

SOFTWARE CAPABILITIES OF SRI LANKAN ARCHITECTURAL PROFESSIONALS FOR BIM ADOPTION

E.K.A.S. Kumara^{*}, H.S. Jayasena and M.R.M.F. Ariyachandra

Department of Building Economics, University of Moratuwa, Sri Lanka

ABSTRACT

Building Information Modelling (BIM) is a technological and attainable concept, which has upgraded the construction industry into a more diligent industry. It has globalized in a way, which make innovative, cost effective, energy efficient, sustainable and practicable products as well as faster and more effective processes. By the aid of various BIM software packages connected with different disciplines for various stages, this realisation could achieve more accomplishments. However, majority of practitioners of the construction industry only have competencies over the traditional software and this is also one of the major constraints for not applying BIM to the construction organizations. Therefore, construction practitioners must have proficiency over the competencies required for effective BIM products. Interestingly, there seems that many BIM tools have similarities to conventional tools. Software developers over the world have developed several BIM software tools for each of the disciplines which are currently involved in the projects. Majority of the recently completed BIM assignments have typically used software suites belonging to Autodesk software developers, as such there is high potential of using such suits in early BIM projects in Sri Lanka. Hence, this study aims to identify extent to which BIM like activities in conventional tools are practiced in the Sri Lankan industry.

It synthesizes the findings of a literature review on software disciplines which are used in the BIM implementation by various professionals in each of the stages of project sequence. Through the desk study and the expert interviews a qualitative study conducted to identify the gap between 3D BIM modelling competencies with the current competency level of the Sri Lankan Architect. It was found that, working in Revit is more like building a building than drawing one. Further, the great thing about Revit is that all the objects work not the same as in AutoCAD. So if designer know how to place a wall in CAD, but designer can't place a wall in Revit. Because it use object oriented method. Fundamentals are just about the same, there are of course a few differences but can work through those fairly easily. According to the summary, can be concluded that Sri Lankan Architects much familiar about few of the task. But, the handling/performing such activities much differ than what they follow.

Keywords: Architects' activities; AutoCAD; Building Information Modelling; Revit; Sri Lankan Architects' Competency.

1. INTRODUCTION

BIM implementation in the construction industry will result in a great change for the professionals as well (Harris, 2011). Reddy (2011) stated that although in practice, BIM is considered as a three-dimensional (3-D) computer aided design software program; in reality BIM is a process improvement approach that influences data to analyze and predict results during different phases of the building life cycle. Hence, transitioning to BIM is "hard and expensive" which may create havoc and frustration. Moreover, implementation is challenging both technical (hardware/software) and firm cultural-wise. This basically means, educate everyone in the office, and assign separate tasks, increasing hardware and buying expensive BIM software (Deutsch, 2011). Accordingly, Jayasena and Weddickara (2012) identified that there is lack of technical knowledge in getting the best use of BIM. However, in-depth technical knowledge is not necessary to perform BIM. By using developed initiative software the user can work with BIM effectively. Therefore, the profession of architecture is the first step to adopt BIM. When it comes to the adoption of BIM the architectural firm will

^{*}Corresponding Author: E-mail - arunashanthaqs@gmail.com

have to perform and incorporate the technology into the firm's business model. This will demand changes in project delivery methods and the composition of the firm's staff.

During the last two decades when the application of BIM tools over the traditional tools is considered at beginning some United Kingdom (UK) architect firms have used 2D Computer Aided Design (CAD) tools. However, with this 2D drafting bring inefficiency situation for the building construction process such as timescales, duplication, lack of rigorous design process, lack of effective design management and communication etc. (Liker, 2004; Koskela, 2003).

When considering BIM implementation capability and the BIM Software Environment (BIMSE) of the Sri Lanka Rogers *et al.* (2015) discovered that although currently construction industry in the Sri Lanka is in wealthy manner, but it is poor in the BIM adoption to the construction. Due to the less identical systems and being a developing country, there is a need to appliance strategies to embrace BIM.

