

BIM: Integrating Cost Estimates at Initial/Design Stage

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Abstract

The accuracy of the cost estimates is very important in the initial stage because it will determine the viability of the project and provide the project budget. Therefore, Inaccuracy of the cost estimates beyond the acceptable range will cause the cost overrun in the later stage. This research aims to recommend BIM to be applied as a part of the cost management process and to improve the cost estimating at the initial/design stage. In addition, this research will investigate the factors influencing the accuracy, why BIM not been applied to reduce the inaccuracy and how BIM can be integrated into cost estimates at the initial / design stage. This research was carried out via literature review, questionnaire survey and semi-structured interview. It was indicated that insufficient information related to the project, poor communication between project team and complexity of design and construction are the three most factors influenced the accuracy of cost estimates. While collaborating and sharing information between the project team, and investment in software and training are the barriers in implementing BIM. This research found that the insufficient information related to the project is the most agreed factors from the respondents that influencing the accuracy of cost estimates at initial/design stage. The research also found out that BIM is an integrated multi-disciplinary tool that serves architecture, structural and M&E. In addition, the capabilities of BIM in assisting cost estimates allow QS to focus more value adding activities in estimating such as: identifying construction assemblies, pricing and factoring risks, which are essential for high quality estimates. In conclusion, with the capability of BIM and its integration will help to minimize the error and enhance the project cost estimates in the future.

Keywords: *Accuracy, Cost Estimates, BIM, Integration*

1.0 Introduction

Quantity surveyor are unable to attend the accuracy when they compared with the analyze sample[1]. Furthermore, the Construction Industry Research and Information Association (CIRIA) has highlighted, the construction practice should change the way of managing the design project to ensure the effectiveness and optimize solution to prevent some cost irregularities, even standardization come into place [2].

The exchange and flow of the information at the initial/design stage is a critical factor in order to ensure the quantity surveyor make the correct assumption which related to the design, planning and constructive evolve [3]. The impact of the accuracy of the cost estimating will determine the viability of the development of the project, it will make the project continue as plan or abandoned, and sometimes it faced with the legal issue when [4] cited Ashworth (2010). [5]cited RICS (2009), articulated the cost and planning process has been found to be inconsistent, inaccurate and results in poor cost management services provided by quantity surveyor. Due to this, the construction professionals should think way forward to improve the estimating accuracy and enhance further the quality of estimating for construction project. Through the revolution in the information technology (IT) industry, building information modeling (BIM) was created to increase value, lower risk and be agile enough to meet new opportunity and challenges in the construction industry.

2.0 Literature Review

Early stage cost estimation is about the forecasting of the cost of a project during the planning and design stage [6]. Cost estimates provide information to the owner or client about the expectation of the cost of projects which includes the breakdown of the elemental cost. Cost planning is used to ensure that the developer knows in the early stages of a project what the anticipated final cost of the total development may be, including the land cost, legal issues, demolitions, buildings, professionals, furniture, connection, tax, financing and management[7]. It was found that at design stage, the main objective of cost estimation at this stage is evaluating design feasibility within budget constraint[3]. Furthermore, building cost is only one of these items, but the quantity surveyor or cost manager should include all costs in the cost plan or estimate of final cost. The estimates will then become as budget estimate which must be adopted early enough for planning long term financing of the facility [8]. The cost estimates give a significant value on the decision making of the organization to the potential projects when compared to the allocated budget or fund. Later on, this cost estimate will be used as a budget or benchmark to gauge project feasible. Moreover, overestimation leads to a lesser fund available to other projects and underestimation results in difficulty to the contract [9]. Therefore, the accuracy of the earlier cost estimation is a critical factor in the earlier stage of project. Without the accuracy maybe certain projects will be abandoned due to of overestimating or underestimating.

