COMPATIBILITY OF BIM BASED BOQ FOR SRI LANKAN CONSTRUCTION INDUSTRY

M.W. Thiwanka Sandaruwan[1] and H.S. Jayasena[2]

[1]Department of the Built Environment, Liverpool John Moores University, United Kingdom

[2]Department of Building Economics, University of Moratuwa, Sri Lanka

ABSTRACT

Being a key contributor to the Sri Lankan GDP, it is paramount for the construction industry to maximize the productivity, accuracy and efficiency. In order achieve this, it should advance with adoption of modern technologies, computer software and concepts. Many construction industries around the world are getting benefits by implementing Building Information Modelling (BIM) in their projects. BIM has made significant improvement in productivity, accuracy and efficiency. BIM can significantly automate the BOQ preparation process primarily through automated Quantity Take-off from BIM models. The process can deliver accurate quantities as per the model, but these quantities may deviate from quantities measured manually following a Standard Method of Measurement (SMM). But, not implementing automated BOQ process would become wasteful in an effort to implement BIM seeking for its benefits. This research was conducted with the aim of identifying the acceptability of the BIM based BOQ for the Sri Lankan construction industry. A literature survey was first carried out to identify the features of BIM based BOQ. A desk study was followed to identify the deviations of BIM based BOQ from the Sri Lankan conventional BOQ. Based on collected details through these two methods contextualized semi structured interview sessions were conducted to identify the acceptability of deviations in BIM based BOQ for the Sri Lankan construction industry. From the findings through the analysis of collected data, it can be concluded that BIM based BOQ are acceptable to the Sri Lankan construction industry.

Keywords: *Bills of Quantities; Building Information Modelling (BIM); Construction; Pricing; Sri Lanka.*

1. INTRODUCTION

Among the industries in the world, construction industry is one among those having long existence in history. With the development of the other industries in the world, the construction industry also has developed, yet the relative improvement in terms of accuracy, efficiency and productivity is often questioned. To address issues of accuracy, efficiency and productivity, many attempts have been taken; and introduction Building Information Modelling, or BIM as it is widely known, is often identified as a major leap in this endeavor. With incorporation of BIM concept, many new tools, especially the software tools were developed to offer significantly improved accuracy and efficiency to the information aspects of construction industry. Automated quantities from BIM is one of the BIM benefit highly talked about even in Sri Lankan context (Mayouran & Jayasena, 2013).

It is generally acknowledged that with invent of BIM, current construction industry is facing a paradigm shift (Arayici, 2012). BIM automation can deliver highly accurate quantities as per the model, i.e. it offers exact modeled quantities. Industry has had practices of measuring quantities manually following standard methods of measurement (SMMs). Quantities so measured shall deviate from modelled quantities primarily due to several rules of measurement in those SMMs. As the industry is used to price construction works following these rules, it brings the question if the industry capable of adopting the change from the pricing point of view. Since the problem is contextual that each country has its own SMMs, a study was done on Sri Lankan context and presented in this paper.

*Corresponding Author: E-mail – thiwanka.s@asia.com

2. LITERATURE REVIEW

2.1. BUILDING INFORMATION MODELING (BIM)

Building Information Modeling (BIM) is an intelligent 3D model-based process, which was introduced to the Architectural, Engineering and Construction (ACE) industries. BIM is one of the solutions to most of the problems in construction industry (Haron, 2009). BIM is one of the most valuable concepts which was introduced to the construction industry in 21st century. BIM is not only a software and it's a combination of both technology and a process. The technology part helps to stakeholders to visualize the building prior to its construction starts (Nagalingam et al., 2013). BIM concept was started with the development of computer-aided designs in 1970s. From the 1970s to today BIM had following important benchmarks (Jimenez, 2003-2017):

- 1970 – Invention of Computer-aided design (CAD)
- 1984 – Released the first commercial version of ArchiCAD

"Building Information Modelling (BIM) is a new paradigm in the thriving Sustainable construction industry. BIM has a great potential for integration into construction projects life cycle" (Nagalingam *et al.,* 2013). BIM concept started with the invention of the 2D, 3D computer aided design (CAD) in 1970. With the first replacement of the commercial ArchiCAD software in 1986, BIM became a fourth dimension "4D" with adding time factor to the construction designs.