Focusing on the Information Technology (IT) literacy in the country relating to BIM, Jayasena and Weddikkara (2012) emphasized that technology adoption is not the challenge with a reasonably high IT knowledge and Architecture, Engineering and Construction (AEC) professionals with a fair computer competence. The real problem is resistant to change. The Architects are not willing to change according to the environmental change. However, Sri Lankan professionals are still using the traditional methods for carrying out designs and measurement works, which include taking-off from the drawings and then transferring dimensions into spread sheets for issuing out the cost reports to other parties and for design purposes use 2D CAD drawings. Therefore, the identification of the current practice on Architects on their profession and the level of identified competencies will result to development of the Architects who are willing to move towards BIM.

2. CURRENT USE OF IT IN CONSTRUCTION STAGES

The Royal Institute of British Architects (RIBA, 2012) has mentioned that the project life cycle basically consist of seven phases; preparation, design, pre-construction, construction, use and R&D. As Omar *et al.* (2014) have identified that project consist in four phase initiation, planning/design, and execution, controlling and closing. Each phase is executed for the sake of successfulness of the project. Both RIBA (2012) and Omar *et al.* (2014) have identified that the design phase is the most significant chapter that would influence overall project life cycle. This cover task such as concept, design development and technical design. In this phase, ICT and BIM impact is high.

Sommeriville and Craig (2006) have discovered that IT play a major role in the various stages of a construction projects if considered from three standpoints: i.e. Pre-tender, post tender and post-completion. Also it highly affects to procurement and the eventual routes in each project and organization. Finally, there is a need to consider the impact IT has on the humans involved in the delivery of the construction project.

Furthermore, identified professionals who are interest on applications. Table 1, shows that different software application used by main function within the construction company

Table 1: IT Tools, by Construction Project Functions and Phases with Users

Management Function	Top Management	Estimating	Scheduling & Planning	Project Management	Operations Management	Designs Aspects
Typical Task	<ul style="list-style-type: none"> Accounting Software (Microsoft Office Package) Web Portals 	<ul style="list-style-type: none"> Estimating Software Automated Quantity Take-off CAD Document with Microsoft Excel 	<ul style="list-style-type: none"> CPMEx. Microsoft Project, Primavera Monte Carlo Simulation 3D CAD 4D CAD Microsoft Excel 	<ul style="list-style-type: none"> CPM Accounting Software Web Portals 	<ul style="list-style-type: none"> Knowledge mangement Electronic Books Mobile Computers 	<ul style="list-style-type: none"> Autodesk Architecture Autodesk Structure, MEP 3D CAD
Project Phases (RIBA)	<ul style="list-style-type: none"> Inception Feasibility 	<ul style="list-style-type: none"> Outline Proposals Site Operation 	<ul style="list-style-type: none"> Site Operations 	<ul style="list-style-type: none"> Site operation Outline Proposal 	<ul style="list-style-type: none"> Site Operation 	<ul style="list-style-type: none"> Schematic Design

Management Function	Top Management	Estimating	Scheduling & Planning	Project Management	Operations Management	Designs Aspects
	<ul style="list-style-type: none"> • Sketch Planning 		<ul style="list-style-type: none"> • Outline Proposal 			<ul style="list-style-type: none"> • Detail Design • Outline Proposal
IT Tools (Solutions)	<ul style="list-style-type: none"> • Accounting Software (Microsoft Office Package) • Web Portals 	<ul style="list-style-type: none"> • Estimating Software • Automated Quantity take-off • Interoperability with CAD Excel 	<ul style="list-style-type: none"> • Microsoft Project, Primavera • 3D CAD • 4D CAD • Microsoft Excel 	<ul style="list-style-type: none"> • CPM • Accounting Software • Web Portals 	<ul style="list-style-type: none"> • Knowledge management • Electronic Books • Mobile Computers 	<ul style="list-style-type: none"> • Autodesk Architecture • Autodesk Structure, MEP • Sketch up • 3D CAD
Users	<ul style="list-style-type: none"> • Top Mangers 	<ul style="list-style-type: none"> • QS • Engineers 	<ul style="list-style-type: none"> • Project Mangers • Quantity Surveyors 	<ul style="list-style-type: none"> • Project Mangers • Engineers • QS 		<ul style="list-style-type: none"> • Architects • Draftsmen • Contractors • QS

3. BIM TERMINOLOGY

According to Olatunji (2014) there have been several perspectives on the potentiality of BIM deliverables, most popularly in the design and construction context. In addition, National Institute of Building Sciences mentioned that in the construction perspective the BIM is not only a software implementation. It is a different way of thinking. BIM is a process which requires a change from the general process with the project participants (including architects, surveyors and contractors) with effective working environment in common pool.

