

## CHAPTER II

### LITERATURE REVIEW

#### 1. Cost Management

Cost management has become an inseparable process during construction project, it could be divided into planning and controlling process. An accurate cost planning and controlling process are necessary to deliver the project successfully. Professional cost engineer will analyze the project thoroughly to estimate the cost and eventually create a feasible budget for the project.

##### 1.1. Cost Planning Process

Cost estimation could be defined as the summation of individual cost elements, using established methods and valid data, to estimate the future costs of a project, based on what is known today (*Government Accountability Office, U. S. 2009*). The approximate estimation value is the output of cost estimating process.

Upon estimating process, the level of detail is based on several terms such as project maturity, design complexity, etc. According to AACE International Recommended Practice No. RP - 97, cost estimation in construction could be delivered in several different classes such as:

ESTIMATE CLASS	Primary Characteristic		Secondary Characteristic	
	MATURITY LEVEL OF PROJECT DEFINITION DELIVERABLES Expressed as % of complete definition	END USAGE Typical purpose of estimate	METHODOLOGY Typical estimating method	EXPECTED ACCURACY RANGE Typical variation in low and high ranges <sup>(a)</sup>
Class 5	0% to 2%	Concept screening	Capacity factored, parametric models, judgment, or analogy	L: -20% to -50% H: +30% to +100%
Class 4	1% to 15%	Study or feasibility	Equipment factored or parametric models	L: -15% to -30% H: +20% to +50%
Class 3	10% to 40%	Budget authorization or control	Semi-detailed unit costs with assembly level line items	L: -10% to -20% H: +10% to +30%
Class 2	30% to 75%	Control or bid/tender	Detailed unit cost with forced detailed take-off	L: -5% to -15% H: +5% to +20%
Class 1	65% to 100%	Check estimate or bid/tender	Detailed unit cost with detailed take-off	L: -3% to -10% H: +3% to +15%

## **Figure 2.1**

### ***Cost Estimate Classification System – As Applied In Engineering, Procurement, and Construction For The Process Industries***

*Source: AACE International Recommended Practice No. 18R – 97*

#### **Project Maturity Degree**

Project maturity degree corresponds to the level of detail available in the project such as the architectural design or engineering detail. This term will further affect the information available for estimating process. Cost estimating process requires a sufficient information to interpret the project accurately.

#### **Estimate Purpose**

The analysis level certainly represents the purpose of analysis. A rough analysis could be described when many details related to the project are excluded, this could only be used as a feasibility study for the project. On the other hand, a deeper level of analysis generally produce the project budget along with the control method for the budget as well.

#### **Method of Estimation**

Cost estimation method typically consisted of 2 broad categories: stochastic and deterministic (*ASTM, 2017*). The independent variables in stochastic method are generally based on model, metrics, etc. This baseline for the independent variables in stochastic method may not represent the estimation accurate enough as it is still considered as a broad conceptualization. Whilst the deterministic method use a more exact baseline for each independent variable. The independent variables may cover quantity takeoff value, specific condition for each elements, etc. As the estimation level is moving into more detailed class, the method also covers more information to be considered.

#### **Estimation Accuracy**

The term accuracy extends to the plus/minus ( $\pm$ ) percentage against the actual cost of the project, several values has been defined by AACE to determine the accuracy of cost estimation. As the estimation level is going deeper, the accuracy range has to get closer to the actual project cost.

Different level of estimate provides different accuracy and purpose. In term of project bidding or tendering, a highly accurate estimation is required for contractor to deliver the project within budget and time. The cost engineer has to analyze the detailed quantity takeoff and unit cost information, even for external factors which may impact the estimation result should also be considered. Finally, it is very important to apply the highest degree of estimation detail in order to achieve the most accurate estimation result.

## 1.2. Cost Control Process

Cost control as defined by Cambridge Dictionary is “a process of controlling how much a company spends so that the costs stay on the agreed budget, or a certain method to achieve this aim”. There are many perspective regarding to cost control in construction project such as: from how it could affect the survival of a project development, preventing additional cost, achieve a success in delivering a project on time, etc.

In construction project, the relationship between cost and time is a very important aspect. Any variation of time will likely impact the cost as well (Chitkara, K, K. 2005). The cost control process in construction will be carried out on measurement phase and followed by correction phase to ensure that all objectives are fulfilled in the project. On another hand, action process is the consequence taken towards the measurement result. A correction action is taken in order to prevent more cost spent or delays in the project.