After comparatively a long time, BIM added 5D concept to the designs with the release of Autodesk Revit in 2000. Autodesk Revit could be able to allow a cost associate to the construction designs. The First Autodesk Revit project was construction of freedom tower in New York". (Jimenez, 2003-2017).

2.2. BIM FOR STAKEHOLDERS

Building Information Modelling (BIM) has been successful to change the traditional methods in the construction industry and it has been able to replace the traditional construction planning techniques with the new technologies. There are so many features on the BIM concept that can be implemented to the current construction industry. Building Information Modeling (BIM) can be used in the professions of Architecture / MEP Designers, Estimators / Commercial Managers, Project Managers and Civil / MEP Engineers. Among the above professions in a construction industry BIM offers valuable uses for Estimators and Commercial mangers.

2.3. ESTIMATORS / COMMERCIAL MANAGERS

In the pre contract stage the quantity surveyor is known as an estimator and at the post contract stage the quantity surveyor is known as commercial manager. The quantity surveyor can use the BIM concept at each stage of the project. The role of the quantity surveyor in BIM based environment, "As of quantity surveyor job descriptions, the quantity surveyor is responsible for preparation of preliminary estimates for the projects and the feasibility study cost plan to submit to the client (Olatunji *et al.,* 2009).

2.4. BOQ WITH BIM ENVIRONMENT

Traditional BOQs have been prepared manually, but with the development of the current construction industry, productivity and efficiency has taken a very important place. Nadeem et al. (2015) has done a research on current requirements of BIM based BOQs in the industry to increase the product efficiency and the accuracy. According to his explanations, "with the features of the BIM software, it provides 3D visualization to extract quantities and to get a full idea about the building… [and show that] these things help to develop a cost estimate using related BIM software" (Nadeem *et al.,* 2015). The BIM concept, it is very easy for the contractor's quantity surveyor to take off the quantities from giving drawings and specifications (Nadeem *et al.,* 2015).

2.5. FEATURES OF BIM BASED BOQ

Identifying the features of BIM based BOQ is a one of the objectives in this research. This research was designed to do a literature survey to identify the features of BIM based BOQ. Following features were found throughout a good literature survey.

2.5.1. MODEL INFORMATION EXCHANGE

File types or formats of the documents support the BIM tools. The BIM software is capable to work with universal file formats such as IFC / DWG / PDF. In the literature survey of this research, the researchers identified model information exchange as a feature of a BIM based BOQ.

Model information exchange is very important to work in the modern construction industry. BIM based BOQ can be viewed in various types of file with this feature the parties who interested with the of a construction project they can view the BOQ with application what is available with them. BIM model has a feature to export these documents in various formats.

2.5.2. 3D VISUALIZATION

BIM software is capable to build 3D models. 3D modelling is a good way to clash detections. It is very important to identify the clashes in a building before it builds and it can help to avoid the unnecessary design changes as well as the cost revisions. 3D visualization is a great benefit in BIM based BOQ, compared to the conventional BOQ in the Sri Lankan practice, there may be some clashes in the architect design prior to the estimating stages. These clashes should be clearly understood because, if such a situation happened at the construction stage, it will be changing the whole design and also the BOQ work item of the project. Therefore, having a facility of 3D visualization to the BOQ preparation is very important.

2.5.3. RELIABILITY OF INFORMATION PRODUCTION

BIM software is capable to extract and transfer the information and also BIM is a good tool to generate more information related to the projects. For an estimator information are the valuable things in making estimates for a construction project. BIM is a good information source to make BOQ and it consists with more information needed for an estimator.

2.5.4. CUSTOMISATION OF FORMATS

BIM is capable to customize its reports formats. The BIM user can change the report formats as estimator's requirements. In practicing construction projects, there are some requirements in customizing formats. BIM has an ability of editing and changing the formats of its produce.

2.5.5. AUTOMATED QUANTITY TAKE OFF (QTO)

Quantity Take Off task is a major task in any kind of construction project because of the measurement part of a construction project should be accurate and unfailing (Mayouran & Jayasena, 2013). Quantity Take Off task is generally done by quantity surveyors / estimators manually or with the help of software packages such as Computer Aided Design (CAD) or most of the Autodesk projects (Mayouran & Jayasena, 2013). According to the explanation of professor Song Wu it takes a long time to extract quantities from an AutoCAD drawing. Further to his explorations most of the software was developed to minimize the time of skilled people which can survey in the process of and skill people consume in the process of QTO (Quantity Take Off). (Wu *et al.,* 2014). The BIM concept has developed to facilitate the cost estimates in the construction industry. The BIM model is a 3D object, which consists geometrical information and BIM gives opportunity to automatically extract the volumes and the areas of the BIM model (Wu *et al.,* 2014).

