MATERIALS TAKEOFF IN BUILDING INFORMATION MODELING

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ABSTRACT

Appropriate cost estimation, monitoring and controlling are the key point of construction project to succeed. 2D drawing has been a normal source of information and procedure since 1970's. The drawback of drawing based estimating however is its nature where it has limited information that is required by the estimators. In addition, it also requires manual estimation and thus introduces inaccuracy and error in measurement. The source of inaccuracy and error comes from the estimator that needs to review many sheets of drawing for extracting building component and quantification measurement to perform materials takeoff. Therefore, more time is needed to establish unit measurement of the building component. Material takeoff in Building Information Modeling (BIM) is performing takeoff, counts and measurement of building components quantification by using parametric underlying 3D model instead of using conventional method for conducted manual materials takeoff for cost estimation. By performing takeoff, count and measurement by using parametric model instead of conventional method, all possible problems due to miscalculation and human error can be minimized. Besides that, by using BIM model based approach on estimating and materials takeoff, takeoff, count and measurement for quantification can be done quickly and more accurately. The scope of this is study is to perform takeoff, count and measurement by using BIM 3D parametric Architecture Model. The aim of this study is to explore the BIM model based approach on estimating and materials takeoffs. Research method that been used in this study is extracted all building component information about measurement, count and takeoff by using Revit Suite 2014 software as an input for conducting cost estimation. Finally, all the quantification takeoff extracted from parametric model is used for performing cost estimation of the architecture components of this bungalow construction. All the cost estimation is calculated by using Excel data sheet that have been developed by researcher. By using this BIM model approach, researcher believe that it will helps construction project teams for better project coordination in the coming years.

ABSTRAK

Anggaran kos yang sesuai, mengawasi dan mengawal adalah titik utama untuk kejayaan sesebuah pembinaan. Lukisan 2D telah menjadi sumber maklumat dan prosedur sejak tahun 1970-an. Kelemahan lukisan ini untuk perhitungan kuantiti telah menjadi lumrah di dalam dunia di mana ia mempunyai maklumat yang terhad yang diperlukan oleh penganggar. Ia juga memerlukan prosedur perhitungan kuantiti secara manual dan akan menyumbang kepada masalah ketidaktepatan dan kesilapan dalam pengukuran. Kekangan ini berlaku kerana penganggar perlu mengkaji setiap helaian lukisan untuk kerja mengekstrak komponen bangunan dan pengukuran kuantifikasi untuk melaksanakan perhitungan kuantiti bahan dan ini memerlukan lebih banyak masa yang untuk mengeluarkan unit pengukuran komponen bangunan. Perhitungan Kuantiti berdasarkan Bangunan Permodelan Maklumat (BIM) adalah melakukan kerja perhitungan dan pengukuran kuantifikasi komponen bangunan dengan menggunakan 3D model parametrik selain daripada kaedah konvensional. Dengan melakukan kerja perhitungan dan pengukuran kuantiti bahan berdasarkan model 3D parametrik, segala masalah yang mungkin berlaku disebabkan kesilapan perhitungan dan manusia dapat dikurangkan. Selain itu, dengan menggunakan pendekatan berasaskan model BIM di dalam kerja-kerja perhitungan kuantiti bahan, penganggaran dan pengukuran untuk kuantifikasi bahan dapat dilakukan dengan lebih cepat dan lebih tepat. Skop kajian ini adalah untuk melaksanakan perhitungan, penganggaran dan pengukuran untuk bahan mengggunakan model 3D Seni Bina berparameter. Tujuan utama kajian ini adalah untuk meneroka pendekatan model BIM berdasarkan anggaran dan perhitungan kuantiti bahan. Kaedah penyelidikan yang digunakan dalam kajian ini adalah mengekstrakk segala komponen bangunan mengenai kuantiti bahan dengan menggunakan perisian Revit Suite 2014 sebagai input untuk menjalan penganggaran kos. Akhir sekali, semua perhitungan kuantiti bahan yang telah diekstrak daripada model parametrik telah digunakan untuk melaksanakan penganggaran kos untuk pembinaan banglo ini. Semua anggaran kos yang dikira dengan menggunakan lembaran Excel yang telah dibuat oleh penyelidik. Dengan menggunakan pendekatan model BIM, penyelidik percaya bahawa ia akan membantu pasukan projek pembinaan bagi penyelarasan projek yang lebih baik pada tahun-tahun yang mendatang.