According to the design perspective BIM is a development of a computerized model which is mimic the construction process and operation of facility.

“The resulting model, a Building Information Model, is a data-rich, object-oriented, intelligent and parametric digital re-presentation of the facility, from which views and data appropriate to various users’ needs can be extracted and analysed to generate information that can be used to make decisions and improve the process of delivering the facility. The process of using BIM models to improve the planning, design and construction process is increasingly being referred to as Virtual Design and Construction (VDC)” (Associated General Contractors [AGC], 2006: p. 3)

Furthermore, Aranda-Mena *et al.* (2009) believed that this helps to shift to the professionals who still playing in the industry with separate information pools using mismatched different applications. As above mentioned, through the building modelling it provide digital world involving a digital prototype of the model.

4. TRADITIONAL SOFTWARE TOOLS VS BIM TOOLS

The involvement of BIM allows a lot of separated tasks to get synchronized and bring up the ultimate unity of data handling. The 3D visualized drawings, information structures, design precautions and material take-offs are not only automated but also carefully examined for conflicts (Haron, 2013). In other words, compared with conventional software, BIM assisted information structures have more advanced advantages. Hence, each BIM assisted application is well arranged and has the capability to function at higher pace providing more efficiency. Moreover, the expected quality of the output is considerably high.

Due to better design and quality of the item faster and more effective process can be achieved. Benjaoran and Bhokha (2010) have identified that it is a collaboration tool for all project participants. Furthermore, Gong and Caldas (2011) have proposed that BIM is a process that deduct in manual efforts like time and cost saving. Moreover, Gu and London (2010) have mentioned that it identify possibility of conflicts and risk that would be arisen in construction.

According to Sacks and Barak (2007) the replacement of 2D design applications by 3D modelling has been able to reduce working hours of three separated projects by 21%, 55% and 61% respectively. CRCCI (2009)

has stated that switching to BIM, demands the adaptations to new digital environment. In operations of traditional systems, corrections made one section would need to be reapplied to the rest of the sections because of their independence. While those conventional applications had independent graphics, BIM supports interrelated graphic and data structures where editing one part would auto update the rest. Therefore, the manually connected hard copies are comparatively leaps and bounds behind BIM assisted applications.

Furthermore, Chelson (2010) has argued that the collaboration of data bases is able to act as one active unit and operate over a wide range of areas need to be looked after. Moreover, Chelson stated that the use of 3D modelling benefited to each and every step of a massive construction project. In addition, BIM tools include and illustrate the association or relationship between each element. Even though, traditional models are still produced through building modelling, they can also be fed with relevant information easing up the overall process. And in addition to that information can be arranged in accordance to user's requirements.

4.1. BIM TOOLS

Table 2 shows BIM tools used in the building works and the civil and infrastructure engineering.