3. RESEARCH METHODOLOGY

To identify the acceptability of BIM based BOQ for Sri Lankan construction industry this research was designed to be conducted using following data collecting methods.

- Literature survey

- Desk study
- Semi structured interviews

In this research, qualitative research was identified as the research approaches because of the study aimed in-depth of understanding the compatibility of BIM based BOQ for Sri Lankan construction industry, rather than generalized application of it.

Through a literature survey, it's possible to identify what are the previous researches have been done in a particular subject are. To achieve the first objective of the research "Identify the features of BIM based Bill of Quantities**"** literature survey was conducted by using journal articles which are related to this field of study. To achieve the Second objective of the research "Identify the deviations of BIM based BOQ from conventional BOQ in Sri Lanka**"** a desk study was done by referring the Standard Method of Measurement, SLS 573, along with a popular BIM authoring system Autodesk Revit. SLS 573 is the Sri Lankan standard of measurement. In the desk study, the researchers identified some deviations of BIM based BOQs compared to the Conventional BOQs. At the end of desk study six numbers of sample deviations representing key areas of deviations identified were developed to be use at expert interviews.

To achieve the third objective of this research which is "Identify the acceptability of deviations for the Sri Lankan Industry" Six interview sessions with six Quantity Surveyors who are well experienced professionals in the field was conducted.

3.1. RESEARCH SAMPLE

To collect the data to conduct the research and identify the acceptability of deviations for the Sri Lankan Industry, the research sample was selected as follows.

Table 1: Research Sample Size

No	Category	No. of Interviews
01.	Pre-Contract Quantity Surveyors	02 Quantity Surveyors
02.	Post-Contract Quantity Surveyors	02 Quantity Surveyors
03.	Consultant Quantity Surveyors	02 Quantity Surveyors

Sample deviations were presented to the experts requesting their feedback on applicability and acceptability of the changes to the Sri Lankan construction industry from the pricing point of view.

3.2. FINDINGS OF DESK STUDY

The desk study session was conducted in order to identify the deviations of BIM based BOQ from conventional BOQ in Sri Lankan construction industry. During the desk study researchers were able to find out two categories of deviations between BIM based BOQ and the conventional BOQ in Sri Lankan construction industry. These deviations are Quantity adjustments and deviation in element definitions are the key findings of desk study.

3.2.1. QUANTITY ADJUSTMENTS

By referring to the SLS 573 document, researchers could identify some quantity adjustments in BIM based BOQ compared to the conventional BOQ in Sri Lankan construction industry. Automated quantity takes off using the BIM tool is an advanced process, but according to the desk study of the research, it could find some quantity adjustment in automated quantity take off. These quantity adjustments can be found in taking off quantities in surface within minor voids. According to the SLS 573, the measurement rule is to measure with these minor voids, but according to the automated quantity take off with BIM software, all types of voids deducted by the software.

E.g. 01:

According to the SLS 573, measuring of quantities in formwork, there are no deductions made for deductions for voids less than 0.5 m^2.

Table 2: SLS 573 Measurement Rule

INFORMATION PROVIDED					MEASUREMENT RULES	DEFINITION RULES	COVERAGE RULES	SUPPLEMENTARY
CLASSIFICATION TABLE								
2. Soffit of slabs	1 Slab thickness less than ≤ 150 mm	1 Horizontal 2 sloping ≤ 15°	m2		M5. No deduction shall be made for openings of 0.5 m2 or less			

Source: SLS 573

However, according to the Revit quantity take off these minor voids are also deducted by the software.

