check that the model truly implements the assumptions correctly through several possible tests. The first simple check is to input the extremes of the project parameters that will result in a previously known answer for the MOM choice.

The first combination of parameters that would produce for sure an MOM that is used to prepare a brief BOQ is by combining the parameters with high preference percentages for the brief BOQ which are a local client, local contractor, low value project and a lump sum contract as shown in figure 5-1 below:

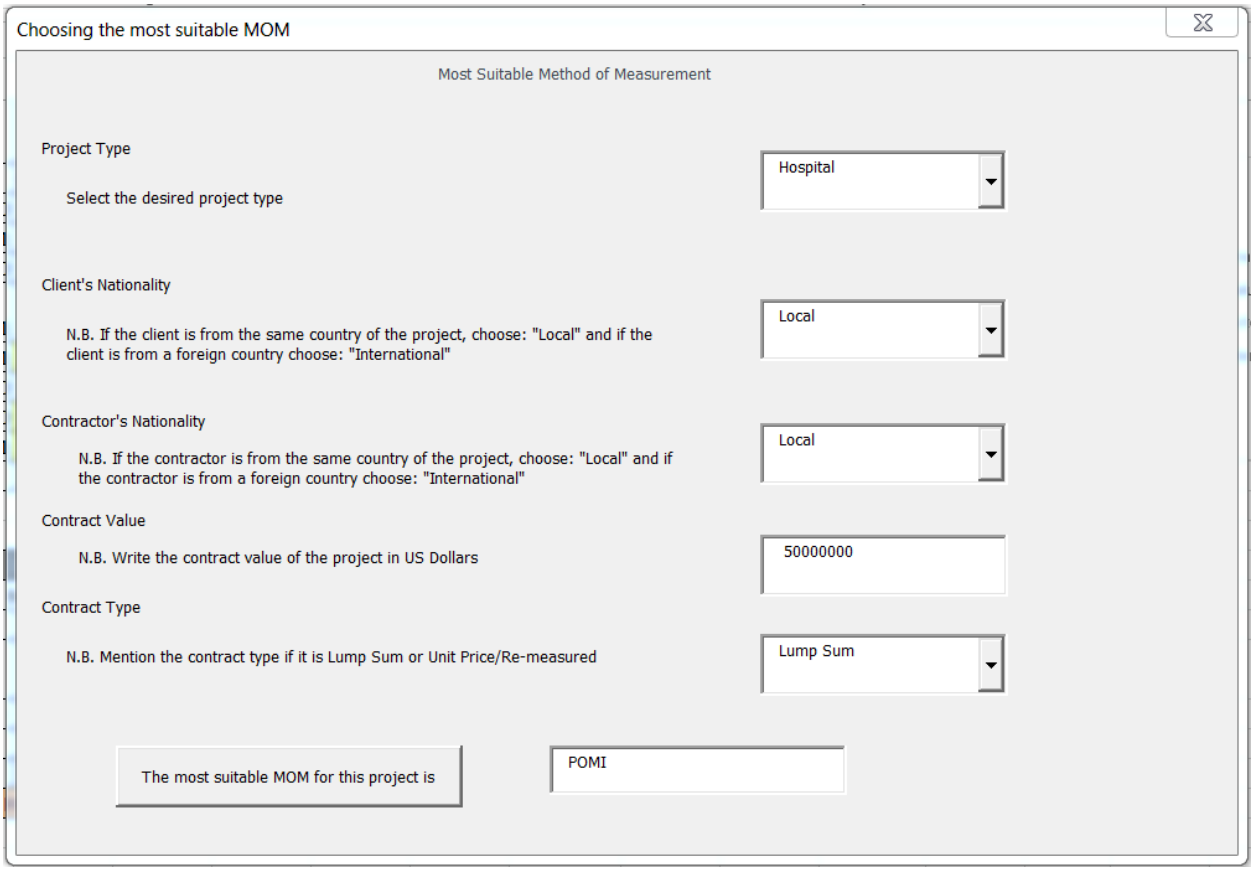

Figure 5-1 Combination of parameters producing a brief MOM

As expected, the combination of parameters used produced an MOM choice of POMI. Checking the other extreme for a detailed MOM of a building project would be by combining the parameters with the choices that have the highest percentage preference of the detailed BOQs. The parameters are international client, international contractor, a high project value and a unit price/re-measured contract as shown in figure 5-2 below:

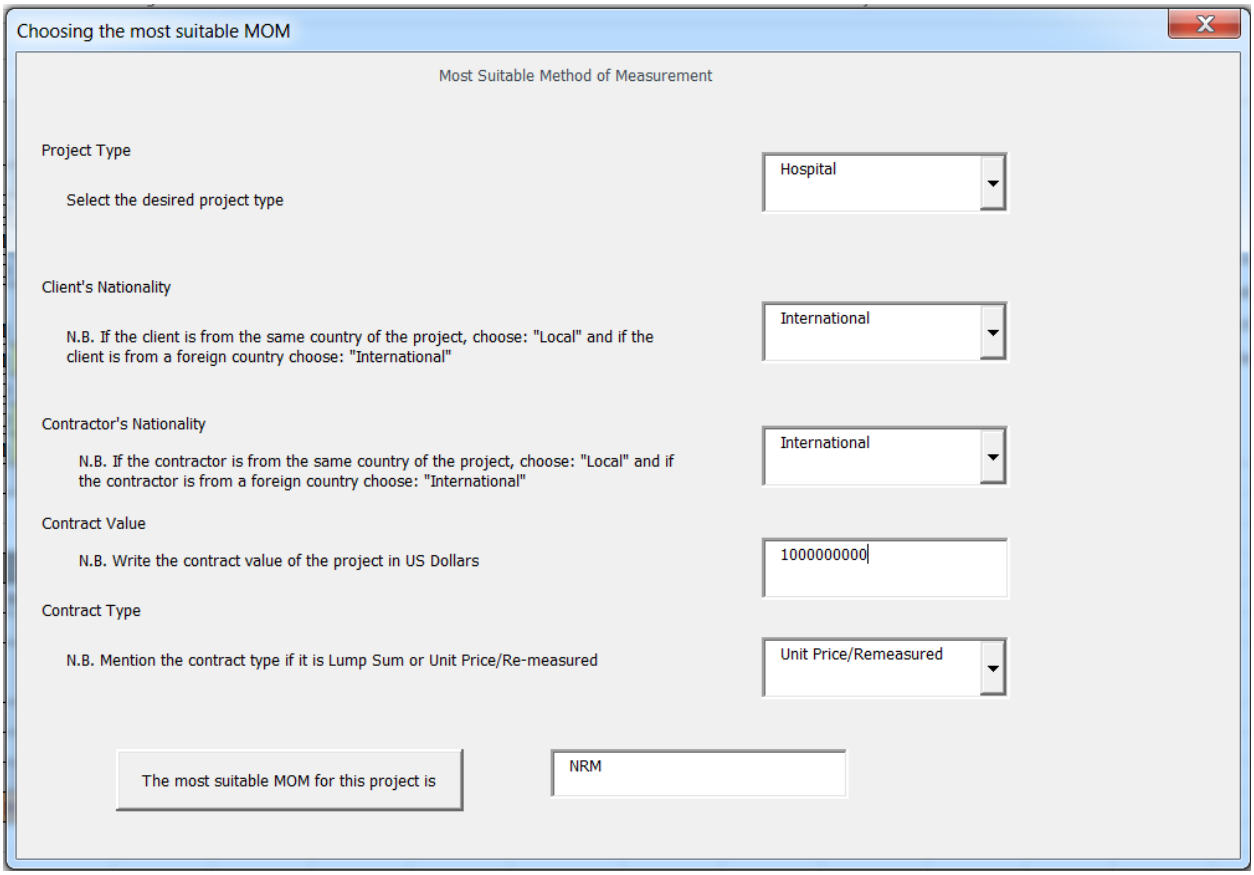

Figure 5-2 Combination of parameters producing a detailed MOM for a building project

As expected, the result was an MOM choice of NRM since the project is a building project. The same combination of parameters can be reused for a civil project in order to check the validity of the code for a choice of one of the civil projects as shown in figure 5-3 below:

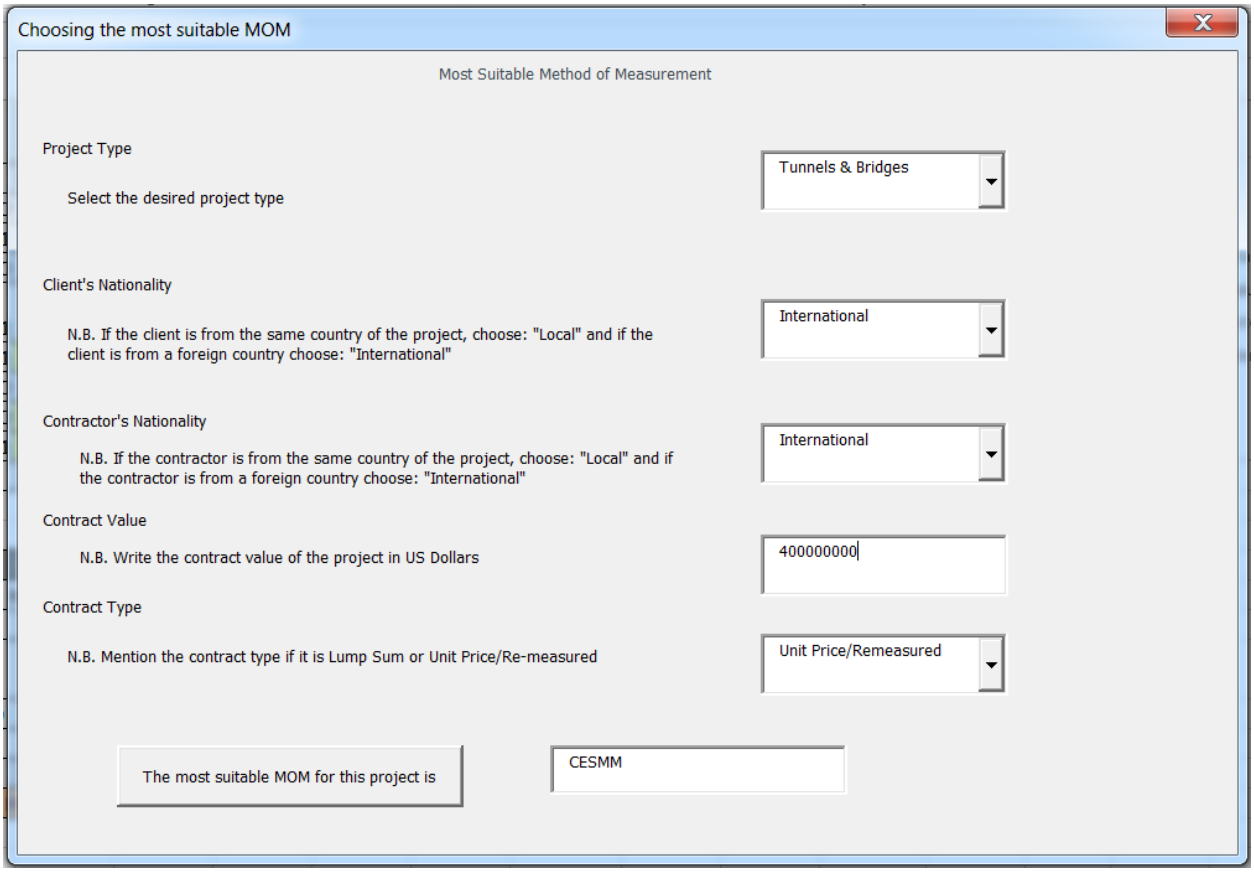

Figure 5-3 Combination of parameters producing a detailed MOM for a civil project

So as expected, the model produced a result of CESMM as the most suitable MOM for a civil project with a combination of parameters that all produced a high preference of a detailed BOQ.

The second step for the model verification was letting the users try the model and send their comments about its performance. The comments received about the usage of the model were that the model is user friendly and the fact that there were hints or guiding tips to guide the choice for each of the project parameter was important in allowing the user to enter the desired project parameters without confusion.

5.2. Model Validation

The model validation is done to check the accuracy of the results of the model and this is done in this research through case studies of real life projects that should have their parameters defined and entered into the model to produce results. These results are compared to MOMs chosen actually in the project and if they are not the same, a logical justification should be made.

Case study 1

A mixed use commercial complex with are 160,000 m^2 located in Egypt. The complex provides services that involves entertainment, retail and cinema. The project is to be constructed for an international client with a value of around 4 billion US dollars. The contract was awarded to an international joint venture with a leading local contractor and the contract is re-measured. In the model, there is no project type of shopping malls, but since it is in the buildings category, it can be selected as hotels and the rest of the parameters are entered as shown in figure 5-4 below:

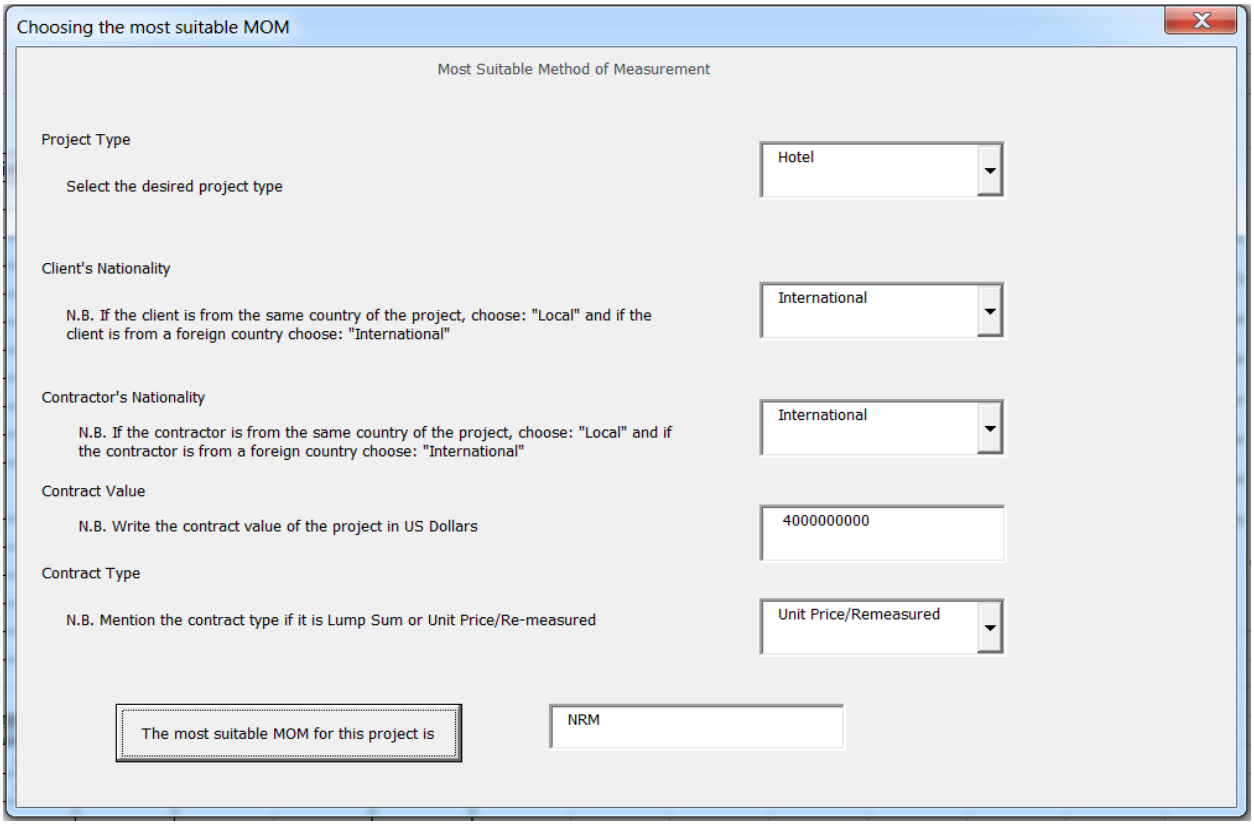

Figure 5-4 Results for case study 1

The result obtained from the model is that the most suitable MOM is the NRM; however, the actual MOM used in preparing the BOQ for this project was POMI. The difference in the results may be justified considering that the project expected start date was in 2012 and the NRM was issued in 2012 and became operative in 2013, so it was hard to use NRM for this project and this can be the reason why POMI was chosen by the client for the preparation of the project's BOQ.

Case Study 2

The second project is an airport terminal to be constructed in United Arab Emirates. The project is done for the public sector which means that the client is local and the contractor is a multinational joint venture where all the contractors are international. The project would have a cost of multibillion US dollars and the contract type is lump sum. So the project parameters are entered in the model as shown in figure 5-5 below:

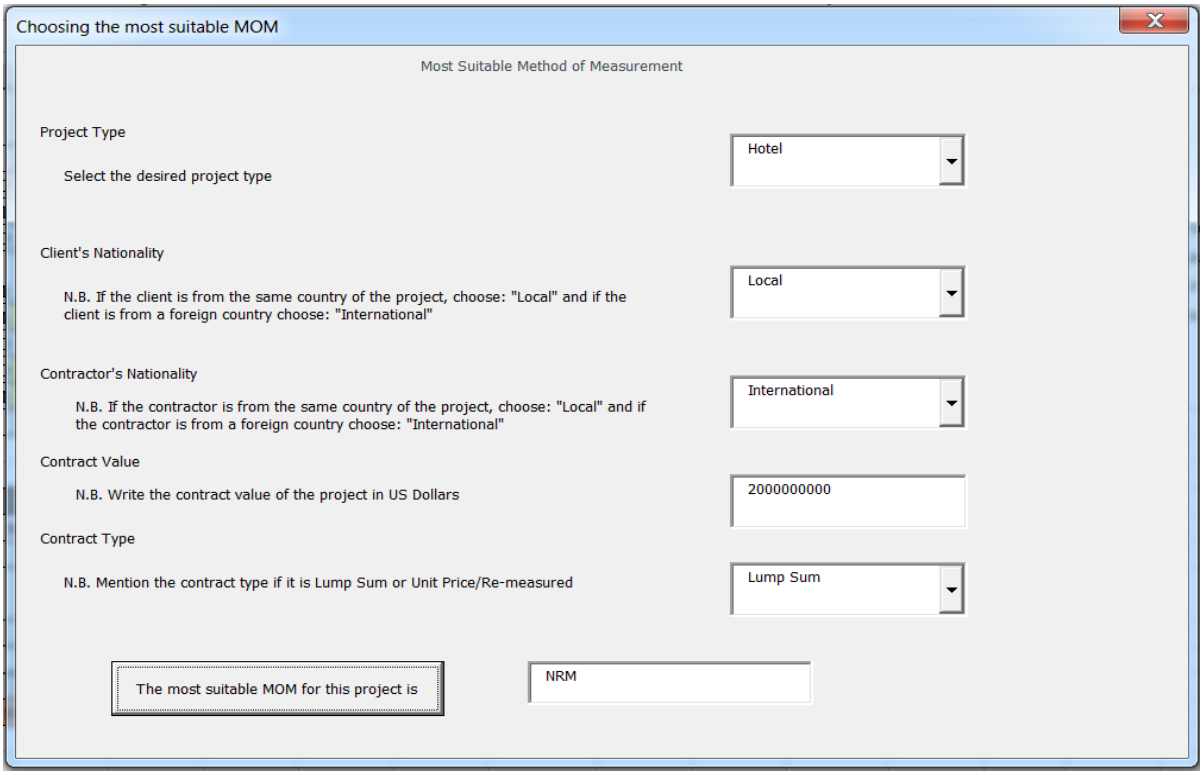

Figure 5-5 Results for case study 2

The project type was also considered as a hotel since there is no match for an airport terminal. The results showed a suitable MOM of NRM to be selected; however, the actual MOM chosen was POMI. To justify this difference, it could be mentioned that the point that NRM has only been issued for a short period of time makes it less likely to be used in large projects such as this airport terminal. In addition to the fact that the project is large and its value is of multibillions which would make preparing the BOQ using NRM a complicated process that would need much training that is difficult to have been provided in the short time since the issuing of NRM. Also the results for case studies 1 and 2 are compatible with the research results that POMI is familiar in the Middle East more than the NRM.