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LISTS OF ABBREVIATION

CRMC	Course on Measurement Rules in Construction
BIM	Building Information Modeling
CAD	Computer Aided Design
BOQ	Bill of Quantity
QTO	Quantity takeoff
JKR	Jabatan Kerja Raya
SMM2	Malaysian Standard Method of Measurement of Building Works Second Edition

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Nowadays, constructions in Malaysia are rapidly developed either in rural area, suburban area or in urban area. A good construction is consists with three components, the first components is scope, secondly is cost and lastly is time. All the components are parts of an integral of quality. Cost is the most critical part of the project. Cost is the amount of money the owner will spend to obtain the project and the amount of money that the designer and construction organization will be compensated for performing the works. The key of the successful project is accurate cost and effective cost monitoring and control. A good project manager can develop financial management plan for initiate budget of the project using reliable cost estimating systems. Cost estimate can be defined as the process of predicting cost to perform scope of work specified for a project. The most cost estimate level of accuracy depends on the method used, availability of cost data and level of project definition (Jrade, 2000). Cost estimation is divided into three main elements that are, material cost, labor cost and lastly is plant and machineries cost. Without proper cost management may lead to the project failure due to incomplete construction or contributed project to be delayed.

Cost estimation is divided into two groups which are design phase used by designers and the other is construction phase used by contractors. Normally for design phase designers must ensure that they designs or design changes are not exceed the owner budget and the most important things is quality and specification must followed owner satisfaction. However, contractor use cost estimation for construction budget and they form construction cost control systems and also by monitoring project cost.

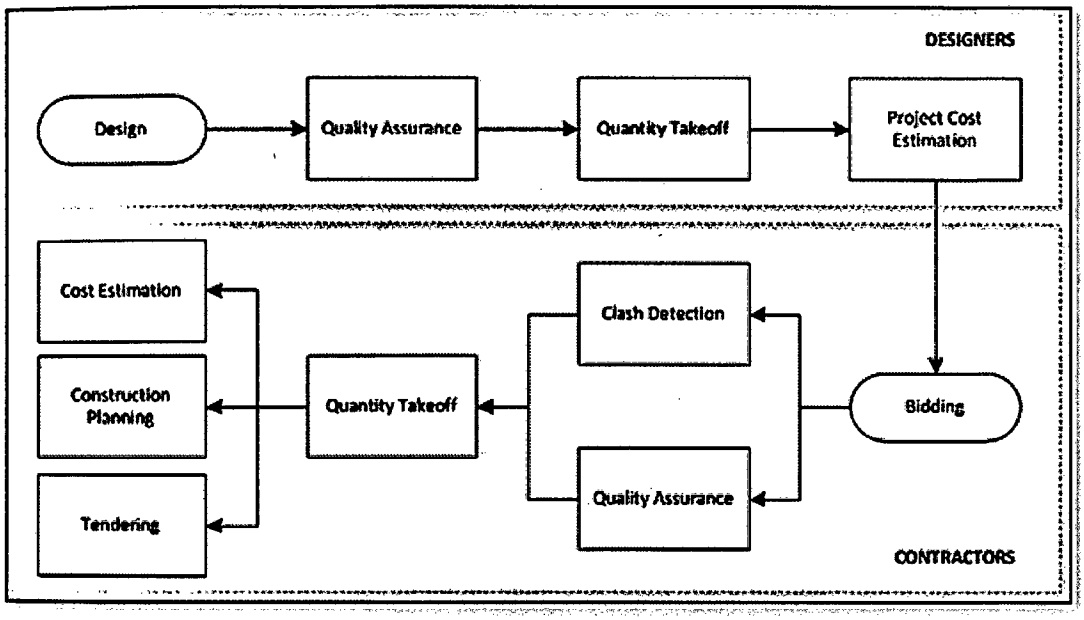

Figure 1.1 : Relation of quantity takeoff with the major tasks in the project life-cycle