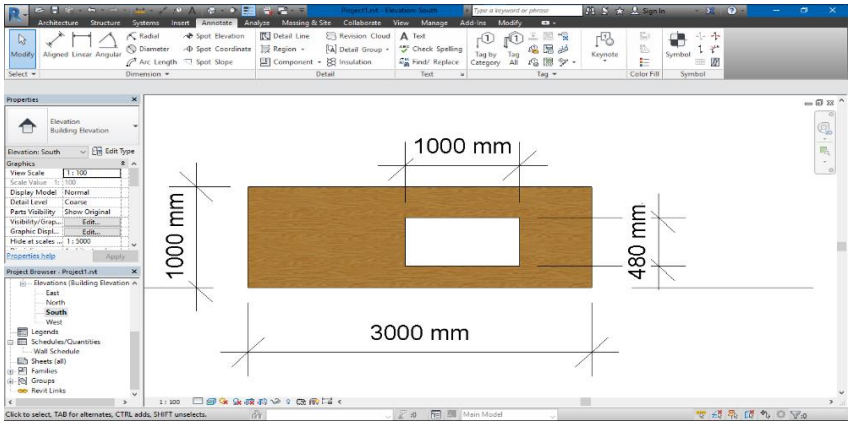

Figure 1: Revit model

The considering plywood sheet is shown in Figure 1, measuring the area of plywood sheet according to the SLS 573 measurement rules the area should be as follows,

Table 3: Quantity Takeoff According to the SLS 573

No.	Description	Unit	Numbers	Times	Length	Width	Height	Quantiy	Total
1	15mm thk 2400mm X 1200mm marine Pllywood sheet								
	Plywood sheet		1	1	3.00	1.00		3.00	
	Ddt								
	Void		1	1	1.00	0.48		(0.48)	
		m^2							**3.00**

Thiwanka :
According to the SLS 573 there is no deductions for voids less than 0.5m2. therefore no deduction made for 0.48m2 void to the Total

Table 3 shows the quantity take off according to the SLS 573. Considering the example taken in Figure 1 taking off the area of plywood sheet as above, but when take off the area from the automated quantity take off in Revit schedules as follows,

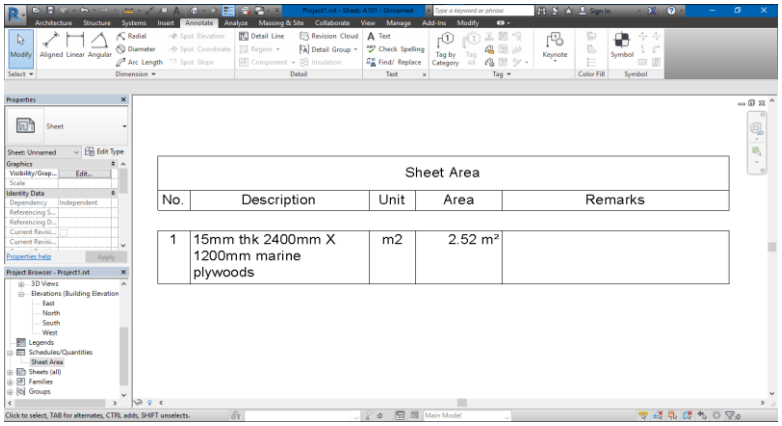

Figure 2: Automated QTO – Revit 2017

Figure 2 shows how the quantities take off in BIM models. According to the BIM, models automated quantity take off in Figure 2 it has deducted the 0.48 m^2 void areas of the plywood sheet.

4. DATA ANALYSIS

There were minor deviations in taking off quantities using Revit quantity schedules. As mentioned in the methodology chapter, the desk study was conducted to find out the deviations of BIM based BOQ from conventional BOQ. This research identified six deviations in the BIM based BOQ and these deviations forwarded to the semi structured expertise interview sessions to identify the acceptability of BIM based BOQ.

4.1. ELEMENT DEFINITION

At the desk study stage, this research could identify some element changes in the BIM based BOQ. These element changes were compared with the BIM based BOQ and conventional BOQ practice in Sri Lankan construction industry. SLS 573 document is used to prepare the BOQ. Definitions / Descriptions in BIM based BOQ can be prepared with the BIM standard and there is a deviation between these two standards.

4.2. SEMI STRUCTURED INTERVIEWS

Semi-structured interviews were used to identify the acceptability of BIM based BOQ for the Sri Lankan construction industry. As mentioned above six interview sessions were carried out among the experts in the construction industry. These experts were consultant quantity surveyors, pre-contract quantity surveyors and post contract quantity surveyors. Table 4 shows the summary of expert interviews. As explained in the above chapter the experts emphasized there are lots of benefits in using BIM based BOQ for the construction projects and there may be minor changes in practicing BIM based BOQ compare to the conventional BOQ in the common practice. Further to their explanations and opinions, they emphasized there are ways to overcome / minimize these adjustments and the changes.

