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Sustainable BIM-Based Cost Estimating for Quantity Surveyors

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Construction cost estimates provided by the Quantity Surveyors are constantly producing errors and inaccuracies due to unmanageable circumstances. Unreliable cost estimates are developed throughout the project stages in which can create more complications towards finishing the projects. The Building Information Modelling (BIM) technology has increasingly become prominent nowadays to facilitate the construction industry stakeholders to overcome those issues. Its exemplary benefits experienced by the users demonstrate that BIM could efficiently assist the cost estimators to establish more reliable measurement of the building quantities that would significantly determine part of the total project costs. BIM automation in the quantities take-off would reduce changes and reworks that effectively improves the development of the costs. This mechanism obliquely governs the Quantity Surveyors as estimators to practise more sustainable practice in establishing more reliable cost estimates. This paper reviews the potentials of the BIM innovation to aid the Quantity Surveyors towards establishing more sustainable practice when incorporates the technology in their cost estimating procedures. It combines the three aspects of people, process and technology in compelling the BIM-based cost estimating to function at its optimum performance. In integrating these three aspects, not only the Quantity Surveyors need to be competent in adapting BIM tools, but also to traditionally master the fundamental of building measurement. By establishing those holistic criteria to incorporate BIM in their cost estimating practice, dealing with other disciplines in the project team will be much easier and BIM application for the intended project will be at its optimum usage.

1. Introduction

Practising sustainability in the construction industry could lead towards sustainable development in maintaining a healthy built environment. With reference to the Brundtland Report launched in 1987, the concept of sustainable development entails the environmental, economic and social aspects (Brundtland, 1987). Environmental aspect concerns on maintaining resources usage; whereas economic aspect involves ability to support economic production; and social aspect construes the system to function at defined level of social well-being. The well-known technology of Building Information Modelling (BIM) has been widely promoted for its potential on sustainability impact towards more integrated information and collaboration in the construction industry.

As reported internationally (NBS, 2016), BIM of many interests has driven the increasing adoption of the technology amongst the construction players in most of their building projects. As comprehensively defined by Eastman et al. (2011), BIM is a modelling technology associated with processes in which building models, represented with digital objects, are created in characterising building components. BIM benefits as described by many authors include cost and time saving, reduced human resource, quality and performance improvement, clash detection, improved accuracy, increased profitability, enhanced collaboration and communication, better presentation and documentation process, improved planning and design, better visualisation and improved information.

In relation to cost estimating practiced by the Quantity Surveyors, the traditional process as described by Peurifoy and Oberlender (2002) involves kick-off meeting, work plan establishment, estimates preparation, estimates documentation, reviews and adjustments, project execution, and feedbacks upon completed

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projects for subsequent improvements. Pertaining to improving the conventional estimating tasks that are continuously dealing with errors, inaccuracies, omissions and ethical flaws, BIM mechanism is claimed to contribute significant solutions towards these issues (Olatunji and Sher, 2010). Having similar processes as conventional method, the BIM-based cost estimating differs only in the application of 3D models rather than using 2D drawings to primarily execute cost estimation (Meerveld et al., 2009). Due to this BIM-adopted estimating process that highly relies upon accurate and complete digital models, the mechanism brings more favours in envisioning costs for construction projects (Sylvester and Dietrich, 2010).
Some of the existing research that have assessed several subjects on cost estimating integrating BIM technology are lacking on investigating the aspects that link BIM and sustainability in establishing a more reliable and accurate cost estimates in construction project. This paper aims to provide a review on how the BIM technology could be incorporated in the cost estimating practice by the Quantity Surveyors towards establishing sustainability concern in the construction industry.

2. Methods

A comprehensive literature review was undertaken for this study mainly from related journal articles and conference papers. This paper limits the study confining the responsibilities of the Quantity Surveyors in cost estimating practice only. Sequentially, substantial information was gathered for the literature using keyword searching such as “sustainable construction”, “sustainability and quantity surveyors”, “sustainable cost estimates”, “sustainability and BIM”, and combinations of a few more. In ensuring that only updated information is reported, this paper refines the search within five years references. The ruling was not applicable for certain data that contain relevant information on particular subjects such as definitions, principles and concepts in studied area. The selected information was presented outlining the pertinent topics of the significant roles of the Quantity Surveyors in using BIM to achieve sustainability in the construction industry, BIM indicators for cost estimates preparation by the Quantity Surveyors, and BIM technology that incorporates the aspects of people, process and technology in cost estimating practice to establish sustainability.

3. Results and discussion

3.1 The significant roles of Quantity Surveyor in using BIM towards sustainable construction

Estimating project costs has become part of major responsibilities of Quantity Surveyors (Gee, 2010) and ensuring that the developed budgets are within the range set by the clients is a main concern. The cost estimating process regardless methods applied depending on project development phases, needs to demonstrate reliable and accurate estimates. The principles of attaining reliability in cost estimates have been broadly discussed. Choosing the appropriate techniques and procedures in estimating the costs is crucial to improve its reliability and accuracy (Azman et al., 2013) for the estimates could be constantly used as tender basis and reference for prospective project management (Samphaongoen, 2010).
Regarding BIM, the technology has been widely deployed in quantity practice around the world to facilitate the Quantity Surveyors in their cost estimating activities. As reported by Tse et al. (2009) the usage of BIM in the construction projects contributes significant involvement of the Quantity Surveyors particularly in materials take-off, as compared to their traditional exercise. Although the operation of BIM could automate building quantities, it does not challenge the roles of the Quantity Surveyors as the technology itself has some restrictions to overcome (Olatunji et al., 2010). The process requires the ultimate knowledge and skills of the Quantity Surveyors to produce more reliable and accurate cost estimates (Nagalingam et al., 2013).