A cost estimate at the early stage is important because later on it will be set as a parameter to monitor the design development. If any element in the cost estimates was not carried out accordingly or missing during the preparation works then it will cause the budget overrun in later stage[10]. Thus, the accuracy of the earlier cost estimate will assist to provide the information to the business organization in order to prepare the allocation of the budget to the respective projects or developments. Without the early estimate it is difficult to determine the project budget requirement and sometimes the organization governance procedure required the budget must be supported with the related documentation such as the preliminary estimates. In the other hand, the accuracy of the cost estimates will determine the performance of the organization in terms of effectiveness and efficiency in managing budget of projects or developments. The capacity of spending also depends on the early cost estimates. Most of the time the client such as a private developer or government used the preliminary cost estimates as the cost limit of the project. The preliminaries cost estimates was prepared accordingly to the initial design with the purpose to ensure the project budget is sufficient [4].

The consultant involvement in cost planning and control is very important in any project[11]. All the information or data related to the cost must be ready and available at this stage which later on its will determine the accuracy of the estimates. There were 2 prominent factors influenced the accuracy of the estimates i.e.:

Table 2.1: The Prominent Factors Affecting the Accuracy of Estimates

Factors	Authors
1. Project characteristic/complexity	Akintoye (2000), Adnan et al. (2013), Aibinu & Pasco (2008)
2. Project information	Liu & Zhu (2007),Azman & Samad (2011), Haron et al. (2011)

According to [15] when they combined the literatures from numerous authors, they defined the factors affecting the accuracy of estimates as follows:

Table 2.2: The Factors Affecting the Accuracy of Estimates

Scope quality	<ul style="list-style-type: none"> • Design scope (plan shape, size, specification and performance) • Design team experience (architect, engineers and etc) • Unclear documentation (project brief/drawings) • Location of project (site and soil conditions and extent of services) • Type and condition of contract • Basis of selection (open, selective and direct negotiation) • Commitment of client to project
Information quality	<ul style="list-style-type: none"> • Cost data (historical and current information)
Uncertainty level	<ul style="list-style-type: none"> • Project technology and complexity level • Market condition and sentiments
Estimator performance	<ul style="list-style-type: none"> • Quantity surveyor (QS) experience • Ability of QS to cope with stress (work pressure) • Communication barrier • Familiarity of QS with the type of projects • Perception of estimating importance
Quality estimating procedure	<ul style="list-style-type: none"> • Expected level of error in estimates • Limited time to prepare estimate due to dateline • Estimating method use in the preparation of estimates • Application of alternative methods by organization • Organization's estimating procedure

Source: (Azman & Samad, 2011)

Thus, from the above, it was found that there were a lot of factors affecting the accuracy of the cost estimates. The accuracy of the cost estimates was seen as the essential part in the construction process, especially at the initial/design stage. This is because the cost estimates will provide the budget before the project being executed. The inaccuracy of the estimates will give effect to the project cost and project budget in overall.

The cost estimates depends on the greater understanding of the total project to arrive at true cost [17]. Furthermore, there were 3 most important methods to improved estimating accuracy [1].

- Ensure sufficient design information is available for estimating
- Check all assumptions with clients and consultants
- Ensure proper design documentation and information management

It can be observed the three forms the above are the best methods to improve the accuracy in estimating. With the proper documentation and information it will ensure all the update data will be delivered to the other parties perfectly. To make sure the information of the data well managed, the better communication should be at the best level. With better communication channel it will bring to the good of co-ordination of works from one consultant to the others. Therefore, these will bring the sufficient design information available for the purpose of estimating process. That's why these three methods were related to each other's. The accuracy of the cost estimates is very important and crucial at the initial stage of the construction process. Sometimes it will be a yardstick to control the design process. It is possible to achieve 100% accuracy, but the degree of the accuracy should between the acceptable ranges. Due to that, the industry should find an innovate process of the construction in order to enhance and improve the quality of the cost management.

Building Information Modeling (BIM) is a combination of technology and process. BIM is just not merely as a software, but it helps the owner/client and design team to visualize the building in simulation way and identify the issues such design, construction and operational[18].

Once the building model is completed, all the information can be generated by users for fabricating, analyzing, scheduling (4D BIM), cost estimating (5D) BIM and for facility management during operation phase. Further, BIM involves generating a visual model of the building which also manages data about it, at the design stage, throughout the construction phase and during working life [19]. Thus, BIM can improve the construction process and found to be well integrated with the all the construction stages. BIM can be viewed as virtual process that encompasses all aspect, disciplines, and system of a facility within a single, virtual model, allowing tam members (owners, architects, engineers, contractors, subcontractors and supplier) to collaborate more accurately and efficiently than traditional processes [20].