Case Study 3

The third project is a site development project for a mixed use complex in Dubai. The client is a UAE mega developer which is considered a local client in this case since the project is in the same country of the client. The contractor responsible for the project execution is an international contractor. The contract type is a re-measured contract with an equivalent amount in US dollars of 20 million. The project parameters are entered as shown in figure 5-6 below:

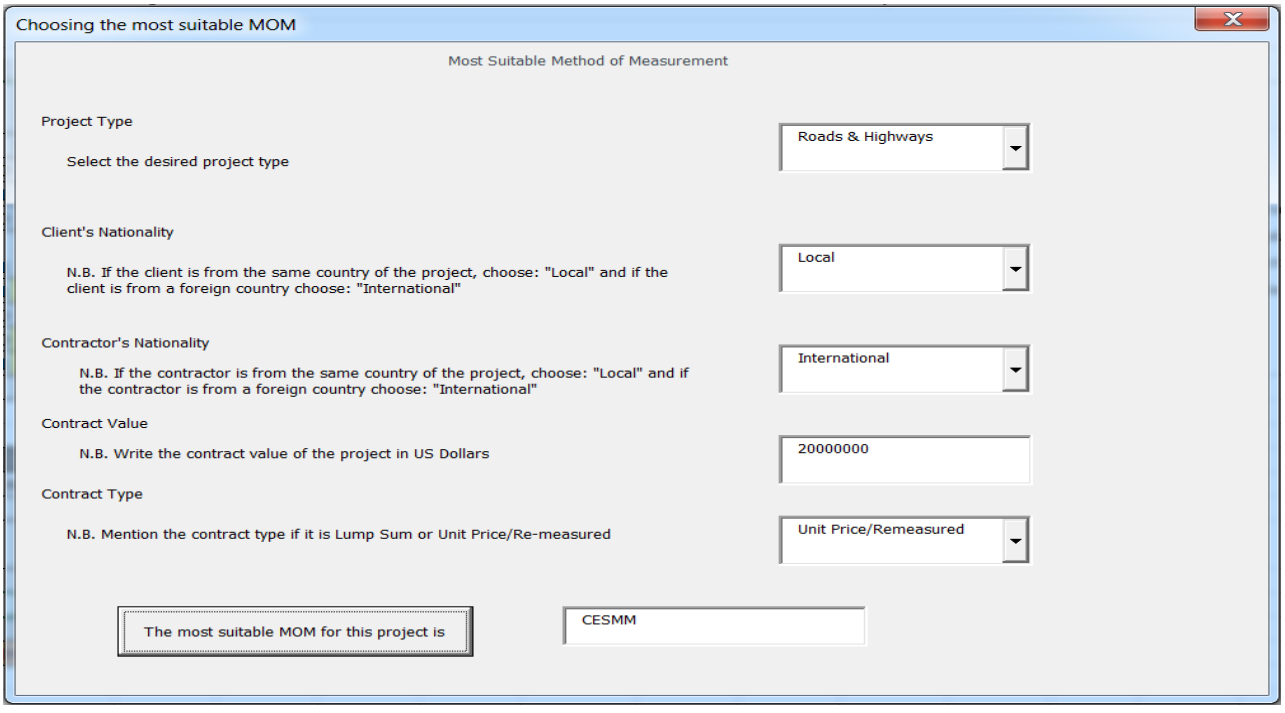

Figure 5-6 Results for case study 3

The result obtained from the model is that CESMM is the most suitable MOM for preparing the BOQ of this project which is the same actual MOM chosen for preparing the BOQ of this project. This is also compatible with the results of this research that CESMM is competent with POMI in the Middle East in case of the civil projects.

Case Study 4

The fourth project is a commercial mall in Dubai in United Arab Emirates. The package of works being studied here is the enabling and external works for the project. The client for this project is a local client and the contractor is an international contractor. The contract type is re-measured contract with a value of 15,000,000 Dirham which is equivalent to around 4,000,000 USD. The project parameters are entered as shown in figure 5-7 below:

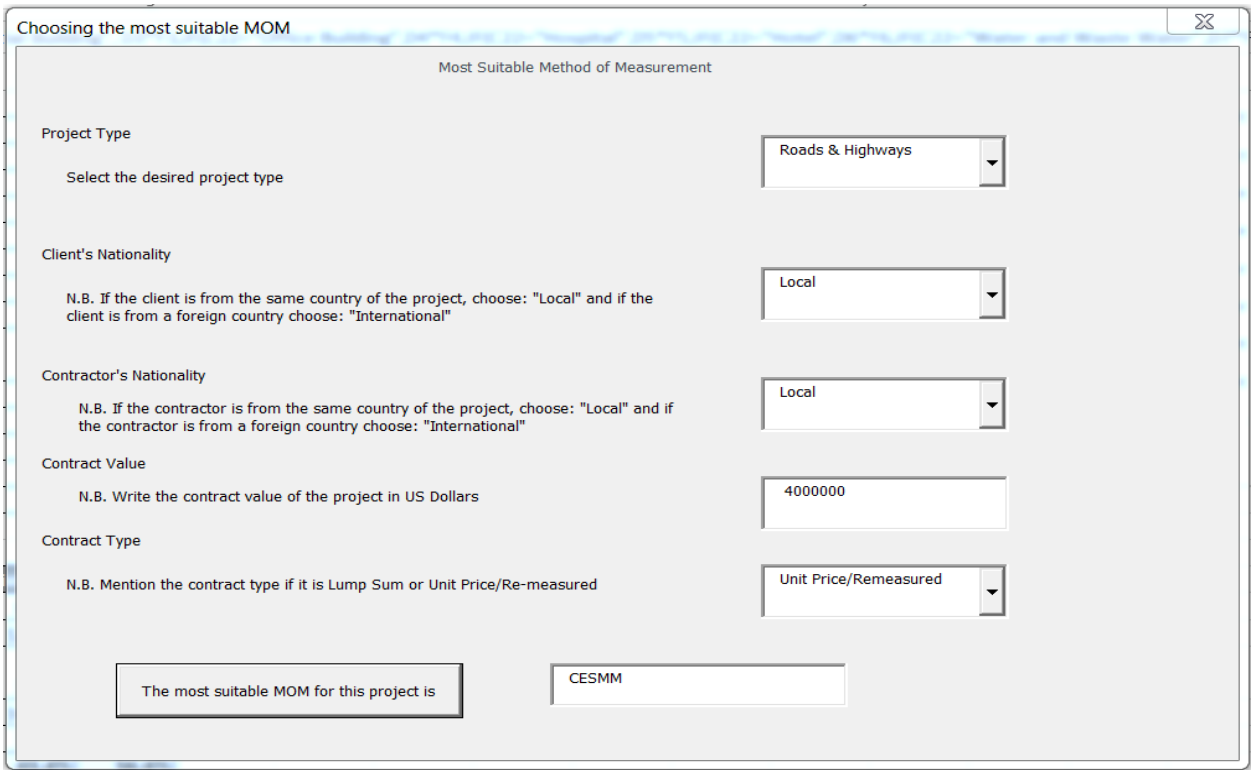

Figure 5-7 Results for case study 4

The result obtained from the model is that CESMM is the most suitable MOM for preparing the BOQ of this project and this is the same actual MOM chosen for preparing the BOQ of this project. This is also

compatible with the results of this research that CESMM is competent with POMI in the Middle East in case of the civil projects.

Case Study 5

The fifth project being investigated is a major highway in Oman which is a civil project. The client here is a local client while the contractor is a multinational contracting firm. The contract type used in this project is a re-measured one with a value of approximately 10,000,000 USD. The project parameters are entered as shown in figure 5-8 below:

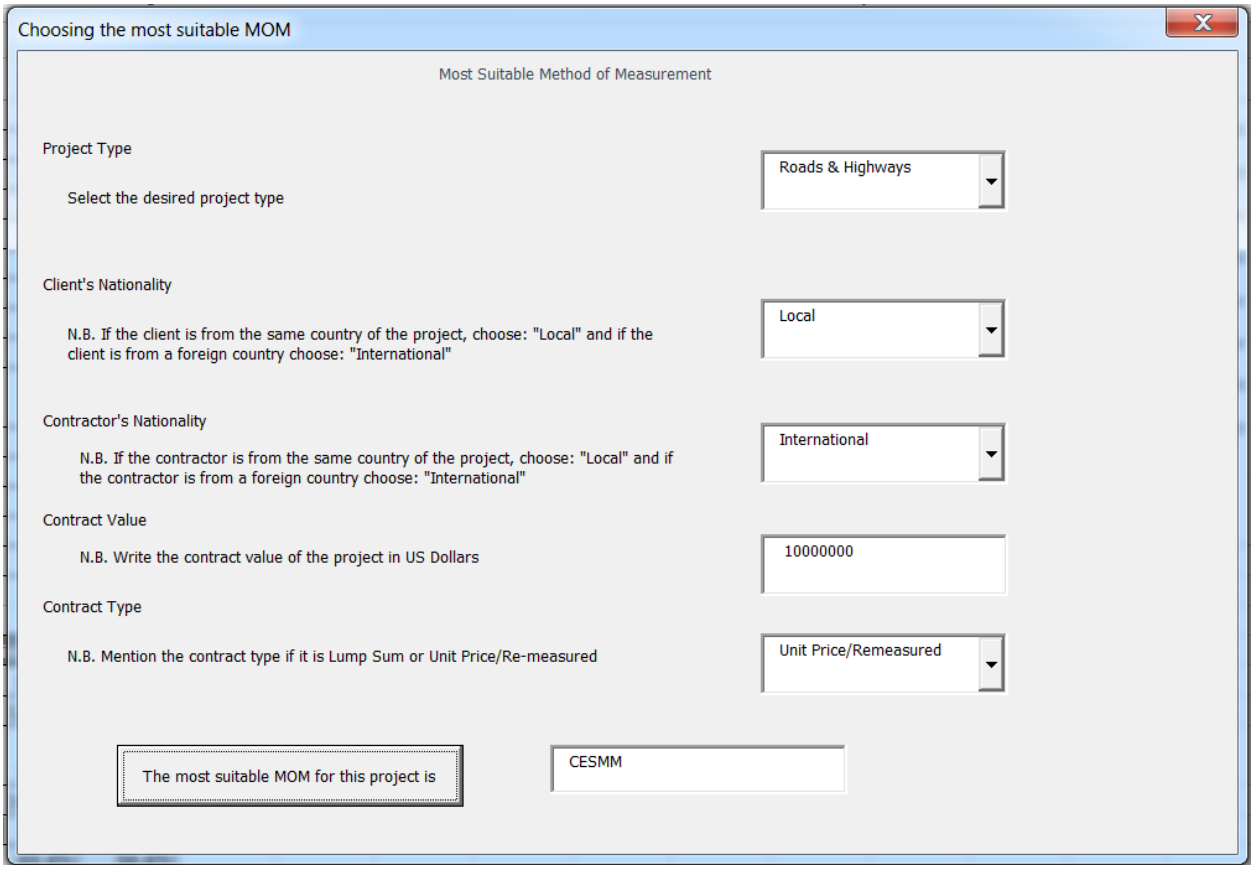

Figure 5-8 Results for case study 5

Again, the result obtained from the model is that CESMM is the most suitable MOM for preparing the BOQ of this project and this is the same actual MOM chosen for preparing the BOQ of this project. This is also compatible with the results of this research that CESMM is competent with POMI in the Middle East in case of the civil projects.

5.3. Results and findings of the Model Verification and Validation

For the model verification, it is obvious that the model satisfies its purpose and the mechanism of producing the results seems reasonable.

Also for the model validation, it seems that the model can be useful in case of the civil projects since it is more likely to provide MOM choices that are the same as the actual ones used in real life projects which was the case in the three case studies of civil projects investigated in this research; however, for the building projects, it might give results that are different since the NRM is still not competent with the POMI in the Middle East and so most of the projects would rely on POMI if the choice was between POMI and NRM regardless of the project parameters.

6. Conclusions and Recommendations

This section summarizes the outcomes of this research as well as the recommendations that were implied from the results or the modifications that could have been done to the research to produce more accurate results.

6.1. Conclusions

From this research, it is possible to reach certain conclusions about some different points as follows:

- Standard MOMs are recognized in the Middle East

The standard MOMs are recognized by quantity surveying professionals in the Middle East and companies using them for the projects and moreover, some countries have issued their own MOMs which were adopted from certain standard MOMs.

- POMI and CESMM have the most recognized percentage among the three being investigated

For the three MOMs being investigated in this research; CESMM, NRM and POMI it is obvious that POMI and CESMM are well recognized in the Middle East and they are competent when it comes to civil projects with a small favor of the CESMM over POMI. For the NRM, it is still not well recognized in the Middle East for the building projects since it is a recently issued MOM and the POMI is dominating over the NRM in the building projects.

- Clients and consultants tend to favor detailed BOQs unlike contractors who tend to prefer brief ones

Regarding the main parties involved in the construction projects who are the clients, consultants and contractors, it is obvious that their perception to the concept of detailed and BOQs differ from each other. The clients and the consultants are most likely to prefer choosing MOMs that produce a detailed BOQ since they believe in its advantage in avoiding project problems and facilitating the process of the cost control during the execution of the project. On the other hand, the contractors don't prefer using MOMs such as NRM and CESMM for their complexity and that they require a lot of effort in pricing them. Also these types of MOMs that limit their possibility of increasing the contract price through variations to

compensate for their possible losses during the project execution unlike MOMs like POMI producing brief or abstract BOQs which have high probability of causing problems since they may be unclear and here the contractors might rely on these points in submitting claims for variations.

- MOM selection depends on specific project parameters

With the different perceptions of the project parties regarding the implications of using a detailed and brief MOM to produce the BOQs, there are some project parameters that govern the choice of the most suitable MOM for a certain project which are the project type, the client's nationality, the contractor's nationality, the contract value, and the contract type assumed in this research. Each combination of parameters guide the choice of specific MOMs for each project.

- The model is more likely to produce results agreeable with the real ones regarding the MOM choices for real life civil projects unlike building projects

The suitable MOM for a project to be selected for the different combination of these project parameters is presented in the model created in this research; however the results for the building projects can be not compatible with actual MOM selections in real life since the NRM is still not recognized in the Middle East and it was recently issued so firms need to train their employees first before using it. However, the case is different for civil projects where the model is more likely to produce suitable results agreeable with the ones used in real life projects since CESMM have been used in the Middle East since for a great period of time and so firms are familiar with its usage and they rely on it in the civil projects whenever it suits the project conditions.

6.2. Recommendations

The recommendations are divided into 2 categories; the first is for the improvement of this research. This can be done through possible improvements like

- Increasing the population of respondents for the questionnaire.

  This can help in making more accurate judgements regarding the standard MOM usage in the Middle East.

- Adding other project parameters such as the built-up area for the project

  Some opinions may claim that adding other project parameters can help in giving more suitable choice of MOMs so adding other project parameters like built-up area for project and giving it weight in the decision making process can help in the accuracy of the selection process of the MOM for the projects.

- Model can involve a more project types

  This may help improve the decision making process for the most suitable MOM.

The second category of recommendations belong to improving the quality of MOM usage in the Middle East. This can be done through:

- Increasing awareness towards each standard MOM usage through university syllabus and training programs by construction firms.

  A suggestion for increasing the awareness towards the MOMs for the people involved within the construction industry may be by including the topic of MOMs in the syllabus of construction students in universities in order to make them aware of the MOMs from an early stage instead of waiting for them to get familiar with it in the professional life. Also, for the construction firms, there should be a training program provided for how to use the standard MOMs for their employees and the firms may also support their employees by helping them gain certifications in this field like for example the RICS certifications in order to guarantee their staff abilities in using the standard MOMs towards a better cost management for the construction projects.