Table 2: BIM Tools

Building Works Tools	
Design Software	Although there are huge software packages on Designing, most Common Practice on designing is ArchiCAD and Revit Package. Graphisoft (2016) have proposed that architects can explore their design idea without compromising on documentation precision and quality due to ArchiCAD. ArchiCAD has begun with version 13.0, now it updated to version 20. Also, ArchiCAD is made by architects for architects, guaranteeing a BIM authoring tool that offers the most natural and intuitive work environment, to achieve the best design workflow. Revit also a BIM tool which is greatly used in AEC industry to design building and its components. Other than that, it provides collaborative capabilities which integrate all the disciplines and enables the design team, the contractor, and the client to exchange diverse ideas and approaches which help to simplify the way buildings are built (Autodesk, Revit, 2016; Autodesk, 2013).
Structural Engineering	Revit Structure and Tekla Structure can be identified as most Commonly used software packages for effective Structural designing. Tekla Structure is a BIM software that enables the creation and management of accurately detailed, highly constructible 3D structural models regardless of material or structural complexity. The models can cover the entire building process from conceptual design to fabrication, erection and construction management. In addition to that Peddinghaus (2016) has stated that modelling with Tekla Structures is the most advanced and integrated way to detail and fabricate all steel structures, such as commercial buildings, industrial plants, sports stadiums, offshore platforms and jackets including miscellaneous steel work. Further Tekla uses CAD standards to create fully interactive structures for all construction projects.
Building Services	Many researches have identifies that there are several applications used for building services such as Revit MEP, Tekla, Bentley package and DD CAD package. As a results of Table: 2.7 shows that Revit package and MagiCAD software packages are applied for most of the projects. . If MagiCAD is integrated with Revit model, it is able to provide significant features for the model. that MagiCAD MEP software consists of different packages for different uses such as MagiCAD ventilation, piping, sprinkler designer, electrical, circuit designer, comfort & energy, room, supports & hangers.
Project Management	Autodesk Navisworks Products deliver project-review software for 3D coordination, 4D planning, near- photorealistic visualization, dynamic simulation, and more accurate analysis for integrate design data, analyse for coordination errors, evaluate construction schedules and communicate with all stakeholders
BIM Visualization	Solibri Model Viewer (SMV) and Navisworks Freedom can be used as most utilize BIM visualisation software tools.
Estimation tools	In order to achieve benefits from BIM technology, quantity surveyors (QS) will have to choose and use a BIM based estimating tool in BIM based projects. Most suitable BIM based estimating applications in the UK market are as follows; Solibri Model Checker v9.6, Autodesk QTO 2016. CostX 6, BIM Measure.

Civil and Infrastructure Engineering Tools

AutoCAD Civil 3D	Civil 3D can provide effective design options and deliver high-quality documentations through the identification and analysis of the project performance. It is mostly used in infrastructure projects such as transportation, land development and water projects.
Tekla Civil	Tekla Civil is a well-known software solution for the civil engineering discipline to fulfil the needs of BIM. Also it enables implementation and distribution of up-to-date information between all operations in the project life cycle. Furthermore, it consists of powerful features to develop the information models, scheduling and planning. Moreover, it offers 3D imagining and can visualize civil projects using a combination of models.

5. WHAT IS THE PRELIMINARY STAGE FOR EFFECTIVE BIM IMPLEMENTATION IN SRI LANKA?

Today the construction industry is willing to provide value for money, and sustainable infrastructure. Also, this has resulted in a shift to BIM (Mihindu and Arayici, 2008). The clients can achieve better efficiency and significant cost savings through proper designing because this stage highly affects to later stages in construction projects, such as construction and operation of facilities. Therefore, the profession of architecture is the first step to adopt BIM (Coates *et al.*, 2010). Moreover, owners are starting to encourage architects and other design professionals, construction managers and construction companies to adopt BIM.

When it comes to the adoption of BIM the architectural firm will have to perform and incorporate the technology into the firm's business model. This will demand changes in project delivery methods and the composition of the firm's staff. Moreover, the productivity increment due to BIM will result in an increase in the attractiveness of the architects and other design professionals (Arayici *et al.*, 2011).

Historically, Sri Lankan architect firms used 2D CAD tool for two decades. Moreover, they used their own procedures, templates and traditional methods to perform their role. As Arayici *et al.* (2011) stated, 2D CAD options lead ineffective designs. There are two main factors should be examined when BIM adopting to a firm, such as purely install the BIM software in the firm structure or it could be runs on top of the existing 2D tools which are already installed. Further it stated that level of support and training should be provided by the software vendor. Software vendors such as ArchiCAD, Revit, Allplan, Vectorworks and Bentley Architecture can be mentioned as architectural software packages which are used in BIM.

To identify the most common BIM applications in the project, few case studies which were considered by many researchers. According to these findings it can be concluded that the most common software is Revit package. Therefore, due to the current use of the firms, can be going to Autodesk Revit Architecture.

5.1. CAD VS REVIT

Tobin (2015) expressed that when moving from AutoCAD to Revit, there are several questions should be asked themselves: Why we should move AutoCAD to Revit? And what the firm can gain due to this transition?, what is the reason for staying with software package which is similar to the AutoCAD environment/interface? What are the dissimilarities which are reflected from Revit models and CAD models, and due to these dissimilarities what are the profits can be accomplished? "Opportunity" can be answered to the first and second question, because Revit models can and will give more opportunities.