Quantity surveyor plays a vital role in the construction industry through managing project cost and responsible for the cost management throughout the entire life span of a project from the feasibility and design stages until building completion [5]. It is a profession that necessitates both a high degree of knowledge and finely honed deployment skills[18]. The tasks are known as very laborious, time-consuming and are always prone to errors. The use of traditional manual quantity surveying practice such as excel spreadsheet and 2D CAD have made quantity surveying tedious and time consuming task, which are less efficient and more susceptible to human errors[19].

The biggest problem in the planning, cost estimation and construction of building is the incorrect visualization of the project information[21]. If it is not fully visualized, understood and communicated, it cannot be represented correctly in the contract documents and may consequently create problems during construction. Therefore with the innovation of BIM into the construction industry, all the factors above can be mitigate for the purpose of improving the service of quantity surveying especially in cost estimates at initial/design stage. It was found that, there were 11 capability of BIM in the quantity surveying practice.

Table 2.3: BIM Capability in Quantity Surveying

No.	Capability
1	Cost appraisal can be prepared quickly at feasibility stage
2	Preliminary cost plan can be prepared by extracting quantities from model
3	Easily update cost plan more details as design developed
4	Easily generate accurate cost estimates for various design alternatives
5	Design changes reflected consistently in all drawing views
6	Cost implication of design changes can be generated easily without manually re-measurement
7	Clash detection reduces design errors and cost estimates revisions
8	Cost checking performs quickly to ensure all items are captured
9	Improve visualization for better understanding of design
10	Automatically quantification for BQ preparation
11	Intelligent information management allows data to be stored in a central coordinated model

Source: (Fung et al., 2014)

The adoption of BIM may redefine traditional professional boundaries in construction and has the potential to automate measurement and facilitate the preparation of accurate estimates[22].The adoption of BIM may redefine traditional professional boundaries in construction and has the potential to automate measurement and facilitate the preparation of

accurate estimates [22]. BIM automatically generates quantities, take-offs and helps to reduce the time and costs required to prepare estimate. Further, another BIM capability is to capture all the changes in the drawing and automatically depicted into the model[5]. Thus it was found that BIM has an ability to ease the complicated, time consuming and risky tasks performed by the quantity surveyor.

BIM also support the full project lifecycle and offers the capability to integrate costing efforts throughout all project phases[23]. The capability of BIM was found is the design changes reflected consistently in all drawing views [24]. BIM also can changes automatically in the model and will also be propagated throughout all drawings views[25]. Therefore, BIM can increase the effectiveness of the quantity surveyor roles and improve the deliverables of every task in the construction process. BIM also may also assist to reduce the risk especially involved with cost in the construction industry. Moreover, implementing BIM into quantity surveying firm will enable quantity surveyors to do their work more accurately and efficiently which will give them competitive advantage. Furthermore, the cost management functions of BIM will change the process of cost management of construction projects, which will shift the responsibilities of the professionals involved, forcing quantity surveyors to focus on different part of the cost management process and create new responsibilities and opportunities or themselves and rearrange the structure they work in[19].

Implementing BIM into construction industry especially to the quantity surveying profession will give more advantage. It will enhance and improve the deliverables quality of works and services render by the quantity surveyor in the future construction industry sector. Thus, implementing BIM in construction project especially into quantity surveying field can overcome construction problems such delay, clash of design and disputes between construction players[26]. BIM gives benefits to the quantity surveyor on the area of visualization, collaboration and work in efficiently. Visualization give a very significant result because it can give better understanding on the complexity of the design and subsequently give the best estimate costing at the initial/design stage. it also increase the constructability, reducing conflict and requesting for information due to having a good visualization approach, reducing time for cost estimation and increasing smooth coordination and information among parties in construction projects[27].

It was found that the cost factor is become the main barrier in implementing BIM in the practice. The cost factor includes the infrastructure, software, and training. The high associated cost also was found as a real barrier for cost consultant invest in BIM, especially if they are planning to use it solely for quantity take-off.