3.2 BIM sustainable indicators for cost estimates preparation

There are some criteria assessments in examining sustainability attributes in the construction industry. For example, a research by Rooshdi et al., (2017) summarised several criteria on the design and construction activities to establish sustainable highway construction. Whereas, Sahamir et al., (2017) identified three main factors of economic, environment and social in assessing green hospital building. In developing reliable and accurate estimates towards optimising clients’ satisfaction, there are numerous factors to be significantly considered by the Quantity Surveyors as estimators before any cost decisions. The factors are varying from project information and its characteristics, project team, clients, contractual matters, and also other external influences (Ismail et al., 2015). Table 1 characterises the elements of the factors in detail and their respective indicators, including project information, project characteristics, client requirements, contract requirements and external influences.

Table 1: Indicators for cost estimates preparation

Cost estimates reliability factors	Indicators
Project information	Value, size/floor area, price intensity, location, type, duration, storey/compactness/volume/opening
Project characteristics	Design & construction (drawing/scope/process), information (flow/availability/quality), complexity (design/construction)
Project team requirements	Experience/expertise/professional level, team alignment/capacity/communication, estimation design/process/procedure, management & technique (time/cost control)
Client requirements	Budget/financial status, return profit/money issues, client characteristic/type, time/quality requirements
Contract requirements	Scope of contract, tender/contract period, tender selection method, procurement route/contractual arrangement, type of contract/standard, pre-contract (design/construction)
External influences	Site requirements, bidding/contractor attributes, market condition (rate/inflation/fluctuation), technology requirements, uncertainties (contingencies/variations), political situation, environmental (climate/geology/disaster), disputes (contract/regulation/payment)

Updated information in any construction projects greatly facilitates the estimators to produce more reliable project costs (Olatunji and Sher, 2010). Amongst the components that compose project information are the project size, values, location and type. The factors that are related to project characteristics include complexity of design and construction, and the quality of information. Project team requirements involve the experience and professional level amongst the estimators, communication, and estimating procedure and its management. Client requirements consolidate the financial and profit, in line with time and quality necessities. Requirement in contract embodies scope, period, types and its arrangement. External influences conjoin site requirement, pre-requisite technology, market conditions, and any other uncertainties.

BIM-based practice has similar processes of conducting cost estimates, but disparate only in the application of 3D models replacing manual 2D drawings (Meerveld et al., 2009). The factors described suffice minimum criteria in enhancing reliability and accuracy of cost estimates, hence should also be used as a benchmark in adapting BIM digital models within the conventional cost estimation procedures. The approach towards BIM-supported cost estimation must consider those factors upon determining the suitability of embedded parameters in BIM models (Ismail et al., 2015).

With regards to measuring sustainability indicators for cost estimates preparation, all the above-mentioned factors also accordingly used as a basis to assess sustainable features in the cost estimating practice by the Quantity Surveyors. Those factors should be critically manipulated to facilitate the Quantity Suveyors to provide more reliable source for more accurate cost outcomes.

3.3 The aspects of people, process and technology in cost estimating practice incorporating BIM to establish sustainability

Whilst captivating the accuracy factors as indicators towards providing a sustainable cost estimate, BIM capabilities in fact enhance the cost estimating practice through imperative aspects encircling those indicators. The main BIM merits to Quantity Surveyors have been featured by various authors such as cost checking for decision making (Matipa et al., 2010), automation of quantity take-off (Wijayakumar and Jayasena, 2013), improved project performance by time, cost and quality aspects (Wong et al., 2014), and value-added to services (Crowley, 2013). Conclusively based on its various benefits, the significant contribution of BIM technology towards sustainable cost estimating practice by the Quantity Surveyors, embraces the elements of people, process and technology. It is believed that the usage of BIM could resolve the low reliability in cost estimates through those elements. The following sections further explain the three elements in influencing cost estimates implementing BIM mechanism to stimulate sustainability in the practice.

3.3.1 People

People are normally gravitated more towards images or visuals rather than normal texts or merely numbers. Digitalised models as mechanised by BIM innovation are amongst the sustainable characteristics that could captivate thus facilitate its users to comprehend building construction more effectively. BIM models visualising actual building configurations helps the Quantity Surveyors to gain more understanding on design and construction in producing cost estimates (Thurairajah and Goucher, 2013). By exploiting the detailed and clearer information extracted from the 3D models, it consequently assists the estimators to develop better cost

decisions. As compared to using traditional 2D drawings that prone towards re-measurement and reworks upon ambiguous particulars, mobilising 3D prototype models within BIM operation could clearly produce much preferable result. Nevertheless, Boon and Prigg (2012) emphasised that in assuring the efficiency of information extraction from BIM models for cost estimation purpose, the Quantity Surveyors need to possess the ability of using digital software. Predominantly, the aspect of people demands the capabilities of the Quantity Surveyors as cost estimators not only to understand the principles of traditional method of building measurement, but also to acquire the knowledge and skill of using digital software related to BIM.

