EFFECTIVENESS OF ADOPTING BIM ON QUANTITY SURVEYING PROFESSION DURING THE PROJECT LIFE CYCLE

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Despite the significant role of the construction industry in nation's wealth and development, the construction industry usually suffers from poor performance in terms of time and cost overruns. This is due to its characteristics in terms of complexity, fragmented nature, a large number of involved parties and a wide range of professions. Quantity surveyors (QSs) profession is one of the key professions with many essential tasks over project life cycle. BIM has been claimed by various professions in the construction industry to enhance the project performance and tackle many problems within it. This research aims to evaluate the effectiveness of adopting BIM on QS profession and its performance in a construction project. The literature was intensively reviewed to determine the main responsibilities of QS over project life cycle when it works the main project parties (client and consultant). In this part of research, the implication of the use of BIM has been specifically dealt with the work in pre-construction stage. A set of criteria were extracted and identified based on the main responsibilities of QS profession by conducting structured interviews with clients and consultants. Many scenarios were produced, after modelling a multi-storey building project utilizing Revit Architecture Software, to reflect the effectiveness of using BIM with various tasks of QSs. The model facilitates generation of different scenarios based on outcomes. The initial results revealed that adopting BIM improves the accuracy and reliability of QSs outputs at early stage of project and enhances the documentation of project performance over project life cycle. Also, the results demonstrate that project parties get benefits, from BIM adoption by their QSs, in terms of more reliable budgeting, less errors in quantities measurement, better documentation considering the limitation of adopting BIM, lack of BIM standard and the compatibility between the BIM software.

Keywords: surveying, project life cycle, 5D BIM, industry foundation classes

INTRODUCTION

The construction industry, nowadays, is developing at a rapid pace and contributing to growth of nation's economy (Seed, 2015) further to its contribution to the economy of the country's gross national input, Kumar (2015). It is considered as a major productive sector besides its strong linkages with other industries (Durdyev& Ismail,

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2012). In construction, client's needs are prioritised on the one hand and the benefits of other stakeholders on the other (Chini and Valdez, 2003). Despite of its large investment growth and its contribution to the economics, the construction industry is still struggling from underperformance in term of quality and productivity (Love, *et al.,* 2013). Construction projects are very complex in nature, due to the multi interchangeable activities; result in lack of coordination and ineffective communication (Gamil and Abdul Rahman, 2017). Two common challenges faced by the construction industry related to documentation including the quality of data generated and utilised during the project; and the ways of communicating and sharing the relevant data between the stakeholders (Crotty, 2012). These problems as indicated by Purnus and Bodea (2015) may affect the timely completion of the project at the predetermined budget, agreed level of quality and the end profitability. Further, Akmal *et al.,* (2018) specified that, unreliable cost of the construction projects, which is developed during the construction stages, could lead to unhealthy construction environments, create more complication towards the project closing, and influence the predetermined objectives of the project outcomes and targets, hence the overall project success.

Cost overrun, unpredictable completion and low productivity are considered as most frequently problems faced by the construction industry (Proverbs *et al.,* 2000). Accuracy in the quantity take-off process is one of the key functions in the construction industry which in turn affects project cost and the overall performance (Monteiro and Martin, 2013). Due to the complexity of the construction project, the industry may face financial challenges in term of poor productivity, profitability and inconsistent performance (Armstrong, 2017). In order to overcome and handle those problems, it is essential to maintain the value of the projects, by employing an innovative approach. Quantity surveyors play an important role in providing cost and contract advice on the built environment as pointed out by Cruywagen and Lille (2017) in addition to their crucial responsibilities towards the project parties over the project life cycle. Hence, acquisition and effective adoption of IT skills by the QS at an adequate level of knowledge, is required for more accuracy and reliability of construction cost. To do so, QSs must work with the latest technology such as BIM to improve the quality of the services provide by the QSs. The main objective of this paper is to provide a clear insight on the roles and responsibilities of the QSs and investigate the potential effectiveness of adoption BIM tools on the level of accuracy of quantity measurement.

Attributes of the Quantity Surveyors

Quantity survey is a major part of the construction scenario and determines to a great extent the changes in the economic growth, Purnus and Bodea (2015). QS has been defined by the renowned Seeley (1997) as a person who, on behalf of the employer, is professionally trained, qualified and experienced in dealing with building costs, construction management and construction communication issues. Since the QS is highly involved in many tasks and activities within construction projects, there is a need to assess the skills of the quantity surveyors, to understand their current approach to identify the opportunities and to address the market changes (Jennings and Betts, 1996). QSs have to monitor and provide a clear status about the financial situation of the project during the project life cycle with a high level of efficiency and consistency, (Cartlidge, 2018).