- Updating local MOMs in some countries such as the case in Egypt

  Research can be utilized to focus on issuing, updating local MOMs for some countries as Egypt. Egypt for example has the Egyptian Code guiding the take-off process for the project items but it was not cited by the responses of the questionnaire respondents who came from Egypt which might give a suggestion that it may need to be improved. For this purpose future research can be made by comparing the standard international MOMs with the Egyptian Code of Measurement to identify its weakness points and work on suggesting improvements for the code.

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7. Appendix

Questionnaire for Different Types of Methods of Measurement

I am Abdelrahman Magdy, MSc Candidate for Construction Management in the American University in Cairo. I am currently working on my Thesis for my Master of Science Program in Construction Management and my topic is "How to Choose the Suitable Method of Measurement for a Certain Construction Project" under the supervision of Dr. Samer Ezeldin, the Chairman of the department of Construction Engineering in the American University in Cairo.

Introduction

Many claims and disputes occurred due to some discrepancies in the bill of quantities issued that may have led to misunderstandings in the scope of works or double counting of items or problems in quantifying variation orders in a certain project. Many standard methods of measurement (MOMs) have been issued by several institutions like ICE, RICS, etc.… that are being used to assist in preparing a clear bill of quantities (BOQ) for construction projects.

The Standard MOM can be a solution that be used as a guidance document in the preparation of BOQs since they provide a standard format for the breakdown of project works into small items that clarify the scope and provide standard method for the measurement of such items.

Questionnaire

This is a questionnaire is to help understand the basis on which an MOM is chosen for any project in the Middle East and to determine the factors affecting the MOM choice and the influence of these factors will be integrated in a model that will automatically select the most suitable MOM type for any project depending on its characteristics.

The two types of MOMs are either **Brief** MOM or **Detailed** MOMs.

The three MOMs chosen to be investigated in this survey are

- New Rules of Measurement (NRM) for building works **(Detailed)**
- Civil Engineering Standard Method of Measurement (CESMM) for heavy civil projects **(Detailed)**
- The Principles of Measurement International (POMI) for all construction projects **(Brief)**

You are kindly requested to provide your experience with MOMs and how each can be suitable for a certain project.

For further information please contact me at: a_mhafeez@aucegypt.edu

Section 1 – Background Information

Name: …….

Job Title/Organization Name……..

What type of construction organization are you working for?

Owner
Consultant
Contractor

Section 2 – Bills of Quantities and Standard Methods of Measurements

This section is some general questions about the use of the standard Methods of Measurement (MOMs) in the BOQ preparation.

1- What type of MOMs have you used for preparing BOQs in your previous projects?
Standard
Non-standard
Both

2- How many years of experience do you have in preparing BOQs?
0 – 4 Years
5-10 Years
11-15 Years
More than 10 Years

3- Do you agree that using a standard MOM can decrease the probability of having variations and claims during construction?
Strongly Agree
Agree
Disagree
Strongly Disagree

4- Please select the standard methods you have used
NRM (New Rules of Measurement) for building works
CESMM (Civil Engineering Standard Method of Measurement) for civil projects
POMI (Principles of Measurement International) suitable for most of the construction projects
Other, please specify …….

5- What do you think of having an extremely detailed BOQ in terms of the items' breakdown?

Impact	**Strongly Agree**	**Agree**	**Disagree**	**Strongly Disagree**
Enhances pricing accuracy				
Wastes time in case of small sized projects				
Easily understood by Contractors decreasing mistakes in pricing				
Enhances quantification of claims and variation orders				
Increase price of tender				

6- What do you think of having a short/brief BOQ with limited details?

Impact	**Strongly Agree**	**Agree**	**Disagree**	**Strongly Disagree**
Helps in quick issuance of tender documents				
Neglects necessary details				
Cannot be understood by Contractors causing mistakes in pricing				
Obstacles quantification of Claims and Variation orders				
Decreases price of tender				

7- What do you think is a preferred type of MOM choice for the following project characteristics?

Impact	**Brief**	**Detailed**
Project performed for a local client		
Project performed for an international client		
Project performed by a local contractor		
Project performed by an international client		
Project with high contract value		
Project with low contract value		
Project with lump sum contract		
Project with unit price contract		

8- Please assign weights for the percentage effectiveness of the following parameters in the process of choosing the most suitable MOM for a typical project

Project Parameter	**Percentage effectiveness**
Project Type	
Client's Nationality (Local or International)	
Contractor's Nationality (Local or International)	
Contract Value	
Contract Type (Lump Sum or Unit Price/Re-measured)	

Section 3 – Which MOM is suitable for which type of project?

In this section, you are given some types of projects and for each type, you are requested to put a tick on which type of MOM would you prefer for this project type if it is to be constructed in the **Middle East**.

Project Type	**NRM**	**CESMM**	**POMI**	**Non-Standard**	**Reason (Optional)**
Residential Buildings					
Office Buildings					
Hospitals					
Hotels					
Water & Waste Water Projects					
Roads & Highways					
Tunnels & Bridges					