Implementation of Building Information Model (BIM) in terms of quantity takeoff (QTO) and estimation at construction consultant company in Vietnam

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Student number: 557532 / 1700203

TOPIC:

Implementation of Building Information Model (BIM) in terms of quantity take-offs (QTO) and estimation at construction consultant company in Viet Nam

ABSTRACT

In Vietnamese construction consultant companies, quantity take-offs (QTO) and estimation are two major important tasks of project management. The current approach and methods utilized for QTOs and estimation are traditional. They are made with the help of 2D documentation and supporting tools such as CAD, Microsoft Excel or Accit, GXD. One of the advantages of this method is its easiness to implement however, it also has disadvantages of flexibility and auto-update of information. As for example, in projects when the design changes, QTO and estimation require manual checking and update of information. These not only lead to waste of time and resources but also prone to the high amount of human errors. Building information modeling (BIM) has been widely used in most in developed countries for similar tasks in order to reduce the errors and optimize the workflow and processes. Processes and tools that BIM provide to overcome these shortcomings have huge potential and seem essential for the Vietnamese construction consultant companies. Therefore, this work focuses on investigating BIM as a new method for calculating QTO and estimation and the application of BIM to the working condition of Vietnamese company in those sections.

RESEARCH QUESTION

1. What are current methods and processes of calculating QTO and estimation in construction consultant company in Viet Nam? Do these methods include BIM application?
2. What are the benefits, challenges, and importance of BIM based QTO and estimation? And what benefit BIM brings in QTO and estimation in Vietnamese construction consultant approach?
3. What are the factors to be considered for BIM implementation in Vietnamese construction consultant company?

RESEARCH METHODS AND OBJECTIVES

The thesis will use a mixture of quantitative and qualitative research method using questionnaire survey and interview. The objectives of the research include:

1. To review the existing methods which are used in order to define QTO and estimation in construction consultant company in Viet Nam, focus on BIM methodology.
2. To point out objective and subjective reasons leading to limit in apply BIM in QTO and estimation in construction consultant company in Viet Nam.
3. To propose feasible solutions for applying and developing BIM in QTO and estimation.

RESEARCH TIME FRAME

The research is planned to be carried out in 27 weeks. It starts from 20th of December 2017 and the submission date would be Friday, 20th of July 2018. The study will provide recommendations of some feasible solutions for BIM implementation and development in QTO and estimation at construction consultant company in Viet Nam.

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Abstract

This research focuses on the implementation of BIM on quantity takeoff (QTO) and estimation process in construction consultant companies in Vietnam from the perspectives of investigating BIM as a new method and the application of BIM to the Vietnamese working condition. A literature review was analyzed in order to understand and investigate the research problem and an online survey was distributed in order to find out the main inhibiting reasons for the adoption of BIM in Vietnamese construction consultant company. Overall, the lack of demand in the construction market is the main obstacle, followed by the high initial investment and the concern of risk in investing in the new technology. Besides, the conception of inability to integrate the Vietnamese Standard Construction Codes with BIM tools, the difficulty in approving estimation and a gap in understanding of BIM workflow are also the main limitations. Besides, some mitigation measures to overcome these limitations and barriers are also developed based on the analysis and synthesis of the literature review. In addition, BIM application is initially used in the design, however, it is not considered widely as the method for QTO and estimation process in construction consultant company.

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List of abbreviations

AEC	Architecture, Engineering, and Construction
BIM	Building Information Modeling
CAD	Computer-Aided Design
D	Dimensional
GIFA	Gross internal Floor Area
GSL	Government Soft Landings
IT	Information Technology
MEP	Mechanical, Electrical and Plumbing
MS	Microsoft Software
NBIMS	National BIM Standard
NIBS	National Institute of Building Sciences
NRM	New Rules of Measurement
QTO	Quantity Take Off
RIBA	Royal Institute of British Architects
RICS	Royal Institution of Chartered Surveyors
SMC	Solibri Model Checker
SMM	Standard Method of Measurement
UK	United Kingdom
US	United States
USA	United States of America

1 Introduction

In Vietnamese construction consultant companies, quantity takeoff (QTO) and estimation are two important tasks of project management. The current approach and methods utilized for QTO and estimation process are traditional. They are made with the help of 2D documentation and supporting tools such as CAD, Microsoft Excel or Accit, GXD[1]. One of the advantages of this method is its easiness to implement. However, it also has disadvantages of flexibility and auto-update of information. For example, in projects when the design changes, QTO and estimation require manual checking and updating of information. These not only lead to waste of time and resources but also are prone to the high amount of human errors. Building Information Modeling (BIM) has been widely used in most developed countries for similar tasks in order to reduce the errors and optimize the workflow and processes. Processes and tools that BIM provide to overcome these shortcomings have huge potential. Thus, BIM-based QTO and estimation seems to be an efficient solution for this process in Vietnamese construction consultant companies. The arising research questions are:

1. What are current methods and processes of calculating QTO and estimation in construction consultant company in Vietnam? Do these methods include BIM application?
2. What are the benefits, challenges, and importance of BIM based QTO and estimation? And what benefit BIM brings in QTO and estimation in Vietnamese construction consultant approach?
3. What are the factors to be considered for BIM implementation in Vietnamese construction consultant company?

In order to answer those questions, in this research, a mixture of quantitative and qualitative research method was used, the questionnaire survey was established. The objectives of the research then revealed the following main points below:

- To review the existing methods which are used in order to define QTO and estimation in construction consultant company in Vietnam, focus on BIM methodology.

[1] Ho et al, 2016, p.73.

- To point out objective and subjective reasons leading to limitations in applying BIM in QTO and estimation in construction consultant company in Vietnam.
- To propose feasible solutions for applying and developing BIM in QTO and estimation.

Based on these above objectives, this paper is organized as follows. First of all, a literature review on BIM basis, BIM-based QTO and estimation process, inhibiting factors, consideration factors of BIM implementation in the construction industry are conducted. Secondly, a special section on research questions and the methodology used is presented. In this research, the empirical data are collected through an e-mail survey. After that, the collected data is analyzed using a quantitative analysis method. Finally, from the data analysis and synthesis, the limiting factors are figured out and also the solutions for these limiting factors will be developed in Vietnam condition.

In conclusion, this paper will help to overcome the literature lack, quantifying the limiting factors of BIM deployment, proposing the corresponding solutions and facilitating the Vietnamese consultant companies and professionals to go further in using BIM in managing construction projects.

2 Literature review

2.1 BIM background

2.1.1 What is BIM

There is no universally accepted definition of BIM, however, any researches on BIM cannot start without an overview on BIM definition (Sawhney et al., 2014). Thus, in this subchapter, the author tries to cite some sources of BIM definition which are relevant to the scope of this research.

According to Eastman et al. (2011) BIM is defined as “one of the most promising developments that allows the creation of one or more accurate virtual digitally-constructed models of a building to support design, construction, fabrication, and procurement activities through which the building is realized”.[2]

NBIMS (2014) (National BIM Standards Committee) also defines BIM as “the digital representation of physical and functional characteristics of a facility. As such it serves as a shared knowledge resource for information about a facility, forming a reliable basis for decisions during its life cycle from inception onwards”.[3]

In the report of the business value of BIM – Getting Building Information Modeling to the Bottom Line of McGrawHill Construction (2009), BIM is defined as “the process of creating and using digital models for design, construction and/or operations of projects”.[4]

Sawhney et al. (2014) show that a holistic definition of BIM encompasses three interconnected aspects: the model itself, the process of developing the model and, the use of the model[5]. These aspects are described below:

- The model itself: a computable representation of the physical and functional characteristics of the project.
- The process of developing the model: the hardware and software used for developing the model, electronic data interchange, and interoperability, collaborative workflows, and definition of roles and responsibilities of project team members in relation to BIM and a common data environment.

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[2] Eastman et al., 2011, p.3.
[3] National BIM Standards Committee, 2014.
[4] McGrawHill Construction, 2009, p.4.
[5] Sawhney et al., 2014, p.3, p.4.

- The use of the model: business models, collaborative practices, standards, and semantics, producing real deliverables during the project life cycle.

Besides these definitions of BIM, another view on BIM dimensions is necessary in order to answer the question “What is BIM?“. BIM currently has varied dimensions commonly known as 4D, 5D, 6D, and 7D. The 4D and 5D dimensions are presented shortly as follows:

- The fourth modelling dimension (4D) refers to 3D + time. That is, a model or a modelling workflow is considered to be 4D when the time is added to model objects to allow construction scheduling. (BIMe Initiative, 2018)
- The fifth modelling dimension (5D) refers to 4D + cost. That is, a model (or modelling workflow) is considered to be 5D when cost is linked/embedded within BIM models and Model Components. 5D is used for the purposes of generating Cost Estimates and practicing Target Value Design. (BIMe Initiative, 2018)

According to Sawhney et al. (2014), in this context of the technology behind BIM, the dimensions of BIM, 4D, 5D, 6D, and 7D (albeit with some differences in terminology in different parts of the world) are shown in Figure 1 and Figure 2 below.

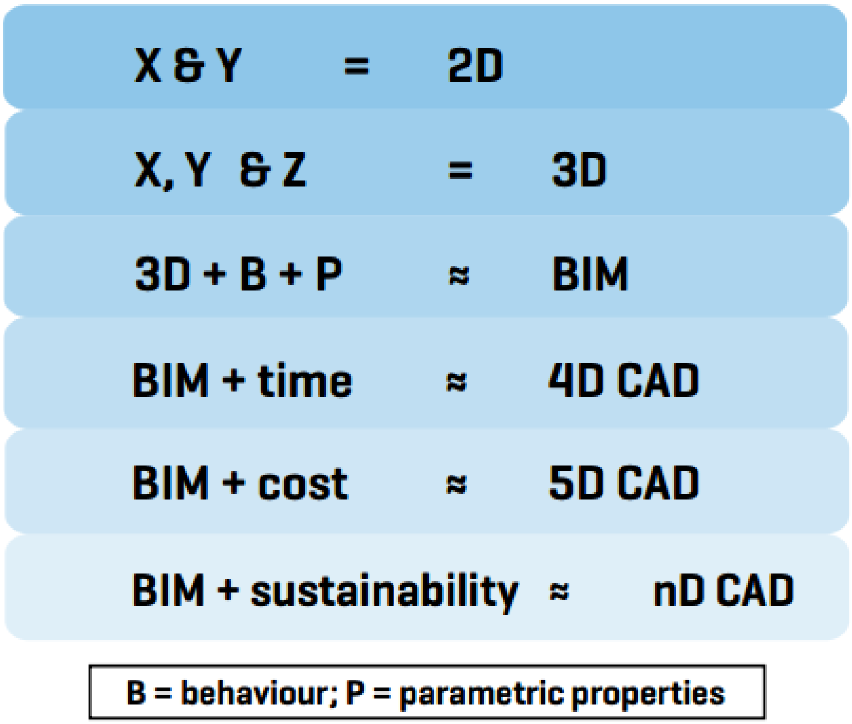

Figure 1: Dimensions of BIM[6]

[6] Sawhney et al., 2014, p.15.

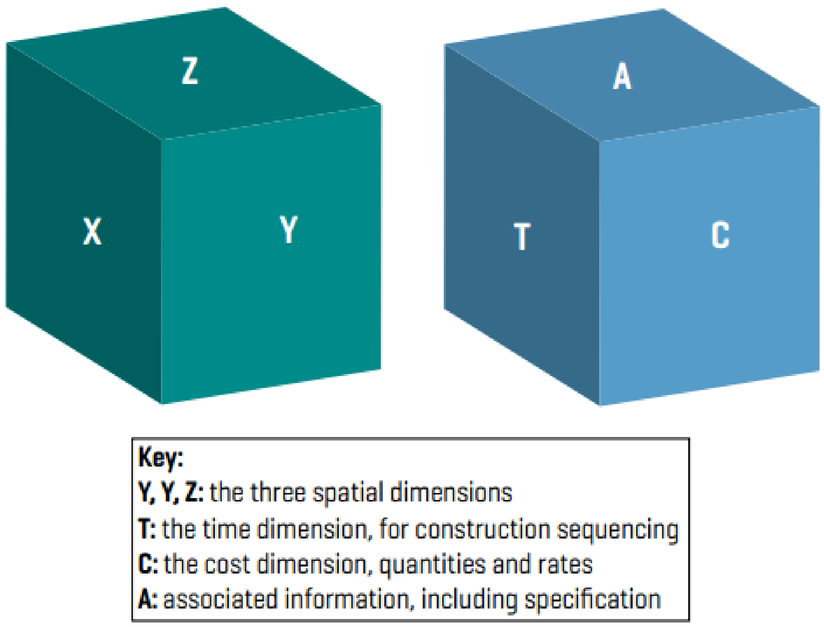

Figure 2: Six dimensions of BIM[7]

2.1.2 BIM development

The BIM concept has been known since the 1970s, but the application has been adopted in many countries since the early 2000s[8]. So far, BIM has been used in many countries around the world, and governments in some countries are aware of the need for BIM in building management[9].