Source : A.Monteiro, J. Pocas Martins, Automation in Construction (2003)

Building Information Modeling (BIM) contains not only geometric data but it come with highly amount of engineering data, functional and performances properties. All the information consists of manufacture, type of material, geometric information that can assist project teams for project coordination. Recently in project construction, projects team mostly rely based on 2D construction drawing for construction phase, documentation and it also including materials takeoff which is lack with information

can assist project team for better project coordination. As we know that, materials takeoff is important part for conducting cost estimation. By using BIM model based approach in estimating and materials takeoff, all takeoffs, count and measurement of building component quantification can be conducted quickly and accurately. Besides that by using BIM approach, all possibilities of error problem due to human error can be minimized. All materials takeoff must be done accurately and it is important part for conducting cost estimation.

1.2 BACKGROUND OF STUDY

Quantity takeoff is used through the life-cycle of the project from the early stage of the project used to estimate project preliminary cost, in tendering stage quantity take off is used to estimated project cost and project duration, before construction stage quantity takeoff is used to forecast and plan the construction activities and work. Lastly, for during construction process is to establish milestone of economic cost balance for contractor. Quantity takeoff is one of the key tasks in construction process since it is foundation for the several other tasks (A.Monteiro, J. Pocas Martins, 2013). Quantity take off is used by estimator for calculate and estimate construction element and workload including material cost, labor cost and plant and machineries cost. This task is used during construction process and to calculate direct cost and indirect cost during the construction process.

Direct cost is the cost has been spent to run the construction activities or works. It is including labor, materials, plant and machineries. Contingencies cost also can be classified direct cost. Direct cost can change immediately depend on the work progress whether it is on schedule or delayed. For indirect cost is overhead cost that cover for the management purpose including site management cost for supervision works, staff for administration and services for water, electric supply, telephone etc. Indirect cost is normally constant although the project on schedule or delayed. Quantity takeoff played an important role in construction phase for contractor. An accurate quantity takeoff is decisive for the economic balance of the contractor's finances as it is the only way of achieving a thorough analysis of the productivity and of the different types of costs in particular projects (A.Monteiro, J. Pocas Martins, 2013).

Therefore materials takeoff must be accurate as possible. According to Autodesk (2013), when preparing thei cost estimates, estimator typically begin by digitizing the architect's paper drawing, or importing their CAD drawings into a cost estimating package or doing manual takeoffs from their drawing. All these method will contribute the potential error problems due to human error and propagate any inaccuracies there may be in the original drawing. By using BIM approach, this entire problem can be minimized as possible. By using BIM model based approaches estimating and material takeoff, all takeoffs, count and measurement of building component quantification can

be obtain directly from underlying 3D parametric model instead of using conventional method that consume too much time for obtaining unit of quantification. By using BIM model based approach, it also helps project team to visualize project sequence more easily for quick understanding and digestion of project information. BIM based approach in estimating and materials takeoff also assist estimator to make crucial decision of prospective of work at any specific time. The most beneficial by using BIM based approach on estimating and materials takeoff is it when there are changes or revision on construction drawing, the changes will change automatically ripples to all related construction documentation and schedules including takeoff, count and measurement because model generated by BIM tools are always constant with the design.