Further, as he stated answers for third and fourth questions, that Revit cannot be compared to AutoCAD. Users can not retreat on any bad habits that staff members may have committed over the years. The real difference of the Revit models and CAD models is, if the designer make any alteration to the element it automatically update throughout the building. Also, anytime and anywhere these alterations/changes can be done. When it considered to BIM following opportunities can be achieved.

- **Quality**

In the Revit models, any alterations/changes can be achieved during the Detail design and Construction Design phases. Further, this process is not hard, also this process help to increase the Quality of the product.

- **Productivity**

Designers can produce document while designing, this help to increase the productivity of the process. Further, if architect changed any element it is reflected to the MEP engineers. Moreover, schedules, drawings, coloured diagrams and take-off schedules can be produced and updated.

- **Cost**

Can be decrease the cost of the designing due to fewer resources. Further, this will help to decrease miscommunication problems.

- **Visualization**

Realistic photo renderings, animations, walkthroughs, 3D realistic models can be produced during any phases of the design process.

- **Facilities Management**

Apart from above benefits, the 3d models can be used to renovations, rectifications, maintenances, and space planning.

Further as stated by Aouad and Arayici (2010), there are some challenges that firms are going to run into when moving from AutoCAD to Revit Architecture. Assume the firm designer's knowledge on the AutoCAD is very high. In such a situation, transition to Revit it is much easier. Because existing knowledge can be used to work with Revit. Further, if they do not have enough knowledge on the AutoCAD, then the road to the Revit is much tougher. Moreover, if the firm working with the multi disciplines parties (Inside or outside), Revit can be best solution for this situation. Apart from these situations, target firms must making an asset in Revit, with that comes time to setup and learn/train on the new system. Further, this should be aligned with the budget.

6. RESEARCH METHODOLOGY

The aim was to identify the competency of the professionals in zero level of the BIM and how much perform the BIM activities through the expected way of their practice. Due to broadness of the approach, target was narrowed to measure the competency level of the Architect professionals who are leading the Sri Lankan construction industry. Further, competency gap of the CAD software suit and BIM based Revit software package related to the Sri Lankan context which is performed by architects were recognized. Moreover, through the CAD, How far the task does is carried out without Revit. Also, get clarified that recognized task how much similar to the Revit environment. Thomas and Brubaker (2008) believed that qualitative methods are in conflict with qualitative approaches. Furthermore, they stated that the best method for the construction research is qualitative method. Therefore, best way is to conduct a qualitative approach. Therefore, considering these facts and according to the nature of the research the best way is the qualitative approach.

6.1. DATA COLLECTION

The challenge was to compare two different type modelling techniques with the BIM related activities which were performed by the Revit used architects. Hence, to perform this task, first identify the Architect activities on 3D modelling. Then through the desk study, get clarified that what are the capabilities on Revit and AutoCAD centred suit is used for perform this activities. Going through he lecturing on Autodesk University identified these competencies. Further using experts interviews from Sri Lankan architect professionals, clarified which tools used in the AutoCAD to fulfil identified activities. This helped to identified to what level of the competencies they have to go to the next level. As identified in the literature, the next level purposed as Revit package. If it not achieve in the AutoCAD, the next step was to identify the option that architect can go or already go. Apart from that get clarified "why it's not practice by architect?"

Also, face to face interviews was conduct with Architects who are expert in their profession. The selecting conduct according to their role in the construction industry. First, focus on two academically experts and two industrial experts for collecting data. However, through this interview technique, it is possible to convey the background knowledge about the respondents in order to get clear answer about their practice on designing. Further, it help extract all the information which actually present. Due to the clarifying and elaborating capabilities of the semi structured techniques it can be used to data collect.

6.2. DATA ANALYSIS

According to the Westbrook (1994) identified that this content analyse process is the popular mechanism which is used among the professionals to analysis data. Also it give logical reliable implications from the given data. Moreover, Thomas and Brubaker (2008) stated that it entails searching through one or more communications to answer questions that researcher bring to the search. Code-based content analysis select to analyse based on the opinions gathered via the qualitative observational study and through interviews. NVivo (Version 11.0) used to cording and make straightforward the collected data for content analysis. Used windows based version to analyse the data.

