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Building Information Modelling Adoption for better cost estimation: Sri Lankan perspective

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Abstract
To achieve competitive productivity and performance over the past eras, the growths of innovative technological concepts are promptly increasing. The waves of Building Information Modelling (BIM) have made everyone's in the construction industry gushing about BIM in building and construction expos. BIM has potential to influence everyone's professions in different ways within the construction industry. Most importantly BIM is capable of improving the accuracy of cost estimates through various BIM related tools which can be applied in the different stages of the traditional cost estimation process. Most of the countries both developed and developing have already re-aligned their cost estimation process with BIM and experiencing the benefits of it. Although the concept of BIM is slightly practiced in Sri Lankan construction industry yet, the majority of organizations still haven't adopted BIM. Therefore, this paper aim is to investigate the level of BIM adaptation of Sri Lankan quantity surveying organizations for a better cost estimation process. The study is interesting because the new knowledge will help to develop strategies for professional development and update the education curricula to train the Quantity Surveyors to face future challenges. As a visual database of building components, BIM can provide accurate and automated quantification, and assist in significantly reducing variability in cost estimates.

Keywords
BIM, Cost estimates, Adoption, Sri Lanka, Quantity surveyor.

1. Introduction
For any construction project cost estimation is an essential task for budgeting and bid preparation and cost planning (Sheikh, 2013). Cost estimation is, predicting the most realistic figure ensuring that sufficient construction funds are available at different or any given stage of a project (Avsatthi, 2016). Therefore, Construction cost estimating involves collecting, analyzing, and summarizing all available data for a project (Holm et al., 2005). Different types of estimates are available such as preliminary estimates which becomes the fundamental guideline to determine projects' feasibility and elemental cost estimates which calculate the total estimated cost of construction project considering the major elements of a building.

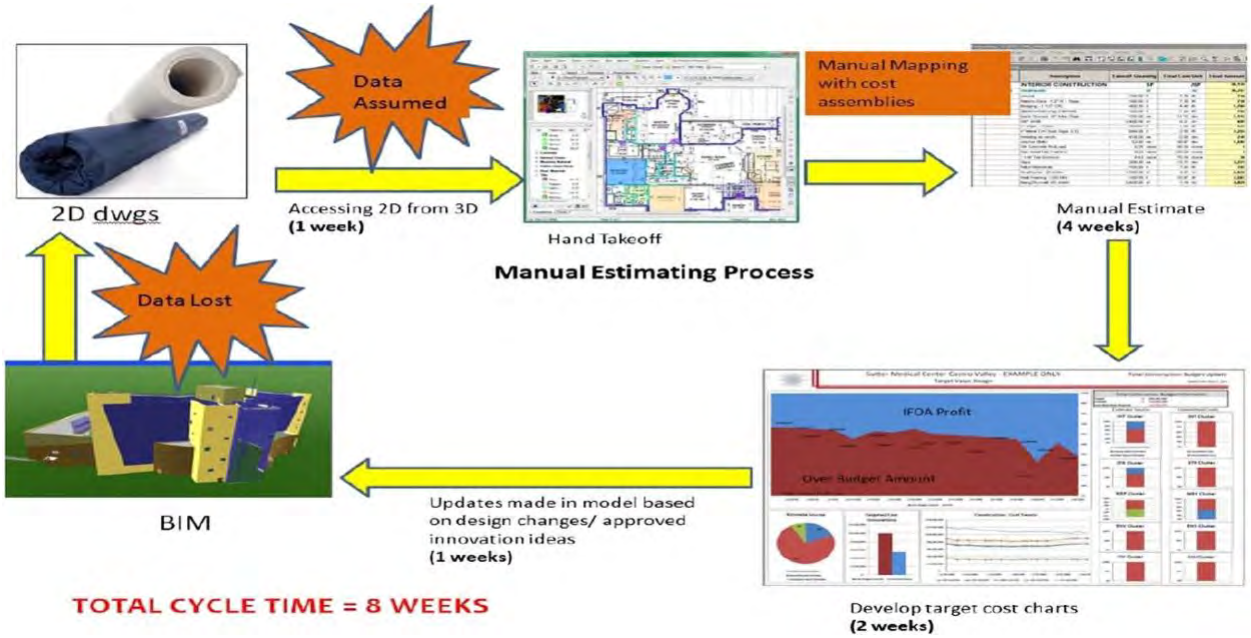
Highly accurate estimates reduce the changes of uncertainties and risks (Avsatthi, 2016). Perhaps, most importantly, an accurate estimation keeps all parties focused on delivering a project on time and under budget. It holds a developer and construction company accountable for increased costs and overruns. When planning a project, such as building, costs can overrun seriously if correct estimates are not considered (Michael, 2017). Therefore, as one of the defining features of successful progress, accurate project cost estimation must take a front seat when it comes to setting up a project's parameters. It's impossible to underestimate the importance of cost estimation when it comes to successfully completing a project. Before even approaching a project, it's important to get a handle on cost estimation to help keep you on task and in touch with project constraints and limitations.