3.3.2 Process

As for aspect related to the process, BIM could provide a sustainable environment through time and cost reduction due to the application of 3D models replacing the usage of conventional paper drawings. Engaging with 2D measurements and 2D designs could lead to errors and omissions causing inaccurate estimating and budgeting (Monteiro and Martins, 2013). However, BIM tools serve detailed and more accurate data to elucidate those issues, hence, making the cost estimating procedures more accelerated with unnecessary cost eliminated. BIM models supplied with rich data could also replace traditional 2D methods in a way that it allows information integration with seamless flow from initial stage towards the end of the project life cycle (Goedert and Meadati, 2008). The aspect of process acknowledges the roles and responsibilities of every discipline in the project team, to adhere with the procedures in integrating sufficient information in the BIM model. The information gathered should be communicated and administered in an appropriate standard methodology or system, accessible by all related stakeholders.

3.3.3 Technology

In conjunction with the sustainability element contained in the BIM-supported cost estimating practice, the aspect of technology necessitates all disciplines to establish substantial and integrated BIM models within their project team. The needs are to cater an effective visualisation of the actual building construction, to provide a reliable database for the project, and to coordinate all data to be adequately utilised by the estimators for cost estimating purpose. BIM visualisation through 3D model views not only represents building properties but also simulates their movement and interaction (CRC Construction Innovation, 2009). In comparison with the traditional method, it was verified that only with BIM 3D visualisation is sufficient to inaugurate accuracy in cost estimates (Shen and Issa, 2010). BIM digital database that contains intelligent objects symbolising building elements provides an archive to all physical and functional output of buildings rather than separated drawings given in conventional ways (Kumanayake and Bandara, 2012). Differs from paper-based drawings, BIM mechanism generates coordinated 3D models integrating all disciplines to effectively communicate the vital information amongst the team (Kumanayake and Bandara, 2012).Table 2 summarises the three aspects of people, process and technology in impacting cost estimates adopting BIM for more sustainable quantity surveying practice.

Table 2: Aspects of people, process & technology in incorporating BIM for sustainable cost estimates

Aspects	BIM-cost estimates sustainable elements	Implementation strategy
People	• Better understanding of actual construction with BIM visualisation • BIM models assist estimators to make better cost decisions	Demands the estimators to have holistic knowledge on both digital Software and fundamental building measurement
Process	• more detailed and accurate data with BIM tools to reduce reworks • BIM models permit information integration throughout project stages	Requires collaboration of all disciplines in project team in corresponding their Roles and responsibilities to provide data
Technology	• Reliable database with simulation and interaction of building properties • Coordinated 3D models to verify clashes in building elements	Needs effective communication and integration of data within team to Establish sufficient and accessible project information for all disciplines

4. Conclusions

In summary, gaining and maintaining sustainability in the construction field is vital in ensuring that the industry could survive its continuation. Being part of the construction team, the Quantity Surveyors should also be accountable to rectify any of their untenable practice that could compromise the goals. One of the most significant tasks identified contributing towards unsustainability in the quantity surveying practice is the establishment of construction cost estimates. Traditionally, the cost estimates produced by the Quantity Surveyors as estimators are perpetually prone to errors, inaccuracies, reworks and countless inconsistencies. The innovation of BIM mechanism has been recognised to conveniently facilitate the Quantity Surveyors in developing more reliable and accurate project cost estimates. The capabilities of the technology in providing more sustainable mechanism in cost estimating practice further induce more viable environment in the construction industry. Through demonstrating the function of people, process and technology, this study shows the significance of practising BIM mechanism as an added-value in their cost estimating activities towards improving sustainability in the field. By utilising such BIM technology, it becomes a fundamental shift in the roles of the Quantity Surveyors to stay reliable and competitive to remain in the much challenging industry.

The effectiveness of implementing BIM to promote sustainability in the construction industry requires several strategic actions integrating those three elements of people, process and technology. Indeed, it begins all-inclusive from the individuals to execute the process accorded with the technology. For example, in retrieving information efficiently from the BIM operation, the users must be competent in employing software of BIM model created. In line with this, the process administered must also be dealt with the other designers in the construction team to obtain adequate and accurate data for the cost estimating preparation purpose. Consequently, incorporating BIM technology within cost estimating practice itself demands sufficient knowledge and skills of the estimators. In overall, to effectively utilise the BIM technology, the usage of the software and the understanding of fundamental building measurement need to be highly integrated. A Quantity Surveyor as a cost estimator and a BIM user therefore, should possess those both qualities. It is to certify that eventually the technology could progress the existing practices in contributing towards sustainability concern in the entire construction industry. Hence, in respect to this matter, more related researches are recommended to be further carried out in the future.

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