## 1.3. Cost Management in Construction Project

There has been a lot of research that talk about cost management in construction project. (Li Youlin. 2018) conducted research to analyze the factors that lead poor construction project cost management in China. According to this research, inefficient information management and misuse information interpretation become some of the contributing factors.

(Perera A and Imriyas K. 2003) developed an integrated construction project cost information system using Ms. Access and Ms. Project. This integrated system development is based on the fact that there are abundant amount of data involved upon performing an accurate cost management in construction project. Therefore, its crucial to create an environment that able to manage all those important data.

(Yismalet, A, G. and Patel, D. 2018) conduct a critical literature review about improving cost management practice and stated that the ability of construction firm to manage large amount

of information plays a role upon delivering successful project. The authors also suggest that creating an integrated system between cost management environment is necessary to ease the project control process.

#### **2.1.4. Cost Management in Construction Project Review Summary**

According to the review above, several key factors that determine the reliability of cost management are listed as follow:

- Mature and complete information for cost management
- High accuracy of cost item analysis result
- Efficient information management under integrated system

Therefore, it is necessary to perform a cost management that covers the complete project information to ensure an accurate analysis under an efficient information management. New Rules of Measurement (NRM) is a measurement standards developed by Royal Institute of Chartered Surveyor (RICS) in United Kingdom. NRM standards are known to provide a complete level of detail for every work item and element in construction project. It is considered to be capable in providing the detailed information baseline for cost management purpose.

#### **2.2.1. BIM in Cost Management**

BIM implementation in construction management has been getting more common nowadays, however those implementation has to be reviewed further to determine the effectiveness.

(Hergunsel, M. F. 2011) studied several BIM utilization activities: visualization and construction planning and monitoring. Visualization is generally the simplest use of BIM to detect clashes or design conflicts. As soon as the BIM model are done, the quantity takeoffs can be generated to provide cost estimations for construction project. Up to this stage, BIM model are capable to accommodate the information needs for cost management.

(Smith, P. 2016) conduct a research that explore the practical issues and constraints faced by cost engineer in accordance with the rapidly developing BIM technology. According to this study, the full potential of BIM in cost management hasn't been achieved. This is commonly due to the lack of substantive data required for cost engineer and other construction professionals to fully reap the benefits the model has the capacity to provide. This requires comprehensive

approach upon developing the BIM model to make a satisfactory model for cost management purpose.

(Azhar, S. 2011) conduct a case study research in projects that involves BIM during their management process, most of the case studied does show a positive impact on cost aspect in implementing BIM. However, this positive benefits are also followed with several constraints upon implementing BIM in cost management process. Those major constraints are: need to develop model that truly reflects how construction process are carried out to ensure model credibility and the need to develop practical strategies to extract important information from the model.

## 2. BIM in Cost Management Review Summary

According to the review above about BIM implementation in cost management, several important points could be summarized:

BIM are capable to accommodate information needs for cost management

A comprehensive approach is necessary to create a BIM model that truly represents how construction process is performed

Practical strategies upon extracting information from BIM model for cost management purpose is necessary

Therefore, a good BIM software that is capable to accommodate all this purpose inside BIM model is crucial. Autodesk Revit is one among many other BIM software available in market, it was developed by Autodesk, Inc in 2002. Autodesk Revit is capable to create broad range of construction objects and integrate them into a whole building model. Autodesk Revit has been widely used by practitioners as it has the capability to provide detailed building information and enable further integration with cost and time aspects.

### 2.1. Ontology Concept

Ontology could be defined as a normative model, that represents the concepts of a knowledge domain and the relationship between concepts (Wang, H. H., Weng, S. W., Gansonre, A., & Wang, W. C. 2014). Ontology is a method of representation, sharing and managing domain knowledge through a concept of taxonomy/hierarchy (El-Diraby, T. A., Lima, C., & Feis, 2005). Ontology could be widely defined as an explicit and formal specification of a conceptualization (Gruber, T. R., & Olsen, G. R., 1994).

The approach in developing ontology has been proposed in many prior researches. However, each ontology approach has their own purpose depending on the research field (Liu, Li, Z., & Jiang, S., 2016). Even in the construction field itself, an ontological approach for cost management may not suit another purpose in the same field. Therefore, the ontology developed in this research will be focused on cost management purpose.

## 2. Ontology Concept in Construction Cost Management

There have been several studies related to the application of ontology framework in Architecture, Engineering and Construction (AEC) industry. Among those studies, some are carried out in cost management focus.