1.3 PROBLEM STATEMENT

The materials or quantity takeoff played an important role in project life-cycles. So, all the materials takeoff and cost estimation must be accurate as possible. Nowadays, most of estimators are relied upon traditional method by depending on 2D construction drawing to come out with materials takeoff and cost estimation. Any miscalculated can lead quantities to be omitted or calculated twice. Estimator played an important role to estimate quantity and cost estimation. Estimator must reviewed drawing by drawing, detailed by detailed, calculate quantity of materials and record all units of measurement for cost estimation. This will lead to the miscalculation problem due to human error. Besides that, traditional method consumed too much time for materials take off and cost estimation. The time spent by estimator on quantification varies by project, but perhaps 50-80% of the time needed to create cost estimate is spent just on quantification (Autodesk, 2007). Furthermore, accuracy and completeness are the most important and critical factors in all estimators around the world. Manual materials takeoff contributed many problem regard to miscalculation and consuming too much time. By using BIM based approach on estimating and materials takeoff, the entire possibilities problem can be reduced and minimized. Therefore, a study must be conducted to explore and refined the use of BIM model based approach on estimating and materials takeoff in Malaysian constructions for better solution in performing materials takeoff.

1.4 AIM AND OBJECTIVE

Aim of this research is to explore the BIM model based approach on estimating and materials takeoff. To achieve the aim, several objectives were identified as following :

i. To collect and extract all materials component from BIM model.
ii. To develop and establishes material takeoff schedule using Revit Suite Software.
iii. To establish the material breakdown and unit of measurement for cost estimation of materials needed.

1.5 RESEARCH METHODOLY

All the data used in this research is based on real bungalow construction. In this research, researcher only focuses more onto architecture works for performing materials takeoff and cost estimation because the limitation of data and information. The entire architecture building component is extracted by using Revit Suite 2014 and takeoff is tabulated into schedules. Revit Suite software is capable for extracting building component based on 3D parametric model generated by it. Then, entire table of materials takeoff is converting to xls format so that Excel can review the input data so that researcher can perform cost estimations. Cost estimation is conducted based on Revit Organization Schedule. There building component extracted by researcher are shown in following below :

i. Wall
ii. Floor
iii. Ceiling
iv. Roof
v. Window
vi. Door

Researcher has breakdown major tasks into subtask for obtain accurate materials takeoff and cost estimation. Researcher has generated data sheet by using Excel so that cost estimation can be conducted more easily. All materials takeoff conducted by researcher also including materials wastage factor. Cost estimation conducted by researcher only focusing on materials price only without labor cost and 15% profits.

1.6 SCOPE OF STUDY

All the data in this research are based on case study and all data are obtained from true construction. This bungalow is using green building concepts construction. The scope of study for this research are :

i. Data collection is based on 3D bungalow model
ii. Extracting all building components from the BIM model using Revit Suite Software
iii. Develop the schedules of materials take of using Revit Suite Software and convert to Microsoft Office Excel.
iv. Breakdown total work into subtasks.
v. Calculating quantities of material and estimating material costing based on Revit Organization Schedules.

1.7 SIGNIFICANT OF STUDY

The results of this study will outline BIM model based estimating and materials takeoff process flow for construction project. Materials takeoff played an important role in project managements and BIM model based on estimating and materials takeoff is substantial improvement to obtain better results in materials takeoff and cost estimation so that it can be calculate more accurately and miscalculation problem due to human error can be minimized. Besides that, BIM model based on estimating and materials takeoff give visualization to estimators throughout construction process. Furthermore, BIM model based on estimating and material takeoff provide decision maker with tool for better monitoring and control of their construction projects. It also can assist planner to make crucial decisions making by visualize details design of prospective works at any specific times.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

The literature review presented to explore the information and facts that used in this research. This chapter will explain the background of the study and related theories about material takeoff in building information modeling. Although the literature review covers a wide variety of theories, this review will focus on three themes are : materials takeoff, weakness using traditional method for conducting materials takeoff and BIM approaches in construction industries. The main focus on this literature review is application of BIM model based on estimating and materials takeoff instead of traditional method to perform materials takeoff.

2.2 MATERIALS TAKEOFF

A material takeoff is the process of analyzing the drawing and determining all the materials required to accomplish the design (Whitt, 2004). Materials takeoff is use to estimate all the quantities of component in building so that unit measurement can be establish to proceed cost estimation. All materials takeoff must be accurate as possible

so that any possibilities about over budget problem can be minimized. Besides that, materials takeoff also important for contractor so that they can manage their financial works and for monitoring project cost. Materials takeoff involving measurement of different building components including architecture works, mechanical and electrical work and lastly structure works. All the measurement is taking off from design element in 2D such as construction drawing and shop drawing.