Sri Lanka is going through a major urbanization and economic development with the end of civil war 2009. As a developing country (IMF, 2012), construction industry plays a major role in development and achievement of the goals of the society (OBG, 2016). The Construction is one of the largest industries in Sri Lanka and contributes to about 8% of the Gross Domestic Product (GDP) (Trading economics, 2016). The Construction industry has complexity in its nature because it contains a large number of parties as clients, contractors, consultants, stakeholders, shareholders, and regulators. According to Central Bank (2015), out of the total workforce of 6.2 million people, therefore, the construction industry is a measurement tool for Sri Lanka, which indicate the economic situation (Langford *et al.*, 2000).

The demand for the Quantity Surveying profession is growing day by day in Sri Lanka (Withanagamge and Senevirathne, 2016). Cost estimation is the most performing role among Sri Lankan quantity surveyors. The success or failure of a project relies on the accuracy of several estimates done throughout the course of the project (Navon, 2005). Hence, the traditional practice of Sri Lankan quantity surveyors hinders the accuracy of cost estimates (De Silva *et al.*, 2014; Gunasekara & Jayasena, 2013; Perera *et al.*, 2010; Weddikkara 2013). Therefore, traditional cost estimation practice is one of the major challenges within the Sri Lankan quantity surveying organizations.

2. Traditional cost estimation process

Accurate cost estimates are essential for a transparent construction process and for the development of the Sri Lankan construction industry (Fernando, 2015). However, preparation of accurate cost estimates is crucial due to the traditional practice of Sri Lankan quantity surveyors (Dissanayake, 2015). Traditional practices can be defined as a particular ethnic group, that has been practicing the same culture since ancient time (Wikipedia, 2017). Also, a continuing pattern of culture belief or practices (Dictionary.com, 2017). Hence, according to researcher's point of view, the traditional practice can be defined as a particular ethnic group continuing a specific pattern without adopting to modern technologies.



As illustrated in figure 1, traditional cost estimate process starts with series of 2D CAD drawings provided by the design team. 2D-based drawings or documents, whether they are designed by hand or with the help of CAD tools, are also error-prone. 2D documents are designed based on other 2D documents developed by a manual process; wrong inputs and interpretations are therefore very common since it is very hard to process complex situations, in particular, connections between various building elements (e.g. a cross-section of the connection of a beam, a column, a wall and a slab) in a 2D frame. Therefore, it does not cater for the accuracy of the estimate using the available set of drawings and specifications (Rathnaweera, 2015). Moreover, as illustrated in above figure it takes up to one week of time to make it 3D using various assumptions.

Based on these drawings QS's doing taking off quantities of tallying components from printed drawing sets which is a very time intensive process which takes up to 50-80% of the time needed to create a cost estimate is spent just on quantification (Wong *et al*., 2014). Extracted quantities from drawings export from spreadsheets to costing applications to produce the project cost estimate. This might take up to four weeks of time to produce cost estimates with manual mapping with cost assemblies. Finally, updates should be carried out considering the design changes. So, the entire process of preparing cost estimates takes up to eight weeks of time to get complete. According to a recent survey carried out by Dissanayake *et al.* (2015), one of the QS had mentioned: *"If we have a reasonable time to prepare estimates with the use of designs developed by Architecture and Engineering departments of the organization it will result in better estimates"*.