Success Criteria of Construction Project

The project success highly depends on the decisions and roles of quantity surveyors in achievements of the predetermined goals which influence the project efficiency in terms of time, cost and quality. Critical project success criteria as highlighted by Atkinson (1999) are closely linked to project effectiveness and productivity measurement. Such criteria are linked to the number of factors; time, cost and quality factors interrelated with each other. The iron triangle of time, cost and quality are the fundamental parameters for measuring project success throughout the life cycle of the project, as stated by Junior, Silva and Pacifico (2017) and agreed by Cunningham, (2013).

Building Information Modelling (BIM)

BIM is a modelling technology and associated set of processes to produce, communicate and analyse building model (Eastman *et al.,* 2012). BIM standards as declared by Crotty (2012) substantially improve the quality of the building drawings to provide a complete picture of the project and facilitate data interchange to be communicated more effectively amongst the project team members.

BIM and Quantity Surveyors

Several studies investigated the BIM adoption by QSs with main focus on quantity measurement, cost estimation, scheduling and planning (Kulasekara *et al.,* 2016). Hence, possession of IT skills by QSs is part of their basic responsibilities provided at the early stage of the construction project (Manzoor& Gunavel, 2017). BIM technology is becoming increasingly a new trend in the construction industry due to its rapid strides in improving the project productivity, efficiency and worldwide construction development. Distinctive attributes of BIM support in automating the construction process by establishing a flow of communication with the project team at all the project phases. Emergence of BIM in the QSs domain has remarkably changes the QS future, despite the challenges and barriers identified through various research studies (Kulasekara *et al.,* 2016). Estimation of the BIM models assists the quantity surveyors, to take an appropriate decision at the early stage to optimize the best outcomes to the stakeholders and all directly benefit from the project (Eastman, *et al.,* 2011). Forgues *et al.,* (2012), revealed that utilizing BIM technology in the area of the cost estimation; takes the project to the best value by applying the most effective quantity take off tools to decrease risk factors of inaccuracy, underestimate or overestimate, as well as shortening time required to completing estimation task with high level of accuracy.

Also, estimating of total cost of the construction project at the early stage of the design process, support the effective delivery process of high-quality project within the proposed budget and scheduled time line and avoid the inaccuracy resulting from the traditional practices. From this point of view, BIM adoption is promising to provide a unique source for accurate cost estimating for the entire lifecycle of the project. Although BIM adoption can bring many benefits to QS and other project professionals, but this is not free of challenges. The challenges of adopting BIM, comprise in the way of how the BIM model responding during the process of quantity take off and throughout the construction process. The scope is to complete the project as per the predetermined schedule and agreed budget Cunningham (2013) and to streamline the delivery of high-quality project (Eastman, *et al.,* 2011). Supportively, adopting BIM tools effectively by quantity surveyors improve the quality of the project (Kulasekara *et al.,* 2016). Quantity take off is one of the fundamental and most automated tasks could be completed with help of BIM tools by the quantity

surveyors form 2D drawings Gee (2010) and Monteiro and Martins (2013). BIM and its allied digital technologies and tools provide enormous opportunities for project cost management professionals to dramatically improve the quality, speed, accuracy, value and sophistication of their cost management services and therein ensure their future as key players in the BIM world (Smith, 2016). QSs are still behind to understand the full potential of BIM in the construction field. It is the time by the construction firms to embrace BIM technology and competing with other industries obtain the full benefits of such a technology. The greatest issues related to the quality/comprehensiveness of the BIM models, are comprising of not providing full access to the designers to the models and software/standards compatibility issues. Acquiring the benefit of adopting BIM technology, is associated with accuracy in estimation, resulting on the cost benefits. It is also linked to the developed model. If the developed models do not visibly reflect the project requirements, this will impact the construction cost as well as the project cost Love, *et al.,* (2013), considering the reliable construction cost as the critical success factor for successful implementing of BIM in the construction industry (Afaria *et al.,* 2018). To sum up, it is believed that BIM empowers project participant to play their roles in improve the project quality on time and predetermined budget. Project quality and productivity could be improved by enhancing the construction players' skills in running the project activities effectively and efficiently (Latiffi *et al.,* 2016). Variety of QTO software helps the quantity surveyors to eliminate the errors during the conventional process of quantity take off, hence, multi BIM based cost estimation programs have been developed (Plebankiewicza, Zimaa, and Skibniewski, 2015). Contrariwise, multi tools of estimation software/ BIM estimation packages lead to deviation in data produced. That is due to the lack of BIM standard, i.e., IFC which necessitates more attention to be paid to overcome the problems associated with BIM standards as raised through the current research.