7. ARCHITECTURAL ACTIVITIES ON SUCCESSFUL BIM MODEL DESIGNING

When considering to “BIM Implementation in Sri Lanka”, the first step is to encourage the architects to implement BIM. This is because architects who involve in the project prior to any involvement by any other professional. To accomplish this endeavour, the existing competency level of Architects on designing and how much those activities related to BIM must be identified. Anyhow through the opinions on current practices, identified the competency gap between the current practices on BIM modelling activities which are identified through the research findings. Apart from that if they not aware of BIM related activities, what they need to develop with their current competencies can be suggested. Hence, the purpose of the research was to identify the gap between their existing level of competency and desired level of competency, if a transition to BIM modelling was to be feasible.

Revit is a BIM software which can be considered as the most applied software package among various software packages. It has been proved through the literature review as well. Although there are lots of software packages used by Architects with supplementary packages, Revit is the most common and all-round software package among them. For effective implementation of BIM, development of the profession of architecture can be considered as first step in effective BIM transition process.

According to the analysis of the findings, one of the things that have to remember is that Revit is not AutoCAD and it does not work like AutoCAD. Revit is really a 3D design tool working completely with objects (e.g. walls, doors & windows). Working in Revit is more like building a building then drawing one. Look, the great thing about Revit is that all the objects work not the same as in AutoCAD. So if designer know how to place a wall in CAD, but you can't place a wall in Revit. Because it use object oriented method. Fundamentals are just about the same, there are of course a few differences but can work through those fairly easily.

According to the desk study and expert survey findings, following conclusions can be arrived at.

Table 3: Summary of the Each Task Performed by Local Architects

Architect Activity	Conclusion on this Activity
Use of fundamental tools to make design elements of the project	Comparing both tools (Revit and CAD), both provide enough capabilities on 3D designing. But in the Sri Lankan Architects only used 2D drafting options for 2D drafting purposes. Such as lines, shapes, array, offsets, layers and text. Although there are 3D modelling options, any of these capabilities on 3D modelling are nor used. Users believe that using such kind of complex options wastes their time. Therefore, they may try other software such as Sketchup. Through the desk study it was identified that, way of handling those options was a little bit more complex than using Revit. Therefore, it can be concluded that users are still not aware of these tools.
Use Visualization techniques to make drawings look beautiful	Although, Revit provides Three different visualization techniques for visualize the model. CAD package users use hatches, different weighted lines, and colours for indicated materials and visualization purposes. When assigning materials on the elements, Revit provides very powerful techniques but local architect use different software packages for this such as <i>Vray, Lumion, Sketchup and 3Ds Max</i> .
Adding furniture, Components for the drawings	Revit provide families and components to fulfil these requirements. AutoCAD provide design center. But current practice is to design and use collected blocks for inserting components to the design. Although there are

Architect Activity	Conclusion on this Activity
	enough capabilities on the CAD, the CAD users following their own methods for perform this task.
Detailing and Documenting the Project Design.	In the AutoCAD, automatic generate system for tagging, detailing and scheduling is not provided. For example, view port besides using callout, adding text instead of using tags, creating detail lines besides model elements, importing AutoCAD schedules besides creating schedules in Revit, and so on. Architect used manual approaches to detailing.
Multi-user collaboration with project activities	Here, users are aware of this task. Used technique is "Xref". It provides limited options compared to work-sharing option in Revit.
Evaluating Lighting and Daylighting performance of the modelling	In this task, current practitioners are not aware and not perform this task.
Use of Add-ins to create an efficient workflow and improve project documentation	In this task, current practitioners are not aware and not perform this task
Explore and manage point clouds to capture the existing condition of a building	In this task, current practitioners are not aware and not perform this task. Current practice is "manual drafting".
Develop better and more efficient company Revit MEP template.	Here, also AutoCAD not provide a similar option related to templates. Current practice is using "previous standard drawings" and "libraries" which were developed as templates.
Produce rapid-energy models in Revit to gain renovation work	<i>In the AutoCAD, not provide capabilities to fulfil this task. Demolitions: Dash/ blue colour, New works: Red/ hatch cross, and existing works: Black double line can be used to perform this task. Then give legend for the drawings.</i>