2.2.1 Importance of Materials Takeoff

The purpose of materials takeoff is to accurately determine all quantity of work that needed to be performed on the project either direct cost or indirect cost. Therefore all the measurement in materials takeoff in should be done carefully to minimize all possible error during materials takeoff are conducted. All the quantity takeoff from all building components are essentially to establish approximately cost estimation each components in building. Materials takeoff also helps estimators to identify problems regardly to cost constrains quickly so that alternative solution can be developed.

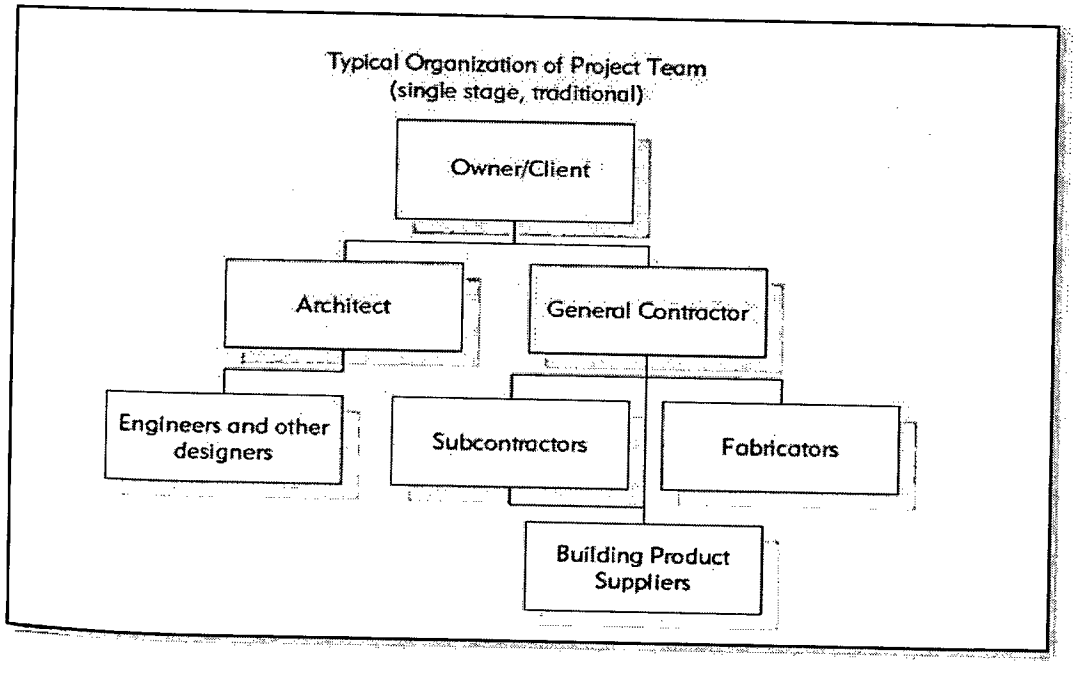

Figure 2.1 : Typical Organization of Project Team

Source : Chuck Eastman, Paul Teicholz, Rafael Sacks, Kathleen Liston (2011)

Materials takeoff gives benefits differently according to the perspective of project team in construction industry. Project team is divided into three parties :

i. Owner or client of the projects
ii. Design professional
iii. Constructor Professional

All this parties played different responsibilities to the construction industries. Owner or client is the person who makes decision to build the facility or decides whether the project is profitable to invest or not. Furthermore, owner or client also responsible for setting parameter on total cost, payment of costs, setup major milestones and the project completion date. For design professional is divided into three groups. First group is architect who engaged by the building owner as agent to design, advises and ensures that the project kept within cost and complies with the design. Secondly are engineer and designer. Engineer is divided into two that are civil and structure engineer who is deal with the site issues, design structural drawing and the person who analysis the all the structure. The other engineer is mechanical and electrical engineer who deal with schematic design for the building such as electrical, plumbing systems for the building. Last party is constructor professional, the person that is responsible to construct the building accordingly specification and quality required.