In the USA, National Institute of Building Sciences (NIBS) began looking at BIM through its Facility Information Council in 1998. The National BIM Standard (NBIMS)-US Project Committee (a project committee of the building SMART alliance of NIBS) was established in 2007 to promote the development of BIM in each sector, state and nationwide, and to announce the national BIM standards.[10] According to McGrawHill (2012), 71% of architects, engineers, contractors, and owners were using BIM in their project, with a 75% growth surge over five years from 2007 to 2012. Contractors at that time were leaders in using BIM, with a 74% adoption rate. Following were engineers, with 67% of BIM adoption.[11]

Meanwhile, the United Kingdom (UK) were later than the USA in adopting BIM in the construction industry. However, two years later, the UK was considered to be leading

[7] Sawhney et al., 2014, p.15.
[8] Jung and Lee, 2015, p.512.
[9] Sawhney et al., 2014, p.6.
[10] Sawhney et al., 2014, p.7.
[11] McGrawHill, 2012, p.1.

the way in the BIM adoption. (Sawhney, et al., 2014). In 2011, UK set a target to reduce the investment cost of public projects by 20% (Cabinet Office, 2011). In order to achieve it, the UK government established the BIM implementation strategy and roadmap on June 2011. This roadmap was piloted in some public projects, and was deployed widely from 2013 to 2015. By 2016, UK ensured that all public investment projects with capital of 5 million £ will apply BIM in appropriate phases[12]. One of the main influence on UK BIM adoption is the BIM maturity model, this ramp model demonstrates a systematic transition of BIM maturity levels in the industry BIM maturity model (Seen at Figure 3 below) [13].

Alongside the maturity model, the UK government has introduced the concept of government soft landings (GSL). With this concept, the UK government is facilitating closer alignment of design and construction with operation and asset management.

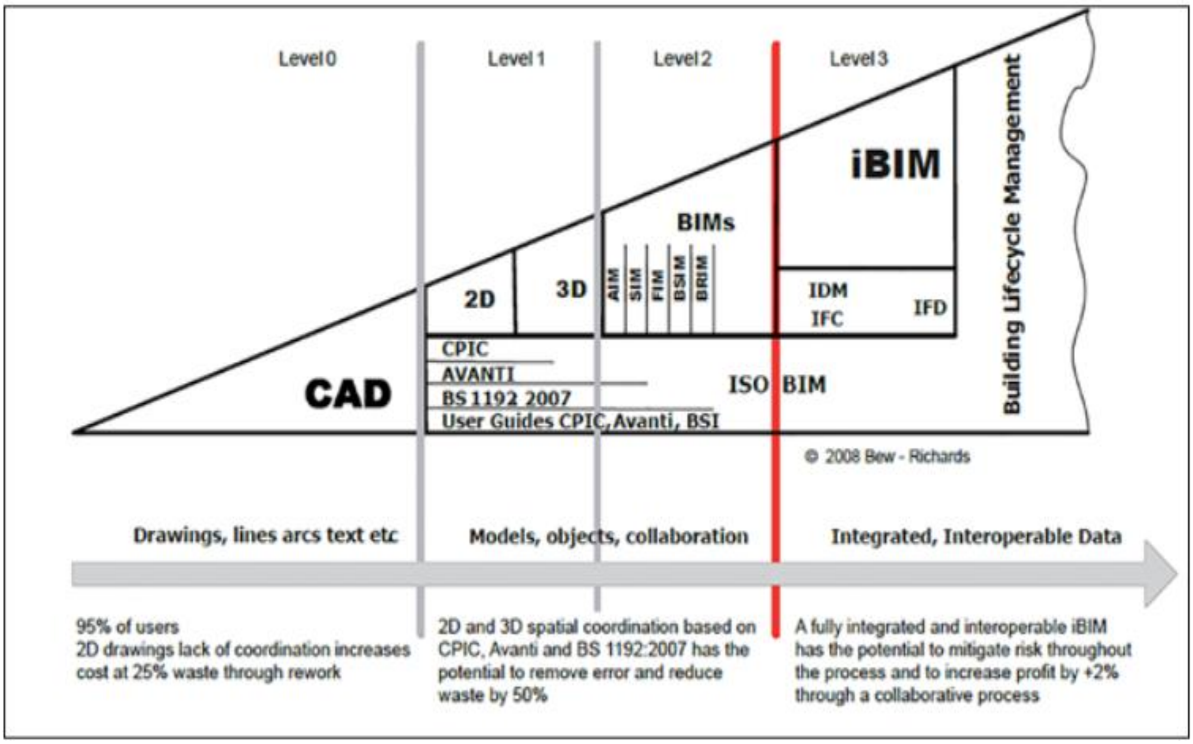

Figure 3: Bew-Richards BIM maturity model[14]

Singapore was the most successful country in applying BIM since it has National standards and BIM Roadmap (Kaneta, et al., 2016). In order to improve the productivity by up to 25% over next decade, The Building and Construction Authority (BCA), implemented the BIM Roadmap in 2010 with the aim that 80% of the construction

[12] Cabinet Office, 2011, p.3.
[13] Sawhney et al., 2014, p.7.
[14] Sawhney et al., 2014, p.7, p.8.

industry use BIM by 2015. To allow the public sector to take the lead, BCA collaborated with GPEs (Government Procurement Entities) to request the use of BIM for their projects from 2012. This is the most important policy to drive the construction industry in Singapore. In May 2012, together with the GPEs, the BCA of Singapore announced “The Singapore BIM Guide“ and “The BIM Particular Conditions“ as a guiding principle for deploying BIM and clarifying the roles and responsibilities of the involving parties for the use of BIM at all stages of the project[15]. According to these guides, it was mandatory for all new building projects of at least 5,000m2 to have engineering BIM e-submissions by 2015. The aim was to achieve a highly integrated and technologically advanced construction industry, with cutting-edge firms and a skilled and proficient workforce in 2020.[16]

In China, according to Sawhney et al. (2014), the first BIM project to be completed in 2008 was the Bird's Nest Stadium in Beijing. At the same year, the Chinese government set up a BIM electronic portal to promote the development of BIM in the construction industry. During this time, many seminars, and discussions on BIM were held with the participation of all stakeholders such as investors, consultants, contractors, researchers and government. In 2012, the Ministry of Urban, Rural and Housing Development issued the "BIM Development Plan 2011-2015" to study software solutions and promote the development of national standards for BIM.[17] In terms of research, universities such as Thanh Hoa, Dong Te, and Nam Trung set up research laboratories for BIM from 2005. By 2007, schools had begun offering courses using BIM software. In 2012, China introduced a master's degree in BIM. (Wang X, 2012)[18].

In addition, some other countries have been actively implementing the development and application of BIM in the construction industry. In Asia, South Korea and Hong Kong are the countries where the public sector is required to adopt BIM in the construction industry. Both countries are building standards and roadmap for implementing BIM in the future. In addition, Malaysia has BIM standards and BIM training programs in university teaching.[19]

[15] Kaneta et al., 2016, p.1036.
[16] Sawhney et al., 2014 ,p.9.
[17] Sawhney et al., 2014, p.9.
[18] Wang X, 2012, p.27, p.28.
[19] Sawhney et al., 2014, p.9, Kwong et al., 2013, p.8, MacGrawHill, 2013, p.2.

Meanwhile, in Europe, besides the UK, Norway, Finland, Netherlands, Denmark also required BIM implementation in the public investment sector in construction. In 2014, standards and routes of BIM adoption in some countries such as France, Australia, Germany were being developed as well. (Sawhney, et al., 2014).

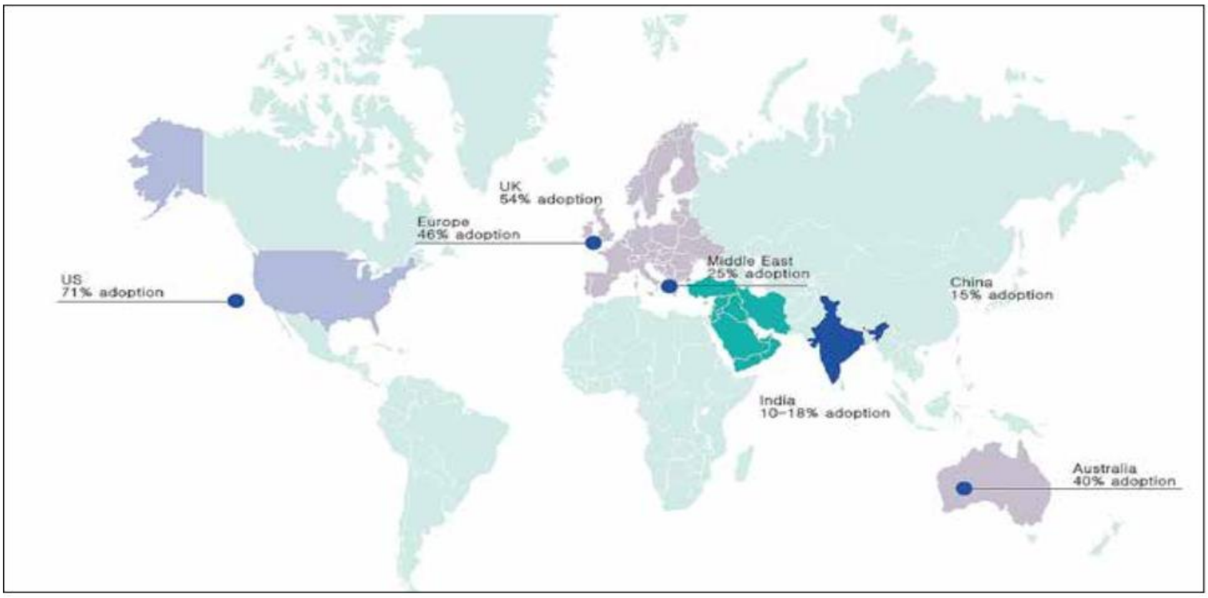

Figure 4: Status of BIM adoption globally[20]

The research of Jung and Lee (2015) "The Status of BIM Adoption on Six Continents" shows that North America, Europe, Oceania (Australia, New Zealand), and Asia were advancing rapidly toward the mature stage of BIM adoption, whereas the Middle East/Africa and South America were still in the early phase. (Jung and Lee, 2015)

2.2 BIM-based QTO and estimation process

2.2.1 Essentials

The QTO process is defined as "the process of calculating the amount, type and installation method of all elements in the object, made before the construction process" (Gołaszewska & Salamak, 2017). The QTO process is the critical part of the cost estimate and is tied strongly with the cost estimate[21]. There are many types of estimation during the designing stage of a construction project, from approximate estimation in the early developing period to more accurate one in the detailed design phase[22]. In this research, the author concentrates on two types of estimations (approximate estimation and detailed estimation) and the process to generate them.

[20] Sawhney et al., 2014, p.8.
[21] Gołaszewska and Salamak, 2017, p.73.
[22] Gołaszewska and Salamak, 2017, p.73., Eastman et al., 2011, p.275.

The traditional way or the paper-based method to calculate quantity takeoff and estimation is being used for long in AEC industry. The 2D drawings are the main database to take off the quantities. The estimator will use them to measure all the needed dimensions of all elements of a project and then enter those numbers in the spreadsheet like MS Excel or a supporting estimate software to calculate those quantities and then generate respective cost estimation. Although, some QTO programs are presented to support this process, they still rely on the manual input. The calculation of QTO in the traditional way is time-consuming and labor-intensive and is prone to human errors, mathematics mistakes. (Bečvarovská & Matějka, 2014) (Gołaszewska & Salamak, 2017)[23].

According to Eastman et al. (2011), in the process of making an approximate estimation, the needed quantities are those related to areas and volumes. For example, the quantities associated with areas are the square meters of function space. The quantities involved with volumes are the dimensions of spaces like perimeter, lengths, high, width and so forth.[24] And after taking them off from concept drawings, these quantities are used to estimate the initial cost for a building by connecting with corresponding prices. Those prices are the reference from previous estimator's experience with similar building or taking from the rates of standard constructions. That depends on where the building is constructed and local regulations. (Gołaszewska & Salamak, 2017)[25]. This approximate estimation looks like a "parametric cost estimate "and unfortunately, the factors of its quantities in this estimation are not usually available in early stage of design. If the first estimation does not fulfil the budget target of owners, some changes have to be made in order to meet this requirement. As the results, the entire manual process of making estimation has to be done again and again until achieving the economical target and engineering solutions. Due to some invisible factors in calculating the quantities in this stage and the fragmented pricing data, this process is tedious and mistakes easily occur. (Eastman , et al., 2011)[26].

Later in the design phase, as the drawing matures, a detailed estimation will be made and along with it, a detailed quantity[27]. The list of accurate quantities such as counts of

[23] Bečvarovská and Matějka, 2014, p.1, p.2, Gołaszewska and Salamak, 2017, p.73.
[24] Eastman et al., 2011, p.275.
[25] Gołaszewska and Salamak, 2017, p.74.
[26] Eastman et al., 2011, p.275.
[27] Eastman et al., 2011, p.276.

components, items, the volume of spaces, weight of materials and so on must be brought out from 2D drawings. A huge number of drawings are needed to be carried on in this period. The traditional way to do quantity takeoff and estimation with the manual way to input data easily lead to occurring mistakes such as overlap volume, missing some items or components.[28]Those mistakes are based on workers' mistakes and workers 'perception [29]. Accordingly, the need for the new technology or new solution for overcoming those shortcomings is necessary. BIM with the use of technological advances made in the area of 3D modeling[30] can be seen as a suitable solution for those shortcomings. The visualization ability of the 3D model can provide more accurate QTO and the automatic ability of BIM method can help estimator/quantity surveyor avoid the human mistake. Furthermore, automatically updating data when something changed can help to significantly reduce the consuming time of this process.

In the traditional cost estimating practices, the level of accuracy for each stage of estimate varies as shown in Table 1.