BIM is the new invention of the technology, which can assist the construction industry to enhance the process and improve the quality of the product. It was designed purposely to collaborate and integrate the multi-disciplinary in the construction industry. With the integration of works, the process can be well coordinated and improved the communication flow. With BIM, the level of the redundant, clashing and mistake of works can be minimized through the construction stages.

3.0 Methodology

Quantitative and qualitative surveys were used in this research. Quantitative research methodology, which is characterized by positivism, measurement, and statistics has dominated the scientific literatures in many disciplines [28]. While Qualitative research is characterized by its aims, which related to understanding some aspect of social life, and its methods which (in general) generate words, rather than numbers, as data for analysis [29]. The research method was design to assist in data collection from numerous respondents and analyzed the views to make the well-informed conclusion at the end of the study. In research, before data can be collected the researcher needs to design the instruments. The instruments actually is a tools use to collect the data. There were two (2) types of research instruments designed for this research i.e. questionnaire survey (quantitative) and interview survey (qualitative). The quantitative instrument is a set of questionnaire survey which consisted of four (4) sections. The questionnaire was generated from

the content and findings collected through literature review. There were about 50 questionnaires were distributed out through self-administrated and electronic copy. The respondents were the quantity surveyors with the organization background from government and private sector. While the semi-structured interviews conducted in order to obtain details and to gather in depth understanding of BIM capabilities to enhance the quality of cost estimates. The entire respondents were the quantity surveyor who experienced and applied the quantity surveying scopes in the construction industry.

Research scope has been limited to the quantity surveyors who were working in consultancy firm and government agencies. The consultancy firms also were limited to the body corporate and partnership membership only, registered with Board of Quantity Surveyors Malaysia (BQSM) and located and within the Klang Valley area. There were about 340 firms from whole Malaysia registered with BQSM and 100 were selected between in Klang Valley area. From the 100 firms selected, there were just 50 of firms registered as partnership or body corporate membership type. It was found that there were less than 10 firms used BIM in their practices. Jabatan Kerja Raya (JKR) under the Ministry of Public Works (KKR) and Universiti Tun Hussien Onn Malaysia (UTHM) were selected as the government agency sampling group. There were consisted from various department such Cawangan Projek Kompleks (PROKOM), Cawangan Bangunan Am and Cawangan Kesihatan. While UTHM it was under the Jabatan Pembangunan.

Only twenty five (25) respondents have returned their response and feedback by completing and duly answered the questionnaires. Hence, the number of responses was insufficient due to limited used of BIM in quantity surveying practice. Initially there were around 50 questionnaires distributed through hardcopy and softcopy in electronic forms but only half gave their feedback while the balance not replied. There were 5 respondents selected as interviewee for this research. The interviewees were selected based on their background, experience and involvement in quantity surveying (QS) field and BIM.

The data collected through the analysis needs to be process in statically for precise explanations. The statistical measures that enable us to work out a single representative figure for the entire data distribution known as central tendency. The arithmetic mean or average will be used in the central tendency for this research. Arithmetic mean is calculated by adding the sum of all individual values in a distribution and dividing sum by the total number of individuals. It was done by using the following formula:

Sample Mean	Population Mean
$\bar{x} = \frac{\sum X}{n}$	$\mu = \frac{\sum X}{N}$

where $\sum X$ is sum of all data values

N is number of data items in population

n is number of data items in sample

4.0 Results and Discussions

This part would be platform to discuss and deliberate data collection and outcomes from the questionnaire survey and semi-structured interview. As shown in Table 4.1, it was discovered that majority of error occurred at the feasibility/preliminary cost estimates and representing 68% response rate.

Table 4.1: Stage Normally Error Occurred During Estimation Process

Stage Normally Error Occurred During Estimation Process	Respondents	Percentage
Feasibility/preliminary cost estimates	17	68%
Elemental cost plan	1	4%
Approximate quantities cost plan	3	12%
Pre-tender estimates	4	16%
Total	25	100%

Table 4.2 shows the area which influenced error during preparation of cost estimates. 72% respondents stated the error was due to incompleteness of the information.