8. CONCLUSIONS AND RECOMMENDATIONS

BIM is considered as a three dimensional (3-D) computer aided design software program; in reality BIM is a process improvement approach that influences data to analyse and predict results during different phases of the building life cycle. Through the literature review, BIM software packages which are used at the different stages by different professionals was explored. Moreover, through the case studies Revit can be exposed as the most commonly used software packages were identified.

When considering to "BIM Implementation in Sri Lanka", the first step is to encourage the architects to implement BIM. This is because architects who involve in the project prior to any involvement by any other professional. To accomplish this endeavour, the existing competency level of Architects on designing and how much those activities related to BIM must be identified. Anyhow through the opinions on current practices, identified the competency gap between the current practices on BIM modelling activities which are identified through the desk study. Apart from that if they not aware of BIM related activities, what they need to develop with their current competencies can be suggested. Hence, the purpose of the research was to identify the gap between their existing level of competency and desired level of competency, if a transition to BIM modelling was to be feasible.

BIM is a technological and attainable concept, which has upgraded the construction industry into a more diligent industry. Due to constraints on the professional's competencies on software it becomes a very hard goal for the Sri Lankan construction Industry. Therefore, starting with the architect profession it will become more achievable. Hence, identification of the current level of the knowledge and the development of the BIM software knowledge, finally the expected goal can be fulfilled. Using above summarized tasks, it showed that competency gap of the architects who following AutoCAD. This research emphasize that architects/designers are following most of the identified activities which are performed by the Revit user. But they are using few supplementary software packages for fulfil few of the activities (like Sketchup, 3D max). Although, there are enough capabilities on the CAD, architects do not practice them. Finally, the research study highlight that through the proper practice on identified options in the Revit and using current competencies, the architects can obtain better performance in the BIM process.

According to the summary, it can be concluded that Sri Lankan Architects much familiar few of the task. But, the handling/performing such activities differs quite a lot from they follow. If they are aware of these tasks then architects can practice it by following a diploma or using internet. Also, if the organization is willing to implement Revit in their organization. Then following methods can be offered,

- Establishment of training programme and lecture sessions for the architects

These training and lecture sessions could enable interaction with the staff to explore and capture the tacit requirements and needs, which could help for further the efficiency gains and improvements via Revit while increasing their current knowledge and skills in CAD. Also, identified competencies can be inculcated through this lecture series.

- Piloting Revit on the selected small projects such as housing projects.

This would be helpful for gradual increase in the use of Revit in the company. Furthermore, it would give an opportunity for training the staff and increasing their skills so that they may become proficient. It also provides the chance to observe what level of efficiency can be achieved via the Revit tool. The piloting projects helped to develop an understanding of what is needed for Revit modelling, which subsequently leads to improvements in how to sequence the steps in efficient BIM modelling through Revit.