Type of Estimate	Construction Development	Expected Percent Error
Conceptual	Programming and schematic design	± 10-20%
Semi-Detailed	Design development	± 5-10%
Detailed	Plans and specification	± 2-4%

Table 1: Variability of Error in Different types of estimate[31]

According to the Table 1, the expected percentage of error in estimates decreases as more design information becomes available to the quantity surveyor along with the development of the design. Thus, conceptual estimate is at higher risk and contains more errors in traditional practices since the project information is still incomplete. (Wu, et al., 2014).

In Vietnam, some recent statistics show that a lot of projects have significantly exceeded the budget. For example, the Highway Ha Noi - Ninh Binh project was adjusted two times[32]. The first time in August 2007, it exceeded total investment over 5.000 billion VND (around 213 million USD). One of the reasons for it was the change in QTO, and it took the dominant percent at 63.46%. The second adjustment in 2010,

[28] Ho et al., 2016, p.103.
[29] Jungsik et al., 2015, p.17.
[30] Sawhney et al., 2014, p.12
[31] Holm et al., 2005 cited by Wu et al., 2014, p.22.
[32] Chau, 2014, p.3.

the budget was increased by 1.282 billion VND (54,4 million USD) including 9.5 billion VND (0,4 million USD) of construction cost. (Chau, 2014). Another example is the Cat Linh - Ha Dong railway project. In 2013, the project just completed 10 km out of total 13 km length (75% of the total volume of the project). However, at that time (after 4 years of construction) the total budget had to add 300 million USD. And almost half of the amount, 134 million USD, was caused by increase in QTO (the original QTO had mistakes). (Nguyen et al, 2016)[33]. Therefore, the need for a new method to do QTO as well as do estimation tasks is obviously and urgently needed.

2.2.2 Benefits

It is obvious that BIM has a vital importance in Architecture, engineering, and construction (AEC) industry. From the economic point of view, BIM has the ability to reduce industry's fragmentation, increase its efficiency, and depress the extend cost due to missing information and less communication. From the technical view point, BIM has huge benefits as well. BIM can improve visualization of the project in conception phase, engineering design quality, and the labor productivity. (Alabdulqader, et al., 2013)[34]. BIM itself can respond to the increased pressures on the building process, meanwhile reducing the operation cost in whole subsequent use of a building. Therefore, BIM practice has significant improvements in comparison to traditional 2D CAD practice. (Eastman , et al., 2011)[35]. Figure 5 shows the main advantages of BIM in a life span of a building.

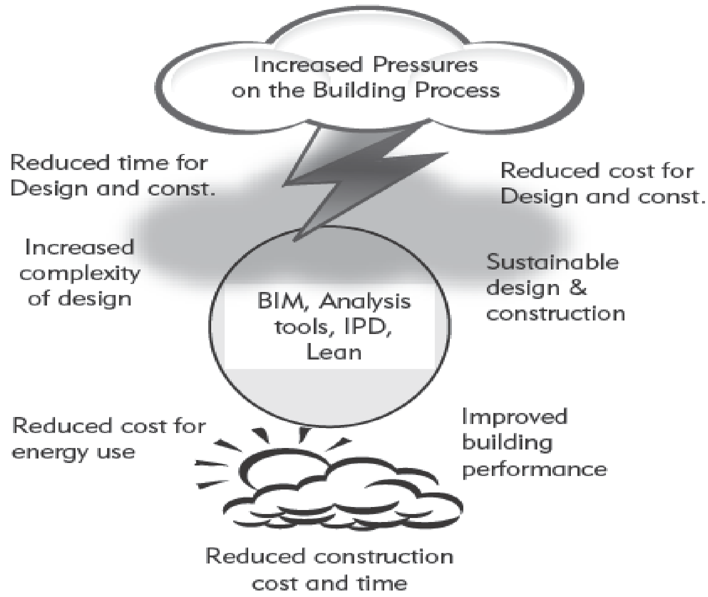

Figure 5: BIM technology and associated processes can help to respond to the increasing pressures on a building over its lifecycle[36]

[33] Nguyen et al., 2016, p.99.
[34] Alabdulqader et al., 2013, p.2.
[35] Eastman et al., 2011, p.20.
[36] Eastman et al., 2011, p.20

In the early design stage of a project, BIM is presented as the great supporting tool to visualize the project as well as to add the engineering values. This advantage is expressed in the ability of BIM to allow designers consider the alternatives for their designs which meet the requirement of client's resources. An accurate bill of quantities can be extracted at any stage of the design. In the early stage, an approximate cost estimation is produced and it needs information of main project quantities such as square feet of residential areas and unit costs for these main quantities. The 3D BIM model not only provides exactly these data but also provides quickly the alternatives. From that point, the owner and the design-build team can explore more options and gain the better overall design in the scope of programmatic and budget requirements.[37]

Beside this benefit, in the case study "Hillwood Commercial Project" which was introduced in a book of Eastman et al. (2011), some specification advantages of using BIM in early stage of design are defined. First of all, it is decreasing the rebuilding and labor-hours to generate an estimation. By using the BIM base estimation tool (DProfiler) working hours can be minimized. With the DProfiler they just need only one experienced member of the design team to do estimation (Usually with the traditional paper - based, they need at least two people in order to do this process, an estimator and an experienced construction project manager). In addition, with the help of the DProfiler, QTO task can be done automatically. Thus, the total needed hours to perform estimation process is significantly reduced. The second benefit is the ability to perform the precise estimation in real time. With the DProfiler tool and thank to the parametric characteristic of BIM model, all elements of the 3D model are ensured to be counted, thus the mistakes are reduced during taking the estimating process. Since this process is almost automatic with Dprofiler, the results when there are changes in the project will be quickly brought out. The project team, therefore, focuses more on analysis of the financial influence on changing of the project instead of assessing the accuracy of cost estimates. The third benefit is the visual estimation. The estimation is not only the number on paper but also is the graphical number in the 3D model. The costs are now linked directly to the physical items on models, it seems impossible to find the components without the cost estimation or vice versa. That improves the accuracy of estimation as well as the monitoring ability of the estimator.[38]

[37] Eastman et al., 2011, p.22, p275, p.557
[38] Eastman et al., 2011, p.564, p.565

In later design stage of the project, those BIM advantages mentioned above are further explored in greater level of detail. As the designs are mature, a detailed estimation needs to be produced. Those benefits of BIM in QTO and estimation process now present as the speed, accuracy, and impact of cost on design decisions aspect.[39]. In a research of Olsen and Taylor (2017), the saving time of using BIM base QTO process in comparison to the traditional method is around 80% faster while providing QTO and estimates that are accurate to within 3%. Table 2 below demonstrates the results of two used methods.

		time [minutes]	
Category	**Contents**	**Manual**	**Revit**
Table of rooms	Floor and ceiling composition	40	20
Foundations	Pads, belts, slabs	125	20
Construction phase	Walls, pillars, girders	420	10
Vertical constructions	Masonry, isolation	450	30
Wall surface	Plasters, paints	330	20
Ceiling composition	Ceiling composition	20	15
Floor composition	Floor composition	40	15
Wall composition	Wall composition	100	20
Facade	Facade	240	20
Roof composition	Roof composition	20	5
Balcony composition	Balcony composition	50	15
Groundwork	Excavations, embankments, removal	120	-
Staircases	Staircases	60	-
Other construction and work	Cleaning, shining, covering	70	20
Tables for take-offs		-	130
Total		**2085**	**340**

Table 2: Time saved using BIM tool for quantity take-off [40]

In the project "Sutter Medical Center, Castro Valley" case study of Eastman et al. (2011), the most valuable benefit was adding the engineering value during designs period. In other words, it is the impact of cost on their design decisions. By using model-based cost estimating process, the project team was able to see quickly the change of cost after they make the change of design. In this case study, the project team decided to use quantity like a monitoring subject for the cost. The quantities were taken off from the 3D model and tracked by every week. In this way, they could see how the design was developing following quantity trend. And they could see the construction options as well and make the decision for model objects.[41]

[39] Eastman et al., 2011, p.473, Bečvarovská and Matějka, 2014, p.3.
[40] Olsen and Taylor, 2017, p.1100.
[41] Eastman et al., 2011, p.473, p.474

2.2.3 Challenges

BIM has its flaws" is the statement that Yan and Damian (2008) and Kiviniemi (2007) agree with. They believe that BIM could not solve all quantification issues although it has the capability of performing most manual work quickly. The resulting question is what challenges can be expected when adapting BIM to a project or an organization in general and to the QTO and estimation process in particular?

According to Eastman et al. (2011), the intelligent use of BIM will reduce the number and severity of problems associated with traditional practices, however, it will also cause significant challenges such as changing in the relationships of project participants and the contractual agreements between them. For more details, it means the challenges with collaboration and teaming; legal changes to documentation ownership and production; changes in practice and use of information. When BIM applies to an organization, Eastman et al. (2011) also mentioned the challenges in implementing BIM process. On their viewpoint, replacing 2D CAD or 3D CAD environment with a building model system not only involves to acquire software, to train staffs and to upgrade hardware, but also requires the changes of almost every aspect of a firm's business (not just doing the same things in a new way).[42]

For the adoption of BIM on QTO and estimation process, the following challenges still remain with BIM-based estimation despite its advanced technology. These challenges can be seen as the issues of the characteristic in working with BIM technology from the perspectives of choosing the software and team communication. (Gołaszewska & Salamak, 2017). The first issue was because of the limitation in access of functional information of cost estimating software. The information which is provided by the software providers or from the websites were usually scarce and did not present the full abilities of the program. They tend to focus on listing the benefits when using BIM application more than the functions of the software. The same case with the tutorial videos. As the result, these missing information affect the choice of suitable cost estimating software for designers. The second challenge, the team communication, is the problem during whole process of making a model and cost estimation. The communication is between the members of the workgroup, which is described as one

[42] Eastman et al., 2011, p.26, p.27.

of the key issues while conducting a project in the BIM environment. Good communication will create a better model product. [43]

In another research of Wu et al. (2014) "How can BIM support the New Rules of Measurement (NRM1)", the challenges are defined as the misconceptions and the lack of awareness of BIM in the current industry. That leads to a wary attitude toward BIM adoption among quantity surveyors. Another challenge is to gain the knowledge of attributes of materials, building systems, and construction processes and to deliver the best value of the investment at the same time.

Wu et al. (2014) also discussed other challenges in BIM based estimation in three subjects: the substandard BIM models and inadequate information; the issues related to data exchange; the lack of standardization and inappropriate pricing format in practice. For the first subject, they found out that BIM models do not exactly tally the needs of the quantity surveyors in terms of quality and information. The reasons are the accuracy and the quality of BIM-based estimation rely upon two factors which are presented in the model: the quality of information, and the details of construction methods. Whether or not assemblies and objects are well developed in the model also influences the accuracy of BIM-based cost estimates. As the results, this creates difficulties for the quantity surveyors in managing and searching for the required information within the model in order to develop cost estimates. The issues related to data exchange are many BIM estimating applications do not accommodate bi-directional data exchange and most software enables only quantities within the model to be constantly transferred and updated during design changes, but not the cost information. The last challenge, the lack of standardization and inappropriate pricing format in practice, comes up because of no industry standard yet for the link between model and cost estimation. They figured out that the BIM software can provide to quantity surveyor/estimator with a full breakdown of quantities. However, they are rarely given in a suitable format for pricing.[44]

2.2.4 Issues

BIM has many benefits and estimators can take advantages from BIM to improve their works by deducting human errors or enhancing accuracy. However, before deciding to

[43] Gołaszewska and Salamak, 2017, p.76.
[44] Wu et al., 2014, p.20.

adopt BIM in QTO and estimation process, the users must be aware in advance of some issues they need to deal with.

According to Eastman et al. (2011), no BIM tool can generate automatically whole cost estimate from the 3D model. It means that BIM is just only starting point of entire estimation process. This issue is noticed as the BIM outcomes for estimation are just only a set of information such as material quantities and assembly names to support the estimator's calculation process. The rest of information that estimator needed is manually entered in by them later on base on the rules of calculation.[45]

Another issue is setting of expectation on the outcome of BIM method. The estimator should understand that the level of BIM quantity takeoffs gives back from level of detail of BIM model. If the BIM model is more accurate, then more detail is generated to the calculation. For instance, if the model included the steel in concrete, the quantity takeoff will has it in the list of outcomes. Otherwise, this steel will not automatically be calculated. (Eastman , et al., 2011)[46]

2.3 Construction consultant companies in Vietnam

2.3.1 Company services

In Vietnam, construction consultant companies are specialized units, operate legally independent and serve clients within contract. The construction consultant company can be classified by level of their service, there are two levels below:

Level 1: Strategic level. These are strategies for clients. Strategies involve the development of building policies to attract domestic and foreign investors or can be the advice about project feasible in term of legal, technical, economic aspect.

Level 2: Tactic level. These are the specific tasks such as project development, designing or biding task . Those tasks are also the supervision, quality inspection or handover of a project during construction time.

The consultant company has the most influence in adopting new technology in the construction process. They are in the first place in defining a construction project. The first-person contacts the investors, gives them ideas and solutions for each stage of a

[45] Eastman et al., 2011, p.279
[46] Eastman et al., 2011, p.280

project. Therefore, they can be the bridge to bring the new technology solution such as BIM to the clients.

2.3.2 Company with BIM

2.3.2.1 Approach BIM

In Vietnam, the BIM concept was first known through architects and engineers who work for foreign consulting firms. After that, many Vietnamese designers gathered in groups such as Hanoi Revit Club, BIM Community in Vietnam to share BIM experiences, BIM tools or BIM processes . However, their exchanges were mainly focused on software applications and were not focused on solutions that can promote the effective application of BIM. (Tran et al, 2014)[47].