Industry Foundation Class - IFC

Industry Foundation Class (IFC) has been established by International Alliance of Interoperability (IAI) in 1994. It is some continuous outcomes to the mission of the building SMART as mentioned in IFC (Laakso and Kiviniemi, 2012). The main objective of IFC is to enabling interoperability in the AEC/FM Industry. IFC is a neutral standard format for open BIM developed in different versions and not controlled by a singular vendor or group of vendors (Hernández *et al.,* 2018). It is described as an interoperability language and it is freely available on the web. The most widely common IFC is IFC 2x3 and the latest version released in 2013 is IFC4 which is yet to be incorporated with most of BIM software (Abanda *et al.,* 2017). The current research highlighted on the main issues raised associated with IFC while exporting the digital models between two common estimation digital tools of BIM.

Roles and Responsibilities of Quantity Surveyors During the Project Life Cycle

As the construction industry grows, more and more skilled roles become available, particularly in positions such as quantity surveyors. The responsibilities of QS vary over project life cycle and depending on the party to whom the QSs works for. Usually, quantity surveyors are responsible for the cost related issues of any construction project-from initial estimates to final material acquisition. Quantity surveyors as defined by RICS (2015) work as the cost managers in all sectors of the construction industry worldwide, since they are involved in all the construction phases from inception to completion and understand all the aspects of construction during building life cycle. They must have the ability to manage cost effectively, equating

quality and value with individual client needs. During capital expenditure phase, QSs are requested to be involved in the activities of studying the project feasibility, construction and execution, extension, refurbishment, maintenance and demolition of a facility. In the pre-construction, construction and post-construction phases of the whole building project, client, consultant and contractor QSs are involved, having essential skills for communication and troubleshooting, in the event of conflicts between the project parties. Monteiro and Martins (2013) indicated that QSs have IT skills for greater accuracy, provided at an early stage for the construction project to be feasible to fulfil the value system of the client.

RESEARCH METHODOLOGY

The methodology of the current research has been designed in two stages to achieve the main objectives. Stage 1 is designed for data collection through literature review and semi structured interview. Whereas Stage 2 is designed to extract quantities of the building elements through BIM software, Autodesk Revit and Naviswork.

Stage 1: Based on the literature review and following the roles and responsibilities of QS, four semi-structured interviews were carried out with consultants QSs and client to identify a set of criteria, to evaluate the QS effectiveness and rank their importance from the point of clients' and consultants' perspectives as shown in Figure 1. However, the criteria were classified into three main stages of the project life cycle, i.e., preconstruction, during construction and post construction and the QSs' responsibilities towards the clients, consultants and contractors have been identified as well. But, due to the limitation of the paper size, roles and responsibilities of the QSs towards the clients and consultants during the preconstruction stage were identified.

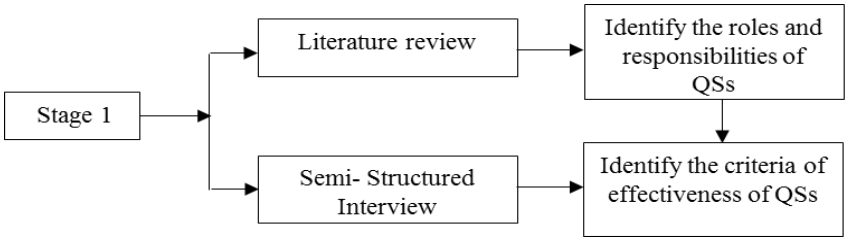


Figure 1 Research Methodology-Stage 1

Stage 2: A BIM model was built by using Autodesk Revit. The building model is a multi-use building consists of, two basement floors for parking and utilities, and six above ground floors for retail, offices, and residential flats. The building model comprises of four different engineering disciplines, Architectural, Structural, Electrical, and Mechanical. For the purpose of the current research, the quantities of structural elements of blinding foundation were extracted using Autodesk Revit and Naviswork. The process of extraction the quantities started by utilizing Autodesk Revit, meanwhile, the model was exported to Naviswork through IFC standard format. IFC standard was selected to study the compatibility between the BIM software and addressing the issues result in exporting the models between BIM software. Accordingly, the results from two packages were compared to evaluate the compatibility and were reflected to match the criteria of the QS effectiveness. The complete process is demonstrated in Figure 2.