9. REFERENCES

- America, A.G.C., 2005. *The contractors guide to BIM*. Available from: <http://iweb.agc.org/iweb/Purchase/ProductDetail.aspx>. [Accessed 05 August 2016]
- Aouad, G. and Arayici, Y., 2010. *Requirements engineering for computer integrated environments in construction*. New Jersey: John Wiley and Sons.
- Aranda-Mena, G., Crawford, J., Chevez, A. and Froese, T., 2009. Building information modelling demystified: does it make business sense to adopt BIM?. *International Journal of managing projects in business*, 2(3), 419-434.
- Arayici, Y., Kiviniemi, A.O., Coates, P., Koskela, L.J., Kagioglou, M., Usher, C. and O'Reilly, K., 2011. *BIM implementation and Adoption Process for an Architectural Practice*.
- Autodesk (2013). *Autodesk AutoCAD Civil 3D 2014: Overview*. [online] Available from: <https://www.youtube.com/watch?v=MB6mhwjpLSg> [Accessed 12 Aug. 2016].
- Autodesk (2016). *Revit*. [online] Available from: <http://www.autodesk.co.uk/products/revit-family/case-studies/architectural-design> [Accessed 22 Aug. 2016].
- Benjaoran, V. and Bhokha, S., 2010. An integrated safety management with construction management using 4D CAD model. *Safety Science*, 48(3), 395-403.
- Chelson, D.E., 2010. *The effects of building information modeling on construction site productivity* (Doctoral dissertation).
- Coates, P., Arayici, Y., Koskela, K., Kagioglou, M., Usher, C. and O'Reilly, K., 2010. *The key performance indicators of the BIM implementation process*.
- Cooperative Research Centre for Construction Innovation (Australia), 2009, *National guidelines for digital modelling*. Brisbane, Qld: Icon Net Pty. Ltd.
- Deutsch, R., 2011. *BIM and integrated design: strategies for architectural practice*. John Wiley & Sons.
- Gu, N. and London, K., 2010. Understanding and facilitating BIM adoption in the AEC industry. *Automation in construction*, 19(8), 988-999.
- Haron, A.T., 2013. *Organisational readiness to implement building information modelling: A framework for design consultants in Malaysia*. Doctoral dissertation, University of Salford.
- Harris, J., 2010. Integration of BIM and business strategy. *McCormick School of Engineering and Applied Science*, Northwestern University, Evanston, IL.
- Innovation, C.C., 2009. National guidelines for digital modelling. *Cooperative Research Centre for Construction Innovation, Brisbane, Australia*.

- Jayasena, H.S. and Weddikkara, C., 2012. Building Information Modelling for Sri Lankan Construction Industry. In *Proceedings of World Construction Conference 2012: Global Challenges in Construction Industry*. 28-30 June 2012. Sri Lanka, 196-201.
- Koskela, L.J., 2003, April. Theory and practice of lean construction: achievements and challenges. In *Proceedings of the 3rd Nordic Conference on Construction Economics & Organisation*. Hansson, Bengt & Landin, Anne (eds). Lund University.
- Liker, J., 2004. *The Toyota way: 14 management principles from the world's greatest manufacturer*. McGraw-Hill.
- Mihindu, S. and Arayici, Y., 2008, July. Digital construction through BIM systems will drive the re-engineering of construction business practices. In *Visualisation, 2008 International Conference*, 29-34. IEEE.
- Olatunji, O.A., 2014. Views on building information modelling, procurement and contract management. *Proceedings of the Institution of Civil Engineers-Management, Procurement and Law*, 167(3), 117-126.
- Omar, M.F., Nawi, M.N.M. and Nursal, A.T., 2014, January. Towards the significance of decision aid in Building Information Modeling (BIM) software selection process. In *E3S Web of Conferences* (3). EDP Sciences.
- Peddinghaus, 2016, *Building Information Modeling, BIM, Tekla BIMsight, Tekla Structures, Interoperability, Tekla Open API* [online]. Available from: http://www.peddinghaus.com/tekla/bim-software/building-information-modeling/software-1/9002_tekla [Accessed 11 Jul. 2016].
- Reddy, K.P., 2012. *BIM for building owners and developers: making a business case for using BIM on projects*. New Jersey: John Wiley & Sons.
- Rogers, J., Chong, H.Y., Preece, C., Lim, C.C. and Jayasena, H.S., 2015. *BIM Development and Trends in Developing Countries: Case Studies*. Bentham Science Publishers.
- Royal Institute of British Architects. (2012). Plan of Work | RIBA Bookshops. Available from <http://www.ribabookshops.com/plan-of-work> [Accessed 25 August 2016].
- Sacks, R. and Barak, R., 2007. Impact of three-dimensional parametric modeling of buildings on productivity in structural engineering practice. *Automation in Construction*, 17(4), 439-449.
- Sommerville, J. and Craig, N., 2006. *Implementing IT in construction*. New York: Routledge. Taylor and Francis Group.
- Tobin, T., 2015. *The Time is Now - Switching from AutoCAD® Architecture to Revit®: The Right Attitude is Everything* [online]. Available from: <http://au.autodesk.com/au-online/classes-on-demand/class-catalog/classes/year-2016/revit/ar17458> [Accessed 3 September 2016].