In design community, some design firms such as VNCC, Hoa Binh, Contrexim, REEM & EM & E Contractors, Polysius Vietnam, etc… have started to apply BIM in their design activities. These companies also have started to build a library system for BIM standards. However, due to high investment cost, no requirements from owners, and no roadmap for this new technology, these companies just narrow adoption of BIM to design activities rather than deploy BIM for further services. (Tran et al, 2014).

2.3.2.2 Legal framework document about BIM

There are some policies promoting BIM application in Vietnam in the recent years. On the side of state management in the construction field, a number of legal documents are issued such as:

The Construction Law, which was adopted by the XIII National Assembly in 18nd of June in 2014, and effective on the first of January in 2015, mentions a number of issues related to BIM such as applying technology, information system on construction actives (Item 3, Article 4), and also mentions the management of information system for the building (Item 1, Article 66). (Construction Law, 2014)[48]

Decree No. 32/2015 / ND-CP on 25 March 2015 of Construction Ministry about management of construction cost, mentions the regulation of project management fee for the project uses the specific project management method (Item 2, Article 23) (Section 2, Article 25)

[47] Tran et al, 2014, p3
[48] Construction Law No, 2014, p4

Decision 79 / QD-BXD dated 15/02/2017 of Construction Ministry about “Standard project management and Construction consulting costs” points the method to calculate consultant fee in case of using BIM application in consulting services. (Section 2, Article 2).

Decision No. 134 / QD-TTg dated 26/01/2015 about the restructuring plan of the construction industry in association with the transformation of the growth model (towards enhancing the quality, efficiency and competitiveness) in the period 2014-2020 issued by Prime Minister also defines the application of the Information Technology Project (BIM) as one of the main solutions to the objectives set out in the scheme.

The stipulation of Resolution No.26 / NQ-CP dated 15/4/2015 of the Government on the subject of "The Promulgation of the Government's Action Program" promotes the application and development of information technology in order to meet the requirements of sustainable development and international integration.

In addition, Department of Transport in Ho Chi Minh city has taken a pioneering step to encourage the application of BIM in the whole transport sector. In the Official Letter No. 4405 / SGTVT-XD dated 23/6/2014 sent to investors, consultants, contractors, its content not only mentions the benefits of BIM but also mentions the new tasks of the Department of Management. The first task is to research BIM application and to prepare a step-by-step technical as well as a workforce for the BIM technology. The second task is to consider investing in the BIM application in terms of the equipment, the production process, and management organization. This letter also mentions “investors should take the first step in studying the regulations of BIM adoption and BIM measurement within the bidding criteria when they select consultants and contractors”. (Nguyen, 2017)

2.3.3 Current method of QTO and estimation process

In Viet Nam, there are currently many methods which are applied in QTO and estimation process. However, the most common way is the manual method (traditional method). In order to do it, based on design documents (concept, engineering and construction drawings), quantity surveyor (QS) or estimator then uses a the software such as G8, Accitt, GXD etc...(The supporting software which is independent based on Microsoft Excel) to calculate QTO. In particular, based on 2D drawings on paper (hard copy) and combinations of soft files (soft copy of the file is as dwg/dxf file), QTO are calculated manually. It means to enter the number from the keyboard into the supporting software such as GXD, Accitt, G8 in order to obtain the final results. This traditional method has the advantage of being easy to use. However, by doing it empirically, these traditional methods have many drawbacks as follows[49]:

- Manually importing data from the keyboard easily leads to a mistake in the calculation process.
- In the process of calculation, if drawings are changed, the estimators/quantity surveyor has to re-enter input data. This process is the cause of risks such as duplication, omissions of quantity.
- People spend too much time in calculations and invest a lot of effort in checking the calculation process.

2.3.3.1 QTO method

In Vietnam, the common order for measuring QTO, which was introduced in the Official letter No. 737 / BXD-VP dated 23/04/2008 of Construction Ministry about the guide for measurements of QTO, is through the following steps:

Step 1: Understanding the drawing;

Step 2: Measuring the design dimensions;

Step 3: Calculating the volume by part, items;

Step 4: Calculating the volume by other part, items;

Step 5: Editing and summary. [50]

Based on this regulation, there are three common ways among estimators/quantity surveyors to calculate QTO. The first way is the calculation by type of works, items. Second is the calculation by order of drawings, and last is the calculation by execution order. These methods based on the simple input information. However, those methods are very passive[51]. For example, in a mega-project, where a huge number of drawings have to be carried out by manual calculation. Thus can lead to mistakes such as

[49] Ho et al., 2016, p.73 ; Ho et al., 2018, p.102, p.103.
[50] Ho et al., 2018, p.102.
[51] Ho et al., 2018, p.103.

overlap volume, missing some items or components. Moreover, a lot of time and efforts will be required from the estimator/ quantity surveyor to handle to final results.[52]

2.3.3.2 Estimation method

In case of an approximate estimate, the quantities are brought out from concept design. And the estimator/quantity surveyor uses the respective prices to estimate cost for the project. According to the guide of Circular No. 06/2016 / TT-BXD in 2016 of Vietnamese Construction Ministry, those prices are defined according to the investment cost rate of a construction project or from the data of the similar projects which were built. [53]

In case of detailed estimation, according to the guide of Circular No. 06/2016 / TT-BXD in 2016 of Vietnamese Construction Ministry, the estimate are defined by QTO and construction unit price or by QTO and construction price. The QTO is determined from the technical designs or shop drawings. [54]

For the construction unit price (or detailed price), two detailed prices are accepted: partly unit price (including material costs, labor costs, machine and equipment expenses) and the full unit price (including material cost, labor costs, machine and equipment expenses, general expenses and pre-calculated taxable income). The basis needed for the determination of construction unit price are:

- The list of construction works which need to be set up according to Standard Construction Codes.
- Construction cost norms.
- The price of materials, labour and equipment (including delivery to construction site but tax).

For the construction price (or detailed price), two detailed prices are accepted: partly unit price (including material costs, labor costs, machine and equipment expenses) and the full unit price (including material cost, labor costs, machine and equipment expenses, general expenses and pre-calculated taxable income) [55].

[52] Ho et al., 2018, p.103.
[53] Construction Ministry, 2016, p.10.
[54] Construction Ministry, 2016, p.45.
[55] Construction Ministry, 2016, p.60.

2.4 Implementation of BIM in QTO and estimation process

2.4.1 BIM method

One of the BIM implementation issues is, "BIM is only a starting point for estimation"[56]. That means no BIM tool can provide the full function as an estimating software. Thus, the estimator should know the options which BIM can offer to leverage for quantity takeoff and to support the estimating process. There are three options that the estimator/ quantity surveyor can consider to adapt to their tasks[57].

Exporting quantities to estimating software are one of the options. Normally, all of the BIM tools offer the function for bringing the quantities (building object quantities) out. The recipient of this data can be a computer program such as a spreadsheet or an external database. In this option, MS Excel is the most common and sufficient program to process the BIM quantities for further needed calculations (Sawyer and Grogan, 2002). An example of Autodesk (2007)[58] in which quantity takeoff was done within Revit and was extracted to an MS Excel program, shows that this option was simply and perfectly suited for the estimation process. In some companies, they created materials takeoff in Revit and then gave this outcome to cost estimator. In addition, this option is the way that data of 3D BIM model is extracted into the format which could be read by a cost estimating software (Forgues, et al., 2012)[59].

Another option is to use the direct link BIM components to an Estimating Software. (Eastman , et al., 2011). These BIM tools can be linked straight to an estimating package through a plugin or third-party tool. The BIM components are directly attached to assemblies, recipes, or items in the estimating package. Figure 6 below is an example of linking between BIM components and assemblies, recipes or items in estimating package. Estimators/surveyors can apply the calculation rules to take off the quantities for the activities of components. They can also apply the construction methods (steps of construction, the order of steps, etc.), resources (labors, equipment, materials, etc.), time, and cost expenditures on these packages. In this option, the estimating software that the estimator/surveyors can use are Innovaya 2007; U.S. Cost 2007; Graphisoft Estimator (Vico 2007). This approach works well for contractors who

[56] Eastman et al, 2011, p279
[57] Eastman et al, 2011, p.277.
[58] Autodesk, 2007, p.2
[59] Forgues et al., 2012, p.780

have standardized on a specific estimating package and BIM tool. Integrating BIM component information from subcontractors and various trades, however, may be difficult to manage if different BIM tools are used [60].

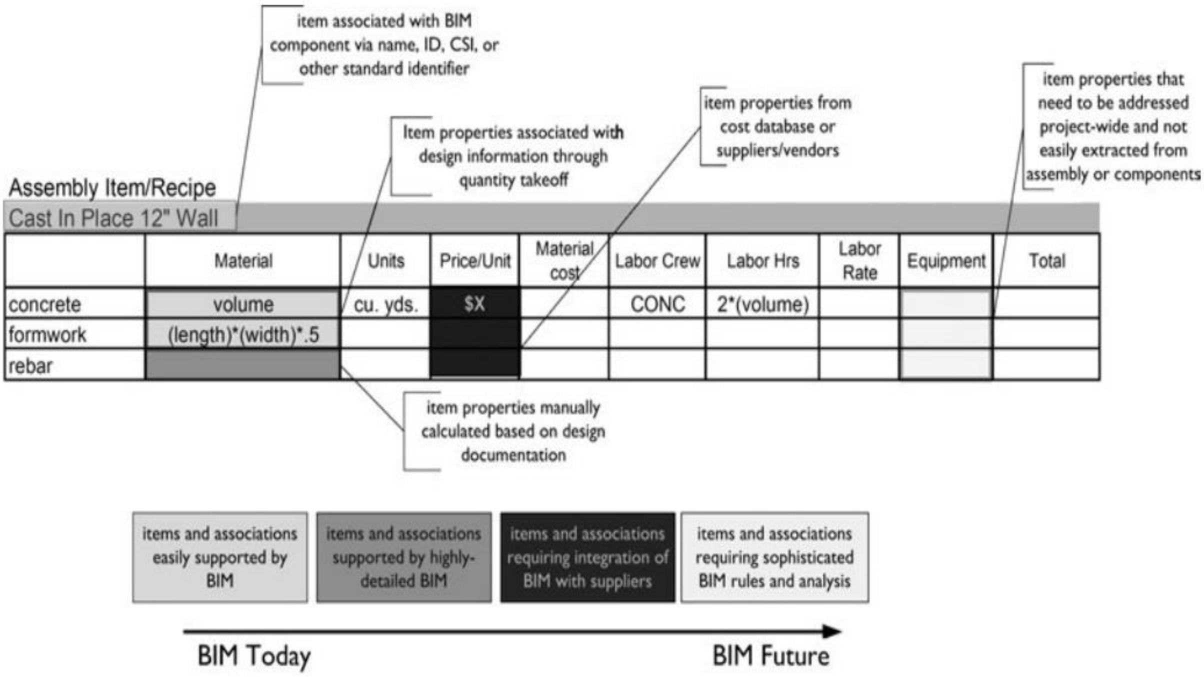

Figure 6: Example of how BIM component definitions relate to estimating assembly items and recipes[61]

The last alternative is using a BIM quantity takeoff tool (Eastman , et al., 2011). This tool is specially designed for the estimator ‘s needs. Estimators/surveyors do not have to learn all of the features contained within a given BIM tool. These tools typically include specific features that link directly to items and assemblies, annotate the model for “conditions”, and create visual takeoff diagrams. These tools offer varying levels of support for automated extraction and manual takeoff features. Estimators/surveyors will need to use a combination of both manual tools and automatic features to support the wide range of takeoff and condition check they need to perform [62]. Autodesk QTO (QTO 2010), Exactal CostX® Version 3.01 (Exactal 2009), Innovaya (Innovaya 2010), and Vico Takeoff Manager (Vico 2010) are efficient tools for this option[63]. These QTO tools not only export the data from BIM model to a readable format for cost estimating software but also map this data (BIM objects) with the cost database (Forgues, et al., 2012).

[60] Eastman et al., 2011, p.277.
[61] Eastman et al. 2011, p.280.
[62] Eastman et al., 2011, p.278.
[63] Forgues et al., 2012, p.780.

In their research, Wu et al., (2014) also show some BIM-based QTO methods. They also highlighted the main content of each method in terms of application conditions and the combination between them. These methods are “The automated takeoff”, “The derived takeoff”, and “The manual takeoff method”. If the model is built in accordance with takeoff requirement, the first approach is in use. This is the most efficient way for QTO by using full advantage of BIM[64]. The quantity information of the building elements is extracted automatically by using QTO tools or BIM authoring tool. The second approach, derived takeoff, is used if some elements do not present in the BIM model. And, these elements are required to be included in QTO as well as can be derived from other building elements. For example, the concrete formwork can be derived from a corresponding concrete element such as columns, or beams. The last method, manual takeoff, is used when the elements are not present in the BIM model. However, they are still the requirements for QTO and they cannot be derived from other elements. In this case, manual takeoff is a good way in combination with BIM-based QTO. (Wu, et al., 2014).

2.4.2 BIM process

The proposed QTO system is used for improving the reliability of estimation through decreasing risk factors and shortening the time required. (Choi, et al., 2015). In this subchapter, the author introduces some QTO and estimation processes which were suggested from other researchers in recently years.