According to the explanations of interviewees' pre-contract stage is the most suitable stage to overcome the minor deviations of BIM based BOQ. Further to the discussion of expert's interview, interviewees emphasised the SLS 573 should be amended to local practise to get the maximum benefits, features to the BIM based BOQ in Sri Lanka. Some interviewees emphasized that the deviation can be covered in preamble notes and avoid the conflict in BOQ quantities.

Table 4: Summary of Expert Interviews

No.	Interview	Deviation	Significance	Additions
1	SSI 001	We do not follow the measurement rule as it is in the SLS 573 therefore can be work according to the BIM based BOQ.	There is not a high significance.	Suggested to develop standards for Sri Lanka to use with BIM

No.	Interview	Deviation	Significance	Additions
2	SSI 002	Most of the cases the end result is same therefore the deviation is acceptable.	significant features can observe in vise versa during practice	
3	SSI 003	There is an impact to the measurement process but can be manageable.	Significance is depending on the project and the including's of the preamble notes.	Suggested to cover the deviation in preamble notes.
4	SSI 004	Quantity deviation is manageable.	Deviation is not highly significant	
5	SSI 005	There is an impact but the deviation can be covered by forming a new rate or provision.	Deviation is significant	Suggested to form a new rate or a provision to safe the contractor.
6	SSI 006	There is an impact to the project but can be manageable	Deviation is not highly significant	Emphasised the importance to amend the SLS 573.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1. CONCLUSIONS

With above key findings now it can be concluded that BIM based BOQ are compatible for Sri Lanka construction industry, with some minor concerns which are manageable.

5.2. RECOMMENDATIONS

According to the key findings of this research, the researchers' recommendation is that the Sri Lankan quantity surveyors / cost estimators shall welcome the BIM technology to the Sri Lankan construction industry without worrying about its compatibility to local practice. Few further recommendations and suggestions can be made from expert interviews. It was emphasized that there is a requirement in amending the Sri Lankan standard of method of measurement (SLS 573) to easily practice with the BIM software. Some professionals in the industry use a non-standard method of measurement, which is easier to work with; but this method of measurement is not generally used for all the construction projects. Yet, it is worth reviewing it in light of BIM. According to the findings of expertise interviews that there are some quantity adjustments in BIM based BOQ and the end result of these adjustments are same as the conventional BOQ.

6. REFERENCES

Haron, A. T., 2009. Buildng Information Modelling in Intergrated Practice. Manchester: University of Salford.

Jimenez, L., 2003-2017. *Rand Group* [Online]. Available from: https://www.randgroup.com/insights/bim-overview-building-information-modelling-part-ii/ [Accessed 02 August 2017].

Mayouran, W. and Jayasena, H. S., 2013. Automation of BIM Quantity Take-Off to suit QS's, Colombo. *The Second World Construction Symposium 2013: Socio-Economic Sustainability in Construction.* Colombo.

Nadeem, A., Wong, A. and Wong, F. K. W., 2015. Bill of Quantities with 3D Views Using Building Information, *Arabian Journal for Science and Engineering, 40(9),* 2465–2477.

Nagalingam, G., Jayasena, H. S. and Ranadewa, . K. A. T. O., 2013. Building Information Modeling and Future Quantity Surveor's Practice in Sri Lankan Construction Industry, Colombo: World Construction Symposium.

Olatunji, O., Sher, W. and Gu, N., 2009. Building Information Modelling and Quantity surveying practice. *Emirates Journal for Engineering Research, 15(1),* 69.

Wu, S., Wood, G. and Ginige, K., 2014. A Technical Review of BIM Based Cost Estimating in UK Quantity Surveying Practice, Standards and Tools. *Journal of Information Technology in Construction, 19(2014),* 536-562.

Arayici, Y, Egbu, C.O. and Coates, S.P., 2012, Building information modelling (BIM) implementation and remote construction projects: issues, challenges, and critiques. *Journal of Information Technology in Construction, 17,* 75-92.