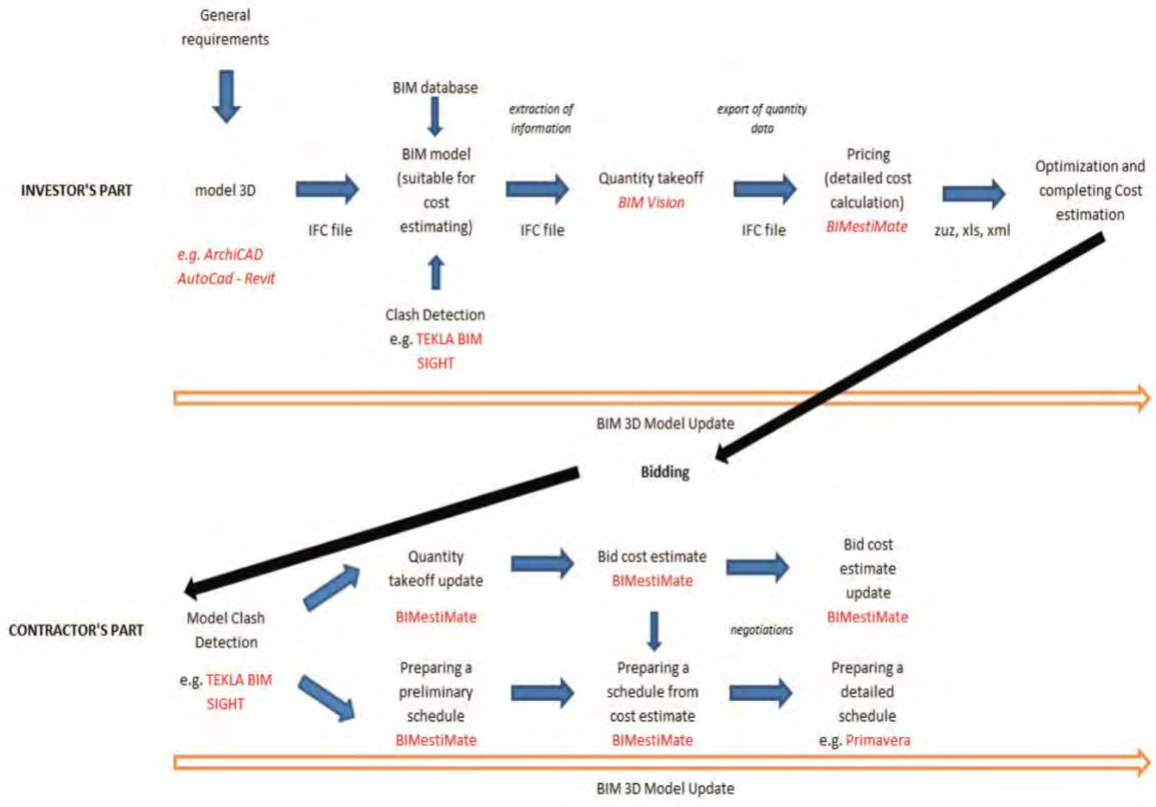
Moreover, in Sri Lanka cost estimates are prepared mainly based on historical cost data. Yet, the performance of usage of historical cost data in cost forecasting in Sri Lankan consultancy practice is poor (Jayasinghe *et al.*, 2015). Poor documentation of past records and lack of availability of cost data are the main causes for poor consultancy practice of QS (Illankoon, 2013). Therefore, most of the cases limited and less accurate information is available by the time of preparing cost estimates, may mean the quantity surveyor must make assumptions about the design details of a project (Perera, 2013). According to one of the respondents *"We do predictions up to the maximum level, on the basis of whatever the information we have"* (Diassanayake *et al.*, 2015). If the provided information is not accurate, then the entire cost estimate

is at a risk due to wrong assumptions made by the QS. Therefore, the majority of the Sri Lankan quantity surveyors are not satisfied with the accuracy level of existing estimating practices (Britto, 2013).

3. BIM-based cost estimation

Most of the developed countries which faced the same problems have successfully improved the accuracy of cost estimates by adopting BIM, into their estimation process. BIM has changed the way of buildings are designed, documented, analyzed, procured, constructed and managed by introducing a new culture of working for all construction disciplines, (Aranda-Mena *et al.*, 2008; Hardin, 2009). Most importantly it improves the accuracy of cost estimates by removing unwanted time-consuming tasks from entire estimation process.

According to figure 2, the foremost step in BIM-based cost estimation is to prepare a 3D model of a building along with a knowledge base, that is, all the vital information available at each stage of the investment. Tekla BIM Sight allows detecting clashes from the intersection of elements in superimposed drawings. Therefore, corrections can be done at the early stage of the project as it collects information about the building structure using a facility BIM model, projections, sections, and guidelines, as well as cost estimations.