Eastman et al., (2011), mentioned a QTO and estimation process of BIM method in contrast to the traditional paper-based (as shown in Figure 7 below). This process was recommended in case the estimator used a BIM QTO tool to perform this process[65].

In an analysis of this BIM-based estimating process, Wu et al. (2014) show that the intelligence of BIM in conceptual estimates is to allow all cost information to be linked to the model. And, this connection remains consistent with the design throughout the project phases and enables changes to be readily accommodated in quantities, measurements, and cost. As a result, the estimator/quantity surveyor can spend less time and effort to work on this process, and use these savings to attend to higher value project-specific factors.

[64] Wu et al.,2014, p39
[65] Eastman et al., 2011, p278

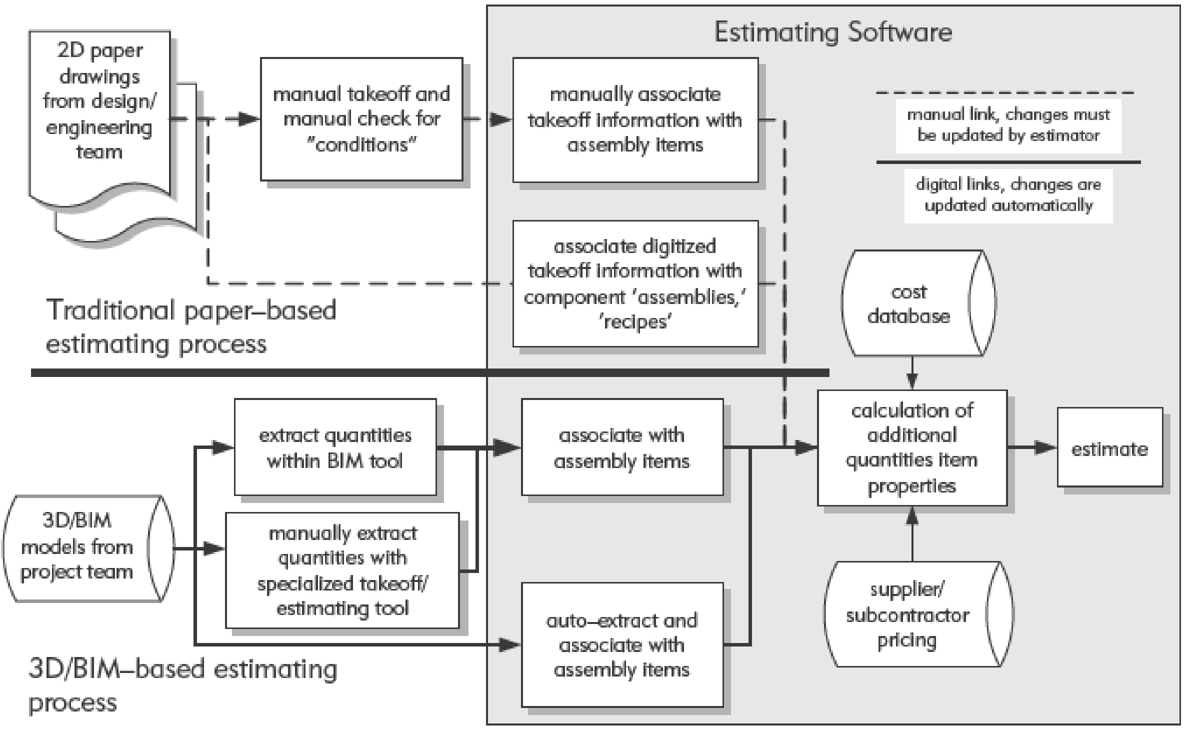

Figure 7: Conceptual diagram of a BIM quantity takeoff and estimating process [66]

In addition, Wu et al. (2014) noticed that the BIM model is commonly structured by designers to a hierarchical categorization of the elements. (Seen at Figure 8)

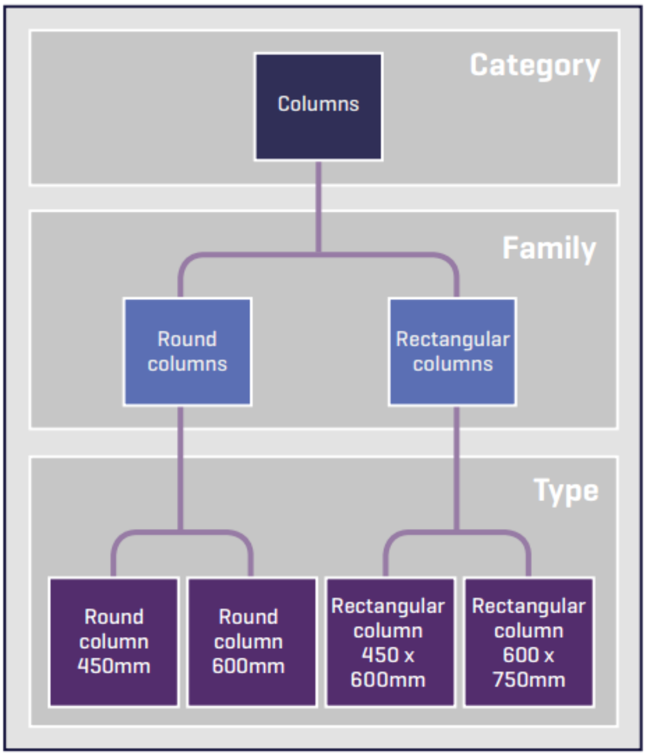

Figure 8: Hierarchical structure of BIM model in Revit Architecture[67]

[66] Eastman et al., 2011, p.279.
[67] Wu et al., 2014, p. 25.

However, from the cost estimating perspective, they suggested that BIM model should be structured based on building elements and its components (Seen at Figure 9). These components are known as the construction recipes and are classified into systems and trades in the construction point of view. As a result, the queries are enhanced and improved to the information during the entire quantification process.[68]

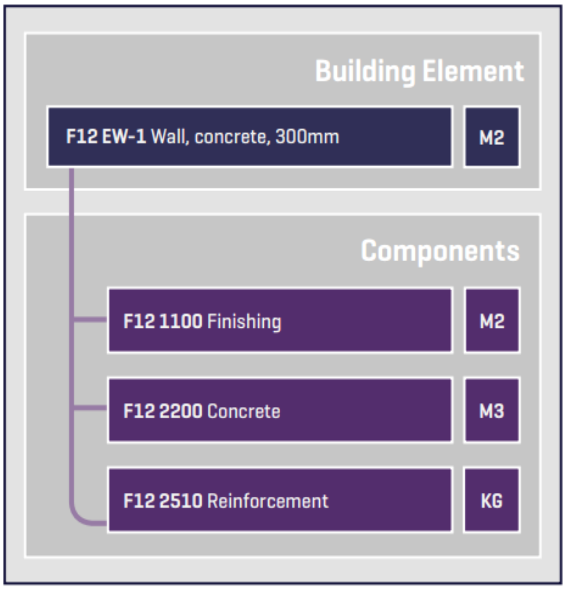

Figure 9: Classification of Building Elements and Components[69]

2.4.3 BIM workflow

The BIM workflow for QTO and estimation process depends upon the project type, the team, and the BIM tool in use[70]. And, the workflow was recommended following the cost estimation type for each design phase. (Choi, et al., 2015).

In the case study "Hillwood Commercial Project - BIM for conceptual cost estimating" of Eastman et al. (2011), a workflow was created as shown in Figure 10 below. It included: development and modeling of a design scenario using parametric building components and/or project templates; evaluation-based estimating using cost information associated with building components from a cost database, such as RSMeans, with insight from an experienced designer and project manager; and presentation and review of the estimated design option, involving the owner and the design-build team. This entire process can be performed for multiple design scenarios[71].

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[68] Wu et al., 2014, p.24.
[69] Wu et al., 2014, p. 25.
[70] Eastman et al., 2011, p.560.
[71] Eastman et al., 2011, p.560.

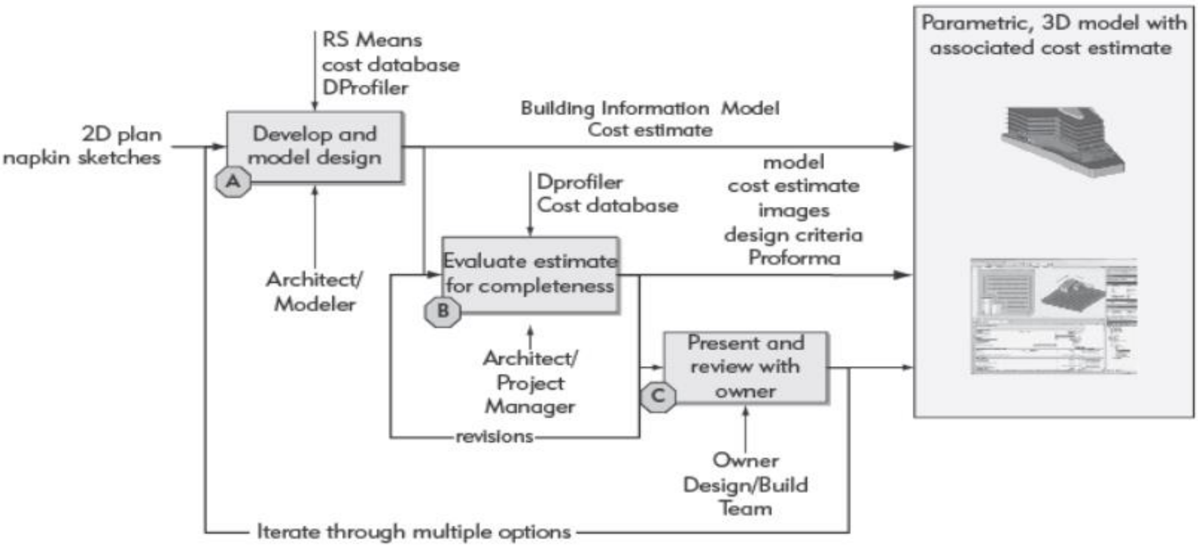

Figure 10: Conceptual estimating workflow using DProfiler[72]

In another case study “Sutter Medical Center, Castro Valley“ of Eastman et al. (2011), another recommendation for workflow in detailed estimation was conducted as shown in Figure 11 below. In order to build this process, many attempts were made to figure out the suitable component between BIM design and BIM estimating software as well as the collaboration between the design team and builders to make Model-Based estimating a close to reality[73].

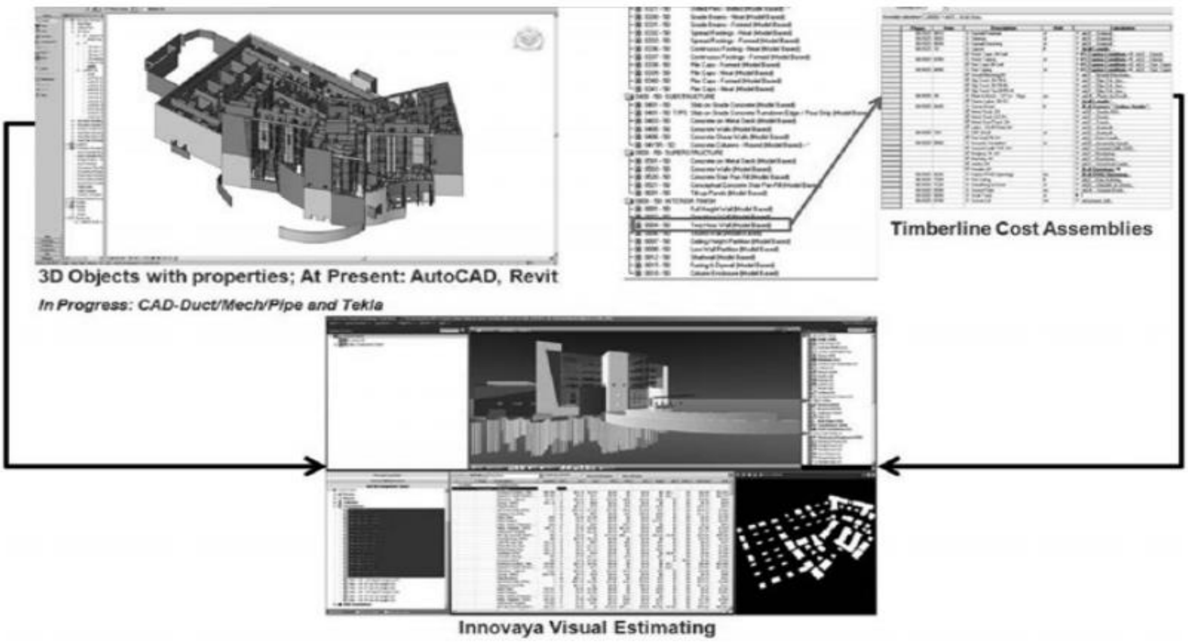

Figure 11: The process of model-based cost estimating using Innovaya to integrate AutoCAD or Revit model with the Timberline estimating system [74]

[72] Eastman et al., 2011, p.560.
[73] Eastman et al., 2011, p.466, p.467.
[74] Eastman et al., 2011, p.469.

In this case study, they found out a few interoperability problems in taking quantity data from the BIM models to the estimating tools. Adding to this challenge was the variety of cost databases such as Excel, Timberline, Quickbid, Accubid, and so forth, being used by different companies. Identifying one modeling tool and one estimating tool for the project was impractical given this variety. The solutions were to try and to test the combinations of software. Later on, the compatibility components to use in the project were figured out (Seen at Figure 12)[75].