In client's perspective, materials takeoff process is use to obtain all important information in construction industries such as cash flows, periodic projects accounts and cost variations. All the information is important for client to make crucial decision whether the project is profitable to invest or not. Besides that, all information from the materials takeoff is important to assist client to apply value engineering to cut costs and possibly quality in the project. The information can then be easily communicated to the client to keep them informed of the progress and financial status of the project (Rashid, Mustapa and Wahid, 2006). For the design professional perspective, materials takeoff provides useful information to them because it identified the total cost of project construction and budget of the projects. Materials takeoff then translated into work programme, cost plan and project cash flow and budgets. All the information gained from materials takeoff can improved better project supervision and cost controlling. Time and cost is played an important role in projects. When the time is increased, it will lead the cost of the project also increased. Lastly for constructor professional

perspective, there are two phase for constructor professional that are tendering phase and construction phase if they won the tendering phase the project will be awarded to them. For the tendering phase, estimator performed materials takeoff and cost estimation as accurately as possible the cost of the given construction. Cost estimation is including materials cost, labor cost and profit gained. For example, estimator calculates RM 69 per meter square of brickwall. This include of 15% profit, price of brick and mortar and also labor cost including skill worker and general worker per hour/m^2. The estimator uses current pricing information for different aspects of the proposed construction (Ashworth, 2002). The taking of list is important to contractor because it can be used to calculate all the cost estimation to list into Bill of Quantities (BOQ) for the preparation of the tender. Besides that, taking list in BOQ can be used by contractor to preparing pricing and estimate the proposed construction costs. If constructor professional won the tendering phase, the proposed project then will be award to them. For the construction process, materials takeoff can be used as financial management as a basis of the construction of the proposed project on site.

Furthermore, materials takeoff also can be conducted for the procurement process during the construction process. All quantities of materials that been taking off will be used for materials order or to obtain quotation from suppliers. Normally for the procurement process, the list of quantity takeoff from the building components is use to obtain cost estimation after list of quotation is obtained from the suppliers. Normally the information sent to suppliers to obtain the quotation are :

i. Specification of the materials (Refer from Bill of Quantities).
ii. Quantity of materials required for the construction.
iii. Address of the site and name of Contractor Company.
iv. The delivery dates required by the contractor. This is the most crucial part because it is important for the material arrangement in site and foreman cost when unloading the materials required.

2.2.2 Traditional Guideline for Performing Materials Takeoff

During construction, estimator needs to measure quantities for preparation of variation orders. Traditional methods for materials takeoff is estimator using manual method for conducting materials takeoff. Estimator reviewed all construction drawing, details drawing and shop drawing to conduct materials takeoff. This is the most important part for conducting material takeoff. All the taking off must be done carefully to minimize possible error during the taking off. The goal of materials takeoff is to calculate every items and components of building in the project. Materials takeoff also required a strong understanding of the work involving in each of the different disciplines of the project. The method of measurement must follow Malaysian Standard Method Measurement (SMM2). If there are changes that require re-measurement, the quantities will be measured from the as-built drawings instead of on-site measurement. Below is the guideline must be followed by estimator during conducting materials takeoff :

i. Carefully check the drawing and the specification. Estimator must reviewed all the construction drawing and shop drawing.
ii. Estimator must visualize all the design process during extracting building components during performing materials takeoff.
iii. Review all the elevation of the drawing and cross-section of the drawing to avoid any quantity is omitted or calculated twice.
iv. Care should be taken to cover each item or costly mistake can be occurred.
v. The quantities calculated must be adjusted for waste.
vi. When performing calculations, avoid rounding off until the final quantity summary.
vii. When measuring dimensions, ensure that the correct scale is being used.
viii. Be careful that the drawing has not been reduced or that the area being worked in is not a different scale.