The second step is transferring quantities directly from the model (IFC file) or is extra-added if it is necessary for cost estimation. This approach associates with software such as, Autodesk QTO, Vico Office, and CostX which are specialized in Quantity Take-Off (QTO) and enable to transfer the BIM models and their embedded information from BIM design tools into their system. These tools could be used for both automated extraction and manual take-off features. Such calculations are more accurate with fewer errors and omissions. They can generate visual take off diagrams while providing visualization of models whereby the quantity surveyor can mark off the building components using colors enabling to cross-check the take-off lists and to see which components have or have not been included in the estimate (Eastman *et al*., 2011). During the construction process, it allows quantity surveyors to insert additional clarifications to the model to clarify the conditions wherever necessary for the inter-linked items and assemblies. Even if the Quantity surveyors are not having an in-depth understanding of BIM design platforms, this approach provides an advantage for the quantity surveyors to work using familiar QTO software.

Once the quantity take-off is completed and both descriptions of the identified items (introduced in the design process from a library or adopted individually) and their quantities are prepared, the actual cost estimation may begin. As the unit rates are computed for all items, the items are priced automatically. Costs of all items are calculated automatically "on the fly" on the basis of adopted or computed prices. A list of the elements that are estimated is created automatically as records in the cost estimation application, which makes it ready for valuation.

4. Methodology

As BIM is currently becoming the buzz word among the construction industry, an assumption was made prior to the research investigations that a few organizations are taking BIM as potential business marketing, which led to the claims of implementing BIM, although their statuses were arguable. Many publications recognize as the primary technology for BIM the use of 3D parametric tools (Construction Project Information, 2009; Eastman *et al.*, 2011; Elvin, 2007; NIBS, 2007; Smith &Tardif, 2009). Therefore, organizations were selected based on the use of BIM tools such as Revit, Costx.
To identify the company which at least, has started implementing BIM / engaged in a BIM-based process, a few techniques were engaged:

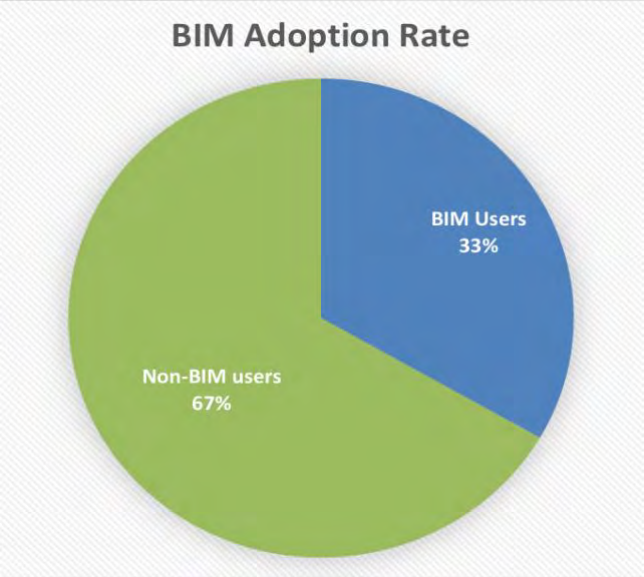
a. Direct communication with QS organizations in Sri Lanka
b. Attachment and collaboration with ICTAD and IQSSL (Institute of quantity surveyor's Sri Lanka)
c. Direct communication with Construction professionals in Sri Lanka

Nine companies were identified through above techniques, contact numbers and email addresses were obtained. Applications for conducting preliminary interviews were then requested via phone calling and emails. Out of Nine companies, 5 positively responded to the request. A preliminary interview is a process where the researcher attempts to get a brief picture regarding the current involvement of BIM within the company.

Following questions were asked during the preliminary interviews, which are:
a. As part of screening process: To make sure the company has fully/partially incorporated BIM into their business.
b. As part of refining the interview question: To get a brief picture of the company. This information helps to identify related questions that suit the company level of BIM usage.
c. As part of research strategy: To develop trust and credibility so that the researcher could gain access to carry out data collection.

5. Discussion

According to figure 3, out of nine organizations, there were only 3 quantity surveying organizations which are 33% currently using BIM or engaged with a BIM process. Rest of the organizations (67%) are not using or in a process of adopting of BIM.