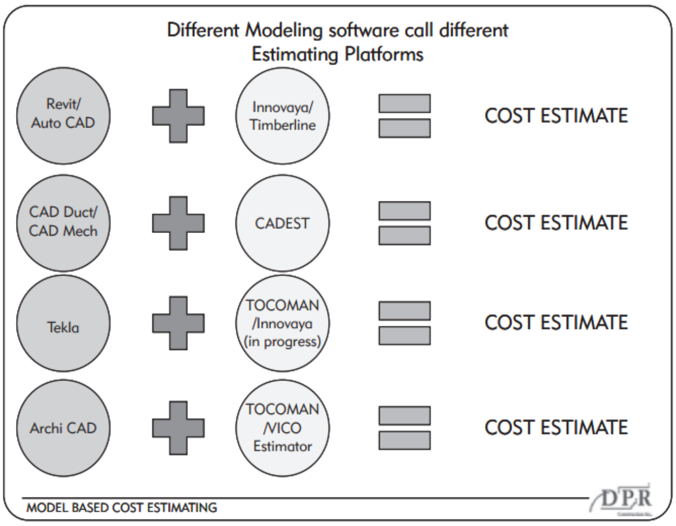

Figure 12: Compatibility of 3D BIM systems with cost estimating, systems as determined by DPR analysis at the start of the project[76]

At the end of testing, they found out that Innovaya Visual Estimating' was a quite suitable tool for their project in term of automatic quantity takeoff. Most of the needed quantities for estimation were extracted from the Revit model with the support of Innovaya tool, at 86%. They also determined the traditional quantity takeoff method was used for roughly 14 percent of performing work. (Eastman , et al., 2011). Furthermore, they also figured out the effective team for the model-based cost estimating process as follows:

Architects and structural engineers, who were developing the model

The self-perform work estimators, who have estimating knowledge and a cost database for their self-performed work.

[75] Eastman et al., 2011, p.466, p.467
[76] Eastman et al., 2011, p.466.

The virtual building group BIM engineers, who are experienced in both areas and know how to integrate the two. (Eastman , et al., 2011)[77]

In conclusion, from the above case studies, some learned lessons of building a BIM workflow for QTO and estimation process are highlighted below:

- Building a BIM workflow for QTO and estimation process based on each design phase.
- Defining the cost target requirements and the design features of projects.
- Defining the compatibility system between BIM design software and BIM based-cost estimating software.
- Defining whether the part of total quantity takeoff has to be taken by the manual method.
- Building a collaboration team from the early stage of the project. The recommended team for this process should include three professionals in their field: Architect, Estimator, and BIM engineer.

2.4.4 Model and its required information

In terms of quantity and information, if the model does not have all the needs of quantity surveyor/estimator, it will lead to difficulty in managing and searching required information in order to develop cost estimates. It is also a cause of the poor quality of cost estimation. (Eastman, et al., 2011 and Wu et al., 2014). However, requiring all information from the beginning of building 3D BIM model is not advisable. In the BIM project, a lot of information at the wrong time would end up in incorrect decision making and unrealistic project planning[78]. Therefore, it is important to understand which level of information should be the requirements for BIM model with respect to each type of estimation.

In the research of Wu et al. (2014), some recommendations for level of required information in the BIM model were conducted. These levels are for two stages of a project: Preparation (combination of preparation 1 - Appraisal, Design Brief and preparation 2 - Concept, Design Development, Technical design) and Pre-construction (Product Information). As they describe in their research's findings, the BIM model will be mature in correspondence to the phases of a project. At each stage, the level of required information of BIM model are detailed below.

[77] Eastman et al., 2011, p. 466, p.467, p.469.
[78] Wu et al., 2014, p.27.

2.4.4.1 Preparation stage 1

A conceptual BIM model requirement: It is called the model of 3D space objects. It means the model is in three dimensions spaces. It must include information level which can be used to calculate the floor area, external surface area, volume and perimeter and this information can be exported through the schedule[79].

Preliminary BIM model requirement: A preliminary BIM model is developed from a conceptual BIM model by converting the 3D space objects to the major building elements. In Autodesk Revit, the major building elements can be created from mass instances. Standard building element objects should be used to create the building elements. The following building elements should be included in the model:

- Ground floor (floor element)
- Upper floor (floor element)
- Internal and external wall (wall element)
- Windows (window element)
- Door (internal and external) (door element)

The material information and the type definition of the building element might not be included in this 3D BIM Model. But the space definition might be included in the model. In this stage, if the estimate is calculated by element method, the required information for the 3D BIM model is recommended as shown in Table 26: Information Requirement (Can be seen at Appendix A)[80]:

2.4.4.2 Preparation 2 and pre-construction

In this stage, Wu et al. (2014) pointed out that it is important to define agreement between the project team about all building elements which are modelled. They should be the same in agreement as well as document. All different building elements should be identifiable through the type of information from quantity takeoff point of view. The information type depends on the disciplines, different disciplines will lead to different types of information [81].

The measurement rules of the estimation in this stage require specific quantity information of each element. For example, windows can be taken off by count or by

[79] Wu et al., 2014, p.34.
[80] Wu et al., 2014, p.34. to p.36.
[81] Wu et al., 2014, p.39.

area, which both can be provided by the window element. Quantity takeoff typically uses the following quantity information.

- Count
- Length measure (Length, Perimeter, Height)
- Area measure (Net area, Gross area)
- Volume measure (Net volume, Gross volume, Weight)

In this research, the suggested solutions are to model each building element using the modelling tool for that specific building element. For example, modeling walls with the wall tool. The list of main building elements and quantity information available in the Autodesk Revit 2013 can be seen in Table 29: Building elements in Autodesk Revit 2013. (Can be seen at Appendix B)

The data exchange between the quantity takeoff tool and BIM tool has a major impact on the reliability of the quantity information. It is critical to ensure the quantity takeoff can be import the BIM model reliably. It needs to be emphasized that quantity takeoff is only the first step of completing a cost estimation. The quantity information from the BIM model requires organizing and grouping to match the NRM format of cost estimation. Most of the BIM takeoff tools are flexible enough to create new categories to meet any specific requirement, although it is a manual process. Table 30 "The information requirements for BIM element cost planning" of Wu et al. (2014) is a great example for how the BIM information is used to support the measure rules of the formal cost estimation[82]. (Can be seen at Appendix C)

2.4.5 BIM tools

In this subchapter, the author would like to introduce some common applications of BIM tools in the quantity takeoff and estimating process. There are a lot of designs as well as BIM cost-estimating software to support the QTO and estimation process. However, the ability of reading and displaying data from 3D BIM model are different for each software (Gołaszewska & Salamak, 2017)[83].

The purpose of this subject, therefore, is helping the reader, as well as the author, to understand in overall the functions of BIM tools which can support the estimation process. First, the author will introduce some design BIM software which have the BIM

[82] Wu et al., 2014, p.39.
[83] Gołaszewska and Salamak, 2017, p.73.

function to extract quantities from 3D model to the estimating software or can interface with other estimating software. And the author will then go deeper to the BIM base estimating software in the following aspects: Model information exchange; Model Visualization; Reliability of information production; Quantification process; Customization of built-in categories/classifications for standard estimating format; Report generation and export; Change management or revision control (Wu, et al., 2014)[84]. For the first group, some common software are introduced as Revit, Archicad. The second group are presented by Solibri Model Checker (SMC) ver.8; Autodesk Quantity Take-off (QTO) 2012; Exactal CostX Estimating Software ver 3.5.

2.4.5.1 Revit

According to Eastman et al. (2011), Revit is known as Revit Architecture, Revit Structure, and Revit MEP. it performs on Windows OS and on Macs, using the Windows BootCamp@plug-in and runs on 30-and 64 bit processors. Revit is known as the market leader for BIM in architectural design.

Revit has the ability to interface with other software for a different sector of a construction project. Revit can integrate with AutoCAD Civil for site analysis, with Autodesk Inventor for manufacturing components, and with LANDCADD for site planning. For QTO and estimation sector, it can link with many supporting cost software such as US cost, Cost OS, Innovaya, and Sage Timberline as well as Tocoman iLink.[85].

2.4.5.2 Archicad

ArchiCAD is the oldest continuously marketed BIM application for architectural design (Eastman , et al., 2011). Graphisoft, the parent company, began marketing ArchiCAD in the early 1980s. Headquartered is in Budapest, Hungary. Graphisoft was acquired in 2007 by Nemetschek, a German CAD company popular in Europe, with strong civil engineering applications. The current version of ArchiCAD is 22.0. ArchiCAD which supports the Mac platform in addition to Windows. ArchiCAD is a 32-bit application that runs on both 32- and 64-bit versions of the Windows or the Mac Snow Leopard OS.

ArchiCAD's home Web site provides tutorials for carrying out particular IFC exchanges, used in some of these interfaces. Other tools include Virtual Building Explorer 3D, a navigation tool. It also supports direct interfaces with several external tools, including

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[84] Wu et al., 2014, p.39.
[85] Eastman et al., 2011, p.79.

Google SketchUp import Tocoman iLink, and Express for quantity takeoff in terms of costing and scheduling.[86]

2.4.5.3 Exactal CostX Estimating Software ver 3.5

CostX was produced by an Australian. It was developed from software in 2004. It is a powerful estimating tool that promotes BIM based cost management (Wu, et al., 2014). Cost X enables to capture and extract of BIM information such as object properties, dimensions, descriptions and etc., all in single platform, including electronic measurements, spreadsheet calculation and estimation.

Model information exchange: This tool can integrate with Revit BIM through 3D DWF, DWFx, and IFC file format. It also can read the 2D drawing format such as PDF, DWG and the 2D imagines like JPEG, BMP, JPG. (Wu, et al., 2014)

Model Visualisation: CostX provides an excellent visualization of the BIM model with the drawing manipulation tool gives the ability to easily rotate, pan, zoom, spin and navigate around the model. It also can allows users to filter, highlight, hide or invert the layers in the model. (Wu, et al., 2014)

Quantification process: it is simple and does not require in-depth technical knowledge or CAD experience to operate. Cost X is capable for both automatic and manual take-off under the same working process by means of capturing dimensional properties from BIM objects and classifying them into dimension groups and folders. (Wu, et al., 2014)[87]

Reliability of information production: By using cost X, the quality and content of a BIM model can be validated and assessed quickly. The unmeasured objects or possible duplications can be defined quick and effective thanks to the capable of Cost X. Cost X has a visual on screen checking function which allows users to view all the items within the model by color codes and labels. Depending the type of errors on the tests results, users can then decide whether there is any need to create new dimension groups in order to remove the duplicated elements or dimensions. (Wu, et al., 2014)

Customization of built-in categories/classifications for standard estimating format: As other cost estimating BIM base software, Cost X use its standard BIM templates to categorize the object quantities and information into a typical elemental

[86] Eastman et al., 2011, p.82, p.83
[87] Wu et al., 2014, p.59.

breakdown. These classification is not fully compliant with the local standard. However, Cost X is strong to support the manual intervention capability. It is the critical feature in BIM estimating tools. In most cases, the standard information organization structure base on the application' built-in BIM template might not fully meet the users' requirement. With flexibility of performing manual modifications and customization, BIM components can be restructured to the right level of estimating detail. It means that the users can create their own dimension groups base on the their standard and indicate the measurement type for the objects they required to measure. (Wu, et al., 2014)[88]

Report generation and export: All results in measurement and quantity can export to excel file easily with Cost X. Beside that Cost X also support the report with the required format reports. Customization of report format and detail can be straightforward to suit users' needs. (Wu, et al., 2014)

Change management or revision control: Cost X allows users to add the new adjusted BIM model and control automatically the changes by the change management and revision control function. Cost X has the ability to make comparisons between two model design scenarios or versions. Using the color to mark the difference between two BIM model is the visualization function of Cost X to help users control and track the changes or differences within the models. Every design changes are saved into logs. This function offers users/ quantity surveyor to compare or analysis the changes of cost entire the project time. Cost X also allows the users can insert the drawing properties. For example, the drawing number, revision references. And the live link between models information and costing workbooks allows all changes to the BIM model to be captured and all related quantities or cost in the workbook to be updated automatically. (Wu, et al., 2014)[89]

2.4.5.4 Solibri Model Checker (SMC) ver.8

Solibri Model Checker (SMC) Ver. 8 SMC is not a BIM authoring tool. In the beginning, it is the model which is created by the architect/engineer to verify and determine the quality of BIM models by using the specific set of rules. This version first is introduced within the main function is rule checks to BIM models, including visualization and

[88] Wu et al., 2014, p.60.
[89] Wu et al, 2014, p.63.

presentations compilation. In version 8, it is introduced with new function is " information takeoff capabilities". (Wu, et al., 2014)[90]

Model Information Exchange: SMC only supports BIM models in IFC and DWG formats. Therefore the design BIM tools software need to change BIM model into IFC or DWG formats before to read in SMC. The IFC format is found out that it is better to format using in SMC because it allows conversion and merging of most information from BIM model into one single format rather than having it all split up into different DWG files and models to be saved in the native SMC format, providing smaller file sizes compared to the original Revit and IFC versions without losing its information or data. (Wu, et al., 2014)

Model Visualization: This function of the estimating tool is similar to the BIM authoring tools. it allows users to stake the views from different windows under on task pane. The users also have the flexibility to decide which views to add into the window as well as the navigation and explore around the modes. it automatically zooms up to the selected objects in the model when any component is chosen the model tree. Highlighting capability helps users to filter and detect the problems within the model easily based on the error results compiled from the checks. Users can then capture the view and save it into slides in Presentation to coordinate the problems with the designers. In the information take-off process, visualization and highlights functionality enable users to clearly identify the right components to take-off and determine the correct classification for each component. (Wu, et al., 2014)[91]