Table 4.2: The Area Influenced Error in Preparation of Cost Estimates

The Area Influenced Error in Preparation of Cost Estimates	Respondents	Percentage
Wrong quantification	1	4%
Discrepancies	3	12%
Pricing	2	8%
Incompleteness of the information	18	72%
Unit mistake	1	4%
Typo error	0	0%
Total	25	100%

Following from the above results, Table 4.3 illustrated the outcomes on the factor influencing the accuracy of cost estimate at the initial / design stage. The insufficient information related to the project with mean 4.44 ranks highest as the factors influence the accuracy of cost estimates at the initial / design stage.

Table 4.3: Factors Influence the Accuracy of Cost Estimates at Initial/Design Stage

Factors Influence the Accuracy of Cost Estimates at Initial/Design Stage	Mean/Average Index	Ranking
Insufficient information related to the project	4.44	1
Poor communication between project team	4.08	2
Complexity of design and construction	4.00	3
Improper planning	3.92	4

In Table 4.4 shows the capability of BIM to be integrated into the construction process and assisting the cost estimates and it was found that the capability of BIM will allow QS's to focus on more value adding activities in estimating with mean 4.40. Table 4.5 is the outcome of the interview, which validate the result in Table 4.4.

Table 4.4: Capability of BIM in Assisting the Cost Estimates

Capability of BIM in Assisting the Cost Estimates	Mean/average index	Ranking
Allows QS's to focus on more value adding activities in estimating	4.40	1
Better visual representation of project and construction elements	4.32	2
Ability to identify quantities for the appropriate estimating level	4.28	3
BIM tools support the ability to integrate multiple models (e.g. Architectural, structural, mechanical, electrical) to better understand the constructability of the project	4.28	4
Saves quantity surveyor's time by reducing quantity take-off time	4.28	5
Ability to operate models to acquire quantities usable for estimation	4.20	6
BIM tools can provide accurate, automated, and updated quantities	4.16	7
Quickly generate quantities to assist in the decision making process	4.08	8
The quantification process improved in speed and data management	4.08	9
Integrate with professional cost estimating solutions to facilitate the takeoff and pricing process and link BIM components to cost estimating elements.	4.08	10

Table 4.5: Capability of BIM Providing Accuracy Result in the Quantifying the Quantities

No.	How BIM can assist in providing accuracy	Interviewee ID					Total	%
		R1	R2	R3	R4	R5		
1	Comprehensive model based	√	√				2	25%
2	Visualization			√	√		2	25%
3	Clash detection			√	√		2	25%
4	Faster					√	1	13%
5	accurate					√	1	13%
	Total						8	100%

The following Table 4.6 and 4.7 shows the outcomes on the barriers or challenges faced in implementing BIM to the construction industry in Malaysia and how to overcome the barriers/challenges implementing BIM in Malaysia.

Table 4.6: Barriers or Challenges Faced in Implementing BIM to the Construction Industry in Malaysia

Barriers or Challenges Faced in Implementing BIM to the Construction Industry in Malaysia	Mean/average index	Ranking
Collaborating and sharing information between project team	4.04	1
Investment in software, training and hardware	4.00	2
Changes of business process to support BIM	4.00	3

Table 4.7 and 4.8 below shows the outcomes from the interview which validate the result in the Table 4.6 above, which budget/BIM cost is the factor why BIM not been applied in order to reduce the inaccuracy of the cost estimates while seminar/workshop/campaign is a high rank on how to increase awareness in BIM.

Table 4.7: Why BIM has not been applied in Order to Reduce Inaccuracy of the Cost Estimates

No.	Factor	Interviewees'					Total	Percentage
		R1	R2	R3	R4	R5		
1	Budget/BIM cost	√	√		√	√	4	40%
2	No enforcement implementing BIM	√					1	10%
3	Absorptive capacity & knowledge barrier		√				1	10%
4	Working culture			√			1	10%
5	Reluctant to change			√			1	10%
6	No expertise				√		1	10%
7	No awareness				√		1	10%
	Total						10	

Table 4.8: How to Overcome the Issue and How to Increase the Awareness in BIM

No.	How to overcome the issue and how to increase awareness	Interviewees'					Total	Percentage
		R1	R2	R3	R4	R5		
1	Improve BIM process	√					1	9%
2	More exposure/increase person capability to operate BIM	√		√			2	18%
3	Seminar/workshop/campaign	√	√	√	√		4	36%
4	Collaboration from government agencies & professional body		√				1	9%
5	Client initiative to use BIM				√	√	2	18%
6	Imposition of enforcement					√	1	9%
	Total						11	

In Table 4.9 shows the capability of BIM to be integrated into construction stage, multi-disciplinary capability that serves architecture, structural and M&E rank in number 1 with mean 4.20.