Organization A is the first Sri Lankan Organization who started using BIM four years ago. The organization has acquired few licenses for Revit Structure, Revit architecture, Costx-5D estimating, MS Project and AutoCAD. Most importantly, they are the first Sri Lankan organization who's dealing with the First Sri Lankan BIM project going on in Havelock town, Colombo. Other two organizations also using above-mentioned BIM related tools, apart from that one organization using CATO as well. Moreover, they do operate in international markets such as Oman, Quarter, United Arab Emirates.
These organizations offer following services in terms of BIM,
A) Author the 3D model (Revit)
B) Extract drawings from the 3D model
C) Determine associated information such as the Material Taking Off, Weight, Surface Area and Centre of Gravity (Costx)
D) Prepare cost estimates using Costx
E) Conduct Automated Clash Check
F) Deliver Walkthrough Review

Moreover, more than 88% of quantity surveyors agreed that BIM enabled cost estimation process in more effective than the traditional cost estimation process. As BIM tools capable of improving rich three-dimensional (3D) context by aiding QS to identify significant cost-sensitive design features (by overcoming significant limitations of 2D drawings. 3D models created by using BIM technology is capable of providing more transparency on the design for the quantity surveyors. Moreover, BIM has further helped estimators to visualize real-world conditions through a virtual 3D construction, which is a particular benefit in complex designs that are not easily represented in floor plans. Therefore, visualization is one of the basic application of BIM through 3D models, which gives a clear picture of the project scope and characteristics, for quantity surveyors to take accurate measurements from the drawings. Therefore, it has eliminated time-consuming tasks such as double counting, re-measurements, and missing elements. Therefore, quantity surveyors have more time to consider other aspects of the estimate rather counting on elements.

Moreover, many quantity surveyors mentioned that it is very beneficial for them where the QS can carry out a 3D virtual walk-through and make sure everything in the model is factored in the QTO. Any changes made to the model such as editing of plans, sections, elevations or 3D view within the model automatically made to all other documentation, drawings, and outputs, by saving time for the manual revisions. Consequently, design errors caused by inconsistent 2D drawings are eliminated. From the QS perspective, if clashes can be addressed in the design stage, there is a better chance a variation will not occur on site. Also, BIM allows them to identify these conflicts from the federated model before they materialize in the field and this can exclude costly variations during construction. Due to earlier clash detection, it has increased the cost efficiency of the project and reduces the risk of running behind schedule. Moreover, it has reduced errors and omissions in the design drawings by helping quantity surveyors to make correct assumptions and decisions to prepare accurate cost estimates.

Apart from that, due to the rich nature of data within BIM objects, QSs allowed to extract and distinguish information from the 3D model beyond traditional measurements, such as the number of columns within a particular material characteristic. Quantity surveyors can upload or download any information at any stage of the project from these models. Moreover, information can be easily picked from the model to perform an order of magnitude and elemental estimates, even if the geometry from BIM at early stages of design comprises in few quantities. Most importantly the most useful tasks that can be automated through BIM use is quantity takeoff (QTO). A BIM-based model is an assembly of objects defined by specific properties, some of which are the element's geometric attributes. Most BIM tools contain routines to perform calculations using the element's geometric properties and provide spatial quantities like area and volume in text form. BIM-based QTO is reported to provide simpler and yet more detailed and accurate cost estimates of the project, reducing time and expenses.

6. Conclusion

The accuracy of cost estimates is essential to the overall success of the construction project. However, the traditional practice of Sri Lankan quantity surveyors hinders the accuracy of the cost estimates due to challenges such as 2D drawings, manual quantity take-off, lack of information, poor visualization, etc. As a new technology, BIM assist in cost estimating will not obsolete estimators; rather, it promises to free them to focus on higher value task than counting, returning increased value to project processes. It improves the accuracy of cost estimate process through automate quantity take-off, 3D models, improving the information flow, improving visualization etc. as discussed in the literature. Hence, BIM adoption rate for the Sri Lankan construction industry still in infant level, as only a few organizations using BIM tools but the majority of them are not. With the current demand for construction projects in Sri Lanka, BIM is likely to become the project delivery standard in near future. Therefore, it is high time for the Sri Lankan construction industry stakeholders to re-align their organizations with BIM in order to gain more benefits for the overall project life- cycle by increasing total productivity.

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