Quantification Process: SMC Information Take off depends upon the use of classifications and definitions to decide the type of information to be extracted from the model and to create structures and organization to the data within the BIM model prior to quantity take-off process. SMC supports the flexibility of making modifications or changes to its standard built-in classifications to suit the user's requirements so that the components can be restructured to the desired category and information extracted will be more accurate. Upon defining the classifications, users can also decide on either to take-off the whole model or only specific components that were chosen and added

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[90] Wu et al, 2014, p.50.
[91] Wu et al, 2014, p.50.

to the selection basket. The take-off process will then automatically begin and users will be able to see the results in seconds. (Wu, et al., 2014)[92]

Reliability of Information Production: It is the effective application to help quantity surveyor/ Estimators check before the quantification process and they are able to run quick checks to see if there is any missing components or information in the BIM model as well as discrepancies in the design by using Quantity takeoff rule set. They also can transfer the results to the designers to request for changes to the design. With this functionality, quantity surveyors can ensure that the quantity of information to be produced will be more reliable and accurate. (Wu, et al., 2014)[93]

Customization of built-in categories/ classifications for standard estimating format: MSC includes a series of classification rules and take-off definitions which users can utilize to generate standard estimating format quickly. It helps to give users the overview of the quantity and understand what information is held within the model. The original classification system predefined is in accordance with Uniform classification- a common framework used in the United States. SMC allows data to be appended to the BIM models. In general, SMC does not support additional input from users to the BIM model which would change the design of the model, the original value, and properties of the elements. SMC enables users to perform manual input, but only in the aspects of manually creating new classifications or new taking off definitions. (Wu, et al., 2014)[94]

Change management/revision control SMC generally does not support automatic updates of BIM models as there are no bidirectional links between the BIM software and external application. However, if the revised BIM model is manually loaded into the application in IFC format, SMC has the features of enabling automatic identification and locating of any alterations made to the model while retaining unchanged information within the model. With this capability, it provides users with the benefits of comparing the older model with the new one, to clearly identify the differences which affect the quantity and cost of certain components from the QS perspective. (Wu, et al., 2014)

Report generation and export capabilities SMC enables export of taking off results into Excel files with the choice of standard templates available in the system, e.g. area

[92] Wu et al., 2014, p.51.
[93] Wu et al., 2014, p.52.
[94] Wu et al., 2014, p.52.

calculations, building elemental quantities etc. to match with the results. In Excel, users can then modify the layout of the report generated, e.g. add in rows to create the level structures for NRM format, add in columns to input rates and prices to generate cost estimates. (Wu, et al., 2014)[95]

2.4.5.5 Autodesk Quantity Take-off (QTO)2012

Autodesk QTO is developed and released in 2007. The provider of this software is the same one to the Revit. This Autodesk software can both take quantity takeoff information from 3D BIM model as well as traditional 2D drawings. With the simple interfaces, this application enables users to easily understand and familiarize themselves with the tool to perform required taking off and cost estimates. (Wu, et al., 2014)[96]

Model Information Exchange: This application can accept the variety of file formats from both 2D drawing or 3D model format. However, the original Revit file is not directly supported. Autodesk QTO being capable of coordinating both 2D and 3D information is known to have seamlessly brought designs and information together into a single environment. (Wu, et al., 2014)

Model Visualization: The visualization capability in Autodesk QTO mainly involves the basic model navigation features such as pan, select, zoom and rotate. These features enable users to easily explore and identify their required viewing position and location around the BIM model. Similar to other estimating tools. Autodesk QTO supports adjustments of objects visibility and transparency based on building elements to allow precise inspection of the BIM model and increase the accuracy of quantity take-off process. It also automatically highlights the object using different color coding whenever a particular element is selected. This is useful to help users in examining the object properties and scope for measurement. (Wu, et al., 2014)[97]

Quantification Process: Quantification Process Autodesk QTO supports automatic measurement of the entire BIM model. However, it is not a fully automated process on the first time of using the take-off tool in this software, Autodesk QTO does not have the ability to automatically define the types of measurement or assign the objects to the required assembly to extract the correct quantity and create a valid take-off

[95] Wu et al., 2014, p.53
[96] Wu et al., 2014, p.54.
[97] Wu et al., 2014, p.54.

Therefore, users are required to manually assign the objects to items and later adjust the measurement methods for each object element. Once completing this process for the first time, the automated quantity take-off process will run effectively under Autodesk QTO as it has the capability of remembering past element assignments and allow the similar definition to be predictively applied in subsequent BIM projects. (Wu, et al., 2014)[98]

Reliability of information production: This application runs simply as the cost estimating software and does not contain any checking function that helps to assess and check the quality of information within the BIM model. it is not able to detect any duplications or missing quantities in the model. Therefore before starting to do the quantity takeoff, there is a need to check the quality of Model by other software to make sure the accurate results for quantity takeoff process later on. (Wu, et al., 2014)

Customization of built-in categories/ classifications for standard estimating format: Autodesk QTO has the standard classification format which is base on The US construction industry standards such as Masterformat and Uniformat. The users can select the catalogs at the initial project set up in the application. The catalogs define the organizational structure or parameters for grouping the dimensions extracted from BIM projects and also contain the associated rates for costing purposes. However, this catalogs usually do not incorporate to meet the correct standard and users requirement. There are two options in order to use this function. The users can adopt this adopt these structure as a typical format and make modifications and customization. The other option is the users can choose not to incorporate any built-in format for taking off process. Autodesk QTO will then extract quantities from BIM model and places them into groups within the take-off view based on categories in the model tree breakdown. Users are given the flexibility to make adjustments including renaming the group and descriptions, adding in new coding system and structure to map the BIM content and take-off information into the correct groups and level of detail. (Wu, et al., 2014)[99]

Report generation and export: It allows the users to extract measurements or cost results into another file format like excel, word, pdf and etc. Users are given the flexibility to customize the type, style, content, layout, and presentation of the reports using the standard built-in reporting tool. Users can also opt to publish the quantities into BIM

[98] Wu et al., 2014, p.56.
[99] Wu et al., 2014, p.56.

models through common DWF files format. which can be easily accessed using viewer tools. The capability to link cost information into the design supports 5D data integration within a single BIM model and encourages better collaboration when the model is distributed and shared among construction professionals. (Wu, et al., 2014)[100]

Change management or revision control: It allows all quantity information to be cross-referenced and mapped to the specific BIM objects. it means this application enables fast and efficient change management processes. Although Autodesk Qr0 comes with the compare feature within its application, it is not applicable for 3D DWF models but only for the comparison of 2D drawings This enables 2D drawings generated from the 3D BIM model to be compared against another drawing or previous revisions to assist users in visualizing the extent of changes before deciding whether to modify the original quantities. The 2D comparison is useful but it can be problematic when the changes are too extensive. However, Autodesk QTO including selecting BIM objects for take-off, performing manual measurements of drawing geometry and inputting cost information, e.g. material, labor and resources against each item. Given this freedom, it helps to improve the accuracy of quantity information and cost estimates. (Wu, et al., 2014)[101]

2.5 Limitation factors of BIM adoption

Obviously, BIM has a wide range of advantages, however, “Why BIM is not happening as it should be” (Dalmeijer, 2017). This article motivated the author to find out about the limiting factors of adopting BIM in the design companies in general and in QTO and estimation process in particular. According to Reizgevičius et el. (2015), there are three types of barriers: legal, technical and commercial issue which can be seen during BIM implementation[102]. In the research of McGrawHill (2010), these barriers were also analyzed from non-BIM user viewpoit. The purpose of this action was to find out the BIM attitudes among Non-BIM Users and to forecast the future of BIM usage. Receiving views from these researches, these obstacles are divided based on the point of view of two groups: Non-BIM user, and BIM user in international and Vietnam environment. Therefore, the most common reasons for limitation of BIM usage in each specific area are collected. Besides, BIM attitudes were approached closely as well.

[100] Wu et al, 2014, p.57.
[101] Wu et al., 2014, p.57.
[102] Reizgevičius et al., 2015, p.47.

Thus will help to gain the clear view on the obstacles and barriers toward BIM adoption and the suitable solutions can be proposed to overcome them later on.

2.5.1 Limitation factors of Non-BIM user group

In the part of survey about BIM attitudes among the non-BIM users, McGrawHill Construction (2010) found out that the common reason for no usage or hesitating to apply BIM is lack of client's demand[103]. In this report, 55 percent of people in the survey has given this reason. Respondents also believed that their clients are not using BIM. This answer came from 87% of total respondents. In addition, the afraid of changes is a big obstacle as well[104]. It seems the traditional method has been used for long and investing time and money into a new procedure what has not tested and proven is always risky (Olsen and Taylor, 2017). In a research of Reizgevičius et al. (2015), risk is described as the issues of technology, the time and the expense of initial investment. Therefore, users tend to wait and see if the new method is brought the commercial value out or not, they will make the decision later on[105]. Finally, the most common reasons, which were mentioned in many researches, are the time needed to train staff, the cost to update hardware and to buy BIM software (McGrawHill Construction (2010) and Arayici et al. (2011)). As the findings of research of McGrawHill Construction (2010), in UK, Germany and France, more than half amount of people pointed out the reasons for hesitating to adopt BIM are the cost to implement BIM and to purchase BIM software[106]. In other research of Arayici et al. (2011) in UK, time needed to train employees, cost to upgrade hardware, cost of software also mentioned as a certain additional cost and challenges for deploying BIM[107].

In addition, there were some beliefs that lead to negative perception of BIM's future such as BIM will have low or no importance, less efficient on smaller projects, no immediate competitive threat resulting from non-BIM user[108]. According to a research on design firm, some conceptions were also listed[109]:

- No possibility to carry out the project without the 2D CAD drawings;

[103] McGrawHill Construction, 2010, p.13.
[104] Olsen and Taylor, 2017, p.2.
[105] Reizgevičius et el., 2015, p.48.
[106] McGrawHill Construction, 2010, p.13.
[107] Arayici et al, 2011, p.3.
[108] McGrawHill Construction, 2010, p.13.
[109] Reizgevičius et el., 2015, p.46.

- Chosen designer for a project are by lowest tender prices, thus it is not valued to invest time or quality on designer's work with uncertain return;
- Company is just doing small project, therefore low chance for occurring errors in different stage of project.

Besides, lack of internal understanding of BIM[110], the resistance to change[111], are another reasons for slowdown in adopting BIM process.

For non-BIM user group in Vietnam, one research recently revealed the lack of appropriate legal framework such as BIM standard, BIM guides (Nguyen, et al., 2015)[112] is one main roadblock for non-BIM user group to think about the BIM usage. Although they understand the advantages that BIM can bring to them, they still want to wait until certain regulations are established that can ensure their own investment on BIM. In another article of Tran et al. (2014) also indicated the lack of legal framework, BIM expertise, and BIM experience, as well as lack of BIM training program in school or university, are the huge boundaries for deploying BIM in Vietnam[113].

In a research with topic "the roadmap of BIM in Vietnam" of Nguyen et al. (2015), all quantity surveyor engaged in the survey agree that besides the common reasons to limit the BIM usage, the biggest barrier is the habit of using Standard Construction Codes in QTO and estimation process and this code does not coincide the definition of components in BIM software[114].

The last is concerns of BIM technology will replace quantity surveyors and estimators, no needs of their roles in futures. According to (Wu, et al., 2014)[115], some quantity surveyors felt threatened and considered BIM as a major challenge. They were wary of BIM's capability to perform automated number-crunching tasks. And as the sequence, self-preservation is as one of the potential reasons behind the slow adaption to BIM in quantity surveying practice.

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[110] McGrawHill Construction, 2010, p.13.
[111] Arayici et al., 2011, p.2.
[112] Nguyen et el., 2015, p.54.
[113] Tran et el., 2014, p.5.
[114] Nguyen et el., 2015, p.48.
[115] Wu et al., 2014, p.21.

2.5.2 Limitation factors of BIM user group

The users, who use BIM tools in design or in QTO and estimation process, have their own reasons for just adopting BIM in some certain functions or adopting it and then giving it up.

According to Reizgevičius et al. (2015), the initial challenges during applying BIM on an organization are the dilemma of choosing and installing software. In addition, the addressing IT issues and training up and rolling out are notable issues as well. The design company seems struggle with comparing BIM program software. The common question from them is which software will meet the requirements in terms of the quality and budget.