(French, S. S., Fischer, M., Kunx, J., Ishii, K., & Paulson, B. 2003) present a conceptual ontology to represent construction knowledge about the cost-driving features of building project. This ontology framework enables to help estimators to generate and maintain construction cost estimates by avoiding manual preferences that often lead to inconsistencies and inefficiencies in the cost estimating process.

(Abanda, F., Tah, T., Pettang, C., & Manjia, M. 2011) create an ontology framework to specifically estimate labour cost. This ontology framework developed imposes the need for an effective way to manage information generated for construction labour costing. An ontology-based system is proposed and developed in this research. This framework enables to assess whole of labour cost among different projects to determine the most satisfactory labour price.

(Wang, H. H., Weng, S. W., Gansonre, A. A., & Wang, W. C. 2014) analyze case studies to propose cost estimation ontology from both historical data and current professional perspective. The developed ontology-based framework can store cost analysis experiences and knowledge of estimators from previous cases. The study result shows that cost estimators can identify the breakdown items of a work item and retrieve their unit prices when performing cost analysis through the representation framework.

## 2.1. Ontology Concept in Construction Cost Management Summary

Ontology has the capability to work together with many types of information input. From the research reviewed ontology approach has several advantages as follows:

Ontology framework is able to represent abundant information on construction in a structured approach

Ontology framework ables to manage vast amount of information needs in cost management under a certain knowledge basis

Ontology is considered to be the most ideal approach in managing informations related to cost management

There have been several software available to develop ontology framework. Protégé is one among many other ontology developing software that has a good reliability upon developing ontology framework. The output of Protégé could be integrated with rule systems to build a wide range of data management system. Most of the recent researches reviewed are also utilizing Protégé to construct their intelligent framework. Therefore, Protégé will be used as the main software to develop the ontology framework for cost management purpose according to NRM standards for further BIM model development.

#### 4.4. Ontology Concept in BIM Model Development

BIM has been known to provide information needs in a construction project, the informations retrieved may vary from quantification, geometrical positioning, specification etc. However, this functionality has to be facilitated with an organized rule as vast amounts of informations are involved. In accordance to this condition, several researches have employed ontology framework upon utilizing BIM model for different purposes.

*(Karshenas, S., & Niknam, M. 2013)* developed a research that shows how informations construction and project could be represented using ontology approach that enable computer applications to manage, query and share. This research shows how the ontology framework are developed based on several level derived from IFC Format, the framework was later extended to cost item estimation. This research shows a novel approach to achieve data interoperability among element types and element relationships in buildings

*(Liu, X., Li, Z., & Jiang, S. 2016)* proposed an ontology-based representation and reasoning for building cost estimation using China GB50500-2013 standard. In this research, the authors create a systematic framework for information retrieval from the BIM model. The framework are developed based on China GB50500-2013 standard, the framework are later used to assemble the informations retrieved from the BIM model.

*(Feng, C. W., Chen, Y. J., & Yu, H. Y. 2017)* employ the ontology approach on BIM model to facilitate information requirements for subcontractor payment request and ledger. The authors initially developed an ontology framework according to the basic information and payment

request information of work items. These informations are assessed further towards their relationship with BIM elements by using special coding system to distinguished the relationship between BIM elements. Later, programming modules specialized for BIM model are linked with the ontology framework so that the framework could automatically retrieve the specified informations from BIM model.

### **2.3.5. Ontology Concept in BIM Model Development Summary**

From the researches reviewed, ontological approach ables to establish a structured information framework. Under a specific purpose, every related informations could be assembled and used as a guidance upon developing and utilizing BIM model. Eventually, a complete ontology framework regarding to cost management could be used as a guidance upon developing BIM model and later to manage the informations retrieved from the BIM model.

## **2.4. Summary of Literature Review**

Eventually, all of the topics mentioned above could be summarized as follow:

- NRM standards developed by RICS provide a very detailed and comprehensive approach related to cost management in construction project. This standard could be used a baseline upon performing cost management in construction industry.
- BIM technology are capable to help engineers upon performing a construction project assessment, unexceptionally cost management assessment. Despite there's still a drawbacks upon managing the informations retrieved, BIM has an advantage in providing an integrated information source for the project.
- Ontology method could be used as an approach to assemble informations related to cost management as its capable to manage vast amount of informations in a structured and interactive way.

According to the researches reviewed, a proper approach upon managing informations retrieved from BIM model for cost management purpose is necessary. Therefore, the author proposes to create a comprehensive ontology framework based on NRM standards as a guidance upon developing BIM model for cost management purpose.