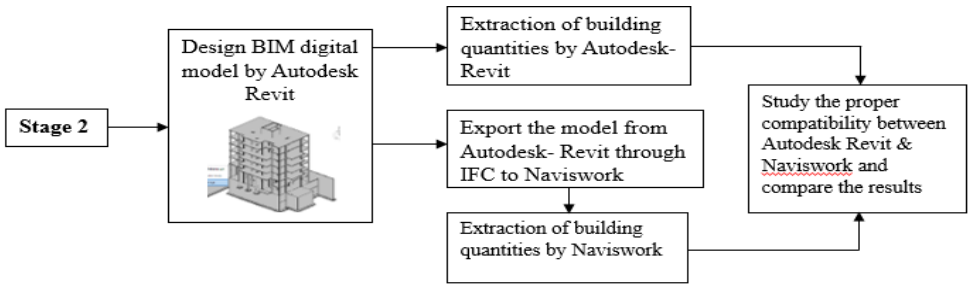


Figure 2 Research Methodology-Stage 2

DATA ANALYSIS AND RESULTS DISCUSSION

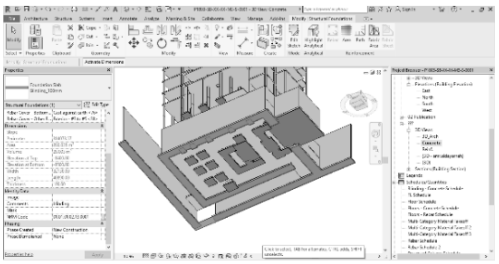
Stage1: Based upon the research methodology, stage 1, the essential criteria were identified as mentioned in the Table 1. Out of all the criteria identified, three major criteria comprising of; accuracy of quantities estimation, speed of quantities generation and cost analysis, planning and adherence to the timeline were the governing ones. The remaining criteria follow the major heads and can be seen Table 1 which summarises the main roles and responsibilities of QS during the preconstruction stage when working for various main parties and the final column show the criteria identified that can help in assessing the QS roles.

Table 1: Summary of the roles and responsibilities of QSs during preconstruction

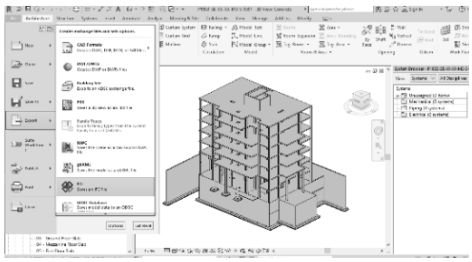
QSs duties / preconstruction stage	Project life cycle Pre-Construction Stage	Criteria ranked based on its importance
Clients	➢ Forecasting the overall project's cost at the initial stage. ➢ Act as a client's financial consultant during project progress. ➢ Ascertain the project feasibility and economic viability. ➢ Provide the client with valuable recommendation to maximize the benefits. ➢ Provide advice during the pre-construction on strategic planning, cost management and cost implications.	✓ Accuracy in estimation ✓ Certainty of Cost Prediction ✓ Cost analysis. ✓ Planning and adherence to the timeline. ✓ Quality of financial data ✓ Contractual administration ✓ Stakeholders satisfactions ✓ Stakeholders benefits ✓ Overall project performance ✓ Degree of improvement
Consultants	➢ Monitor the design team to ensure the design remains within the approved budget. ➢ Manage the financial aspects during the construction process. ➢ QSs, and the design team to figure out an appropriate solution within budget to provide the client with the best value for money. ➢ Produce an accurate priced bill of quantity. ➢ Preparation of tender and contract documents.	

Stage2: Based on the results obtained from stage2, the model was prepared considering the client's requirement and the consultant's specification. Keeping in mind the limitation in the size of paper the quantity analysis of blinding work in preconstruction stage was considered. The input data was fed in Revit and extracted to export in Naviswork through IFC. This is done in order for the QS to check the accuracy of the quantity to be extracted by any software and simultaneously to check its accuracy. It was found that there was a major incompatibility which can be owed to lack standard format which is IFC format as presented in Figure 2a. Phase1 shows the structural BIM model in which the quantity of blinding foundation as calculated in Revit is 28 m^3. Then, the model was exported to Naviswork through IFC and the quantity was found to be 58 m^3. It indicates that the quantity doubled in Naviswork reflecting huge incompatibility and non-feasibility of IFC standards. The foundation was re-modelled by changing the way the input data is fed as shown in Figure 2b.