Table 4.9:How BIM can be Integrated Into Construction Stage

How BIM can be Integrated Into Construction Stage	Mean / average index	Ranking
Multi-disciplinary capability that serves architecture, structural and M&E	4.20	1
Ability to support work process with multiple team members working on the same project	4.08	2
Ability to work on large projects	4.08	3
Direct integration with cost estimating applications	4.04	4
Quality of help and supporting documentation, tutorials and other learning resources	4.04	5
Support construction related task such as quantity take-off, estimating and 4D scheduling	3.92	6

4.1 Discussions

In summary, it was found that the insufficient information related to the project is the most agreed factors from the respondents that influencing the accuracy of cost estimates at initial/design stage. this result also supported by the previous research done by [30] where the accuracy of preliminary estimating methods depends on the availability of information at the time. While for the factors improving the accuracy of the cost estimates at initial/design stage is improve internal work coordination, there was a similarity with the research done by [15].

In the area of application of BIM in order to reduce inaccuracy in cost estimates, the collaborating and sharing information between project team was ranked at first place. This statement was supported by [31] as he stated as the easy access to information offered by BIM allows a better exchange and sharing of ideas among project stakeholders which reduces information errors. Reduce BIM cost is the most agreed to overcome the barrier or challenges in implementing BIM. This result was validate the research done by [26] where mentioned BIM is seen as an expensive technology to be adopted. Similar to report done by [32] where BIM cost was determine as a barrier in implementing BIM in construction industry.

On the capability of BIM in assisting the cost estimates, there were significant result where almost of the factors been agreed by the respondents. At the ranking first place was almost quantity surveyor's to focus on more value adding activities in estimating same as expressed by [19] where both of them discovered the cost management functions of BIM will change the process of cost management of construction projects, which will shift the responsibilities of the professionals involved, forcing quantity surveyor to focus on different part of the cost management process and create new responsibilities and opportunities for themselves, and rearrange the structure that they work in.

On how BIM can be integrated into construction stage, majority of the respondent agreed that it is important in BIM to have Multi-disciplinary capability that serves architecture, structural and M&E. Subsequently followed by ability to support work process with multiple team members working on the same project, ability to work on large project, integrated directly with cost estimating applications and finally provides quality of help and supporting documentation.

5.0 Conclusions

This research was deliberated purposely to give the general overview on the capability of BIM in assisting the preparation of cost estimate at initial/design stage. In the research there were a several weaknesses occurred during preparation of the cost estimates. A cost estimate is important to client for them to allocate the budget and financial forecast. Thus, in order to minimize the error during preparation of cost estimates, BIM was found as a tools/process to overcome the

issue.

Furthermore, from this research it was found that there were a lot of advantages of BIM towards improving the cost estimates. Despite the involvement a huge amount for investment into BIM, the quality produced by BIM will give a significant value to the quantity surveying practice. The capability of BIM in the integration with the all parties involved in construction was seen as one of the factor to enhance the future of construction industry in Malaysia. This is time for Malaysia construction industry to move forward to be competitive in the future global and liberalization market.

Finally, even though there were advantages in the application of BIM towards improving the quality of cost estimates, the industry also faced with the hindrance from the quantity surveyors. The factors relating to ability to sharing information, BIM cost, change of work culture and knowledge has limited the implementation of BIM into the industry. Therefore, the intensive and comprehensive awareness or training program should be organized by the government and private sector to overcome the hindrance. All parties in the construction industry include the education sector, should collaborate together in promoting the implementation of BIM in Malaysia construction industry.

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