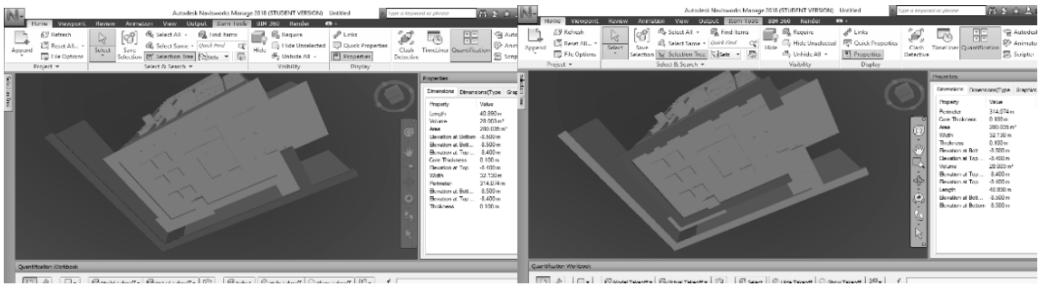
Phase 1- Building the Structural BIM Model and estimating the quantities



Step 1: Estimating the quantities of Blinding foundation = 28m3³



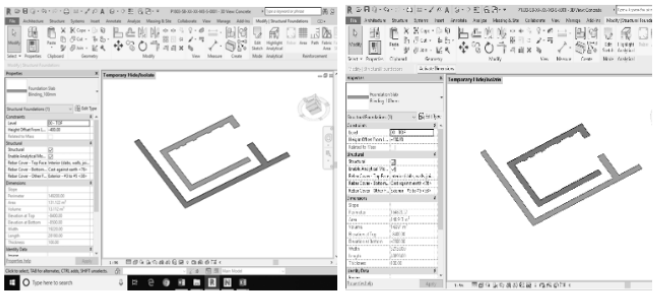
Step 2: Exporting the Model through IFC to Naviswork



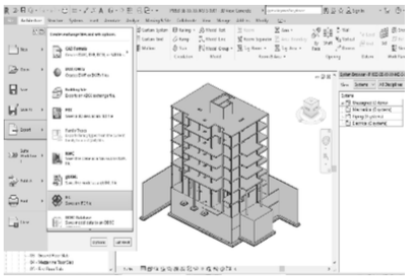
Step 3: Open the Model in Naviswork Estimating the quantities of Blinding foundation in Naviswork = 28x2= 56.0 m³

Figure 2a: Modelling, remodelling and estimating quantities of Blinding Foundation

Phase 2- Re-Building the Structural BIM Model and estimating the quantities§



Step 1: Estimating the quantities of Blinding foundation = 13.112 +14.891= 28.00m³



Step 2: Exporting the Model through IFC to Naviswork

Step 3: Open the Model in Naviswork Estimating the quantities of Blinding foundation = 14.89+13.112= 28.00 m³

Figure 2b: Modelling, remodelling and estimating quantities of Blinding Foundation

The quantity of blinding when calculated as individual entities showed to be the same as calculated in Revit in Stage 1. After transferring the model to Naviswork from

Revit through IFC, it was found the quantity remained the same, thereby, indicating that the way the input data is fed significantly reflects its accuracy.

This can be addressed in by creating two scenarios:

Scenario 1: - Rebuild the model where an anomaly to test the consistency between data results from both packages. It was found that both the software had a different way in reading the model. This was corrected by re-orienting the way input data was fed as shown in Figure 2b. After rebuilding the model as mentioned in scenario 1, it was found that the discrepancy in the result was overcome and the quantity of concrete in blinding was consistent with that calculated quantities using the software. This shows that the data should be input in a way which the BIM commercial software can in synchrony with other software.

Scenario 2- It is to change the design specifications from perspective of the project parties which need further research, keep in mind the necessity in understanding the nature and complexity of the design specifications and the methods of incorporating those specifications in the BIM digital model.

CONCLUSIONS

The accuracy in estimation of quantities based on the criteria considered was effective adopting BIM. However inaccurate quantity estimation would affect the cost analysis and therefore overall project cost would also be affected. Also, it needs time to remodel after identifying the deficits and exporting to Naviswork again. It also consumes a lot of time in the process of rebuilding the model. Hence, it is required to relook how effectively BIM can be adopted by QS for the success of a project and to meet the satisfaction of the client. Most of the construction companies are reluctant to adopt BIM, despite its varied benefits, just for the reason that there is lack of BIM standards. This limitation of IFC can be addressed by suggesting ways to develop and improve IFC standard so that it become an easy and effective reckoner in widely used quantity estimation tools. Because of these limitations in adapting to BIM, the QS normally prefer to stick to the conventional methods of quantities estimation and refraining from adopting other tools of BIM.

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