Software complexity is another obstacle to using BIM for QTO process [116]. In the interview of Olsen and Taylor (2017) for their research, the result showed that this reason was one of two big obstacles of BIM-based QTO. Hartmann and Fischer (2008) summarizes this disadvantage from the viewpoints of general contractors as well. They had to face with this difficulty when BIM was used in their works[117]. Another disadvantage which were noticed in the research of Gołaszewska and Salamak (2017) is the amount of time to build the BIM models from the beginning. The model's design has the gaps and just can likely start to fill as modeling gets more detailed. According to interview analysis, half of needed data such as jobsite overhead, safety equipment, temporary structures, wood blocking, chair rails, countertops, finishes, concrete formwork, temporary fencing, specialties, fire protection, site work, and structural connections, miscellaneous metals, rebar missing from model if estimators/quantity surveyors want to take off quantities for detailed estimation[118]. Olsen and Taylor (2017) also described an addition issue is the simplification of model. It leads to generate directly the defects in QTO as a missing dimension or incorrect amount of elements.[119]

Research of Morgan (2006) not only shows the barrier in estimation process but also shows the disadvantages of using software itself. In his experimented BIM group (a group of people uses Revit software as a BIM tool to do takeoff), almost comments were about the learning curve, trust in the designer and availability[120]. Both groups (BIM user and non-BIM user) had similar difficulties to deal with during QTO process

[116] Olsen and Taylor, 2017, p.1005.
[117] Hartmann & Fischer, 2008, p.5.
[118] Gołaszewska and Salamak, 2017, p.8.
[119] Olsen and Taylor, 2017, p.1004.
[120] Alder and Morgan, 2006, p.44

such as the incorrect drawings, time to learn how to use the software, defining the mistakes, tracking the actual takeoff. (Morgan, 2006)

2.5.3 Summary of limitation factors

Non-BIM user group :

1. Lack of client demand
2. Using the traditional methods for long and it is risky to invest in something new, which was not tested and proven.
3. Time needed to train staff is long, cost to update hardware and buy BIM software are expensive.
4. Belief that BIM is low or no importance in future
5. Belief that BIM is less efficient on smaller projects
6. Belief that no immediate competitive threat resulting from BIM non-user.
7. Belief that no possible to carry out the project without the 2D CAD drawings;
8. Think that chosen designer for a project are by lowest tender prices, thus it is not valued to invest time or quality on designer's work with uncertain return;
9. Company is just doing small project, therefore low chance for occurring errors in different stage of project.
10. Lack of internal understanding of BIM
11. The resistance to change
12. Lack of appropriate legal framework
13. Lack of BIM expertise
14. Lack of BIM training program in school/ university
15. Concerns of BIM technology will replace quantity surveyors and estimators, no needs of their roles in futures.

BIM user group:

1. Choosing the software (BIM tools)
2. Software complexity
3. The big amount of time and effort to build the BIM models from the beginning
4. The company use BIM tools to do its certain functions such as building 3D models, no need to use it for QTO and estimation
5. The missing data for QTO and estimation from model
6. Time to learn how to use the BIM tool to do QTO is long

7. Defining the mistakes of calculation process
8. Tracking the actual QTO
9. Trust in the designer (Model is not corrects)
10. Lack of understanding workflow with BIM base QTO and estimation process
11. The habit of using Standard Construction Codes in QTO and estimation process and Standard and this Standard Construction Codes cannot integrate with BIM software
12. Difficulty in approving QTO and estimation from the checking parties if QTO and estimation are created by BIM tools
13. Lack of resources both software and hardware regarding use of BIM tools.
14. Lack of context for construction methods and procedures, these material quantities cannot be used directly to generate labor and equipment quantities
15. Concerns of BIM technology will replace quantity surveyors and estimators, no needs of their roles in futures.

2.6 Considering factors

According to Eastman et al. (2011), the considerations in adoption of BIM for the design company are the considerations in BIM justification, training, deployment, and phased utilization. In the considerations of BIM justification, Eastman et al. (2011) suggested that the service fee can be added more to the company's fee structure by offering new services. They pointed out BIM can offer company more potential benefits. Those benefits that companies cannot achieve or really difficult to achieve if they do the project based on the traditional method[121]. For example, automatically consistent drawings; easy identification and removal of 3D spatial conflicts; automatic and potentially accurate preparation of bills-of-material; improved support for analysis, cost, and scheduling applications. Therefore, the boarded services which companies can consider are as following:

Concept design development, applying performance-based design using analysis applications and simulation tools to address:

Sustainability and energy efficiency;

Cost and value assessment during design;

[121] Eastman et al., 2011, p.254.

Programmatic assessment using simulation of operations, such as in healthcare facilities.

Integrating design with construction, related to project delivery contractual form:

Improved collaboration with the project team: structural, mechanical, electrical engineers, steel, MEP, precast and curtain wall fabricators. BIM use among a project team improves design review feedback, reduces errors, lowers contingency issues, and leads to faster construction.

Expedited construction, facilitating offsite fabrication of assemblies, reducing field work, and increasing safety.

Automation in procurement, fabrication, and assembly and early procurement of long lead-time items.[122]

For training and deployment consideration, Eastman et al. (2011) also suggested that the company should have an execution plan for making a change to BIM. The more detailed plan, the chance to succeed with BIM is higher. They also recommended that this plan should be related to a company's strategic goals. This connect make a strong foundation for successful adoption of BIM in an organization. On the other hand, BIM is a new IT environment. It, therefore, requires training, system configuration, library, and document template setup as well as adaptation of design review and approval procedures. Those requirements are along with new business practices, and they are side by side with existing production methods. Thus, Eastman et al. (2011) had some advice about BIM training to help an organization easier to approach BIM adoption. The training should start with one or a small number of IT specialists such as system configurations and then introduce a training program for the rest of the company. About deployment consideration, Eastman et al. (2011) noticed that too much details in early stage of project lead to misinterpreted for a design concept. Detailed models are easy to realize while still in the conceptual design phase. However, it may lead to errors and client misunderstanding because of the inadvertently making overreaching decisions that become hard to reverse.[123]

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[122] Eastman et al., 2011, p.254.
[123] Eastman et al., 2011, p.256, p.257.

With the considerations in the phased utilization, Eastman et al. (2011) focused on some other services that can be undertaken by the company (except the new services which introduced earlier on BIM justification). Among these are below:

Integration with cost estimation to allow continuous tracking throughout project development

Integration with specifications for better information management

Design level integration with performance analyses, for energy, air flows, lighting, to address issues only considered intuitively up to now

Development of proprietary company libraries of detailing, room configurations, and other design information to facilitate the transfer of specialized staff knowledge to corporate knowledge

In addition, each type of integration is tied to its own planning and development of workflow and methods. Therefore, a step-by-step approach is a good way to incremental training and adoption of advanced services without undue risks.[124].

Besides those considerations for an organization, the considerations of successful BIM for a project also were presented at many studies. Won and Lee (2010) examined these deliberations in following sectors: critical success factors in BIM adoption, criteria for selecting BIM software, criteria for determining BIM pilot projects and factors for prioritizing BIM functions. In order to do it, they did evaluate factors by using the survey of 61 international BIM experts. In the questionnaire, Won and Lee (2010) used the likert scale to collect the responses to give each factor a value from one to seven (one being not important and seven being highly important).

In the first sector, critical success factors in BIM adoption, nineteen factors were presented and tested. Those factors can be seen at Table 3: Critical success factors in BIM adoption[125]. The results of this sector were presented that information sharing (5.82), a master BIM model team/manager (5.8), and the leadership of the senior management (5.8) were the most important factors.

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[124] Eastman et al., 2011, p.257, p.258.
[125] Won and Lee, 2010, p.2, p.3

No	Factors	Avg.	SD
1	Willingness to share information between project participants	5.82	1.45
2	Master BIM model team/manager	5.80	1.37
3	Leadership of senior management	5.80	1.52
4	Organizational structure to support BIM	5.79	0.74
5	Effective collaboration between project participants	5.64	1.30
6	Continuous investment	5.62	1.52
7	BIM training programs	5.41	1.34
8	Information sharing protocols	5.38	1.52
9	Technical support for interoperability issues	5.20	1.50
10	Standardized work procedures for BIM	5.13	1.70
11	Clients' satisfaction with BIM projects	4.98	1.54
12	Clients' interest/request for BIM	4.77	1.44
13	Shared liability between project participants	4.69	1.23
14	Number of BIM software experts in a company	4.69	1.65
15	Collaboration (project) management tools	4.62	1.74
16	Metrics for quantitatively evaluating the effectiveness of BIM projects	4.62	1.59
17	Abundant BIM libraries	4.62	1.67
18	Number of subcontractors/partners who have experienced BIM projects	4.49	1.20
19	Incentive programs for using BIM	4.20	1.50
	Average	**5.12**	

Table 3: Critical success factors in BIM Adoption[126]

In the second sector, criteria for selecting BIM software, 14 factors were chosen and evaluated. Those factors can be seen at Table 4 below.

No	Factors	Ave.	SD
1	How well a software application currently supports a function of interest	5.48	1.21
2	Are there known successful BIM cases for the software application?	5.46	1.32
3	How interoperable a software application is with other applications	5.35	1.63
4	Expected economic impact (return on investment)	5.25	1.44
5	The scalability of the software (how large of a building can a software handle?)	5.13	1.47
6	Are major subcontractors or business partners currently using the software?	5.10	1.49
7	Easiness to model and add new libraries	5.06	1.35
8	How well do current employees use the software application?	5.00	1.44
9	Is the use of the software application required by contract?	5.00	1.64
10	Learning curve to use the new BIM tool	4.94	1.42
11	Is the software application already in use in several departments?	4.81	1.37
12	Initial investment costs, including hardware, software, and training	4.67	1.38
13	The possibility of obtaining a targeted function in the near future in association with a software vendor's long-term strategy	4.65	1.47
14	How good content libraries are	4.40	1.43
	Average	**5.02**	

Table 4: Results of the questionnaire for selection the optimal BIM software[127]

[126] Won and Lee, 2010, p.3.
[127] Won and Lee, 2010, p.4

The most important factor was "how well the relevant software currently supported the function of interest" (5.48), followed by the factors: "Are there known successful BIM case for the software application?" (5.46) and "How interoperable a software application is with other applications" (5.35).

The purpose of the third sector was to identify which factors are important in determining the adoption priority of BIM functions. Ten factors are identified and investigated, which are shown in Table 5: Results of the questionnaire regarding the criteria for prioritizing BIM functions. The results of investigation show that the most important factor in this sector was "the expected economic impact of adopting the BIM function" (5.58) and besides are these factors: "Is the function required by a company's business strategy?" (5.54), "Is the function required by a client or a specific project?" (5.35).

No	Factors	Ave.	SD
1	Expected economic impact of adopting the BIM function	5.58	1.36
2	Is the function required by a company's business strategy?	5.54	1.15
3	Is the function required by a client or a specific project?	5.35	1.33
4	How well the current BIM technologies can support the area/function of interest	5.27	1.24
5	How well the current employees can use the BIM function	5.06	1.27
6	Can the function be adopted without conflict with a traditional work processes?	4.88	1.57
7	Learning curve (required time to adopt the function)	4.98	1.48
8	Can subcontracts support the function? (collaboration issue)	4.71	1.38
9	How soon the area/function of interest can be supported in association with a software vendor's long-term strategy	4.65	1.44
10	Initial investment costs, including hardware, software, and training	4.50	1.38
	Average	**5.05**	

Table 5: Results of the questionnaire regarding the criteria for prioritizing BIM functions [128]

The last sector is the criteria for determining BIM pilot projects. This explained which factors were essential for selecting BIM pilot projects. Thirteen factors were created through the discussion with two experts in this field. The results were found out for the project manager's interest and willingness in adoption BIM (6.13), whether the clients requested BIM (5.56), and complexity of a project (5.44). The factors and results can be seen at Table 6.[129]

[128] Won and Lee, 2010, p.4
[129] Won and Lee, 2010, p.2, p.5

No	Factors	Ave.	SD
1	Project manager's interest and willingness in adopting BIM	6.13	1.10
2	Request from a client to use BIM	5.56	1.46
3	Complexity of a project (in terms of a building shape or building systems)	5.44	1.70
4	Field engineers' interest and willingness in adopting BIM	5.37	1.47
5	Subcontractors' interest and willingness in adopting BIM	4.77	1.77
6	Architectural firm's use of BIM	5.02	1.77
7	Availability of information on similar projects, which can be compared to the results of a selected pilot project	4.81	1.63
8	Subcontractors' capability to use the BIM tools	4.48	1.60
9	Use of a building (e.g., office, hospital, factory, residential, etc.)	4.54	1.73
10	Types of project delivery system (e.g., design-build, design-bid-build)	4.60	1.76
11	The physical size (floor area) of a project	4.15	1.73
12	The total construction cost of a project	4.15	1.79
13	Location of a site (e.g., overseas projects, domestic projects)	3.38	1.83
	Average	**4.80**	

Table 6: Results of the questionnaire regarding BIM pilot projects[130]

2.7 BIM offers

Eastman et al. (2011) in the book" BIM Handbook" show that the engineering values which generate from BIM adoption will bring to potential benefits for an organization. Meanwhile, Dodge Data & Analytics (2015) assessed that the business benefits are the key factors that will govern a new technology or process to become widely accepted and standardized. In this subchapter, therefore, will be discussed the BIM offers to an organization in terms of the engineering values and business values.

From an engineering value perspective, besides the benefits which were presented at subchapter 2.3.2. Benefits, the advantages of BIM adoption will be described deeper on those are generated directly from the BIM model and those are gained from BIM adoption on a project.

Eastman et al. (2011), in their book "BIM Handbook", mentioned that the greatest advantage of BIM model is to allow designer to accurately visualize their project at any stage. The 3D model is designed directly instead of generating from 2D drawings. By this way, the BIM model displays the dimensions of any objective at the same time. Eastman et al. (2011) also mentioned another significant benefit is the automatic low–level corrections if the changes happen thanks to parametric rules of BIM model. The other notable advantage is the improvement of energy efficiency and sustainability for the building. By using the function" connecting the model to energy analysis tool" of BIM

[130] Won and Lee, 2010, p.5.

model, the efficiency and sustainability aspect are reviewed and applied on a project from the early design phase. Thus reducing the opportunities for modifications in later project stages that could improve the building's energy performance. The last and important benefit has to be mentioned in terms of the engineering value is the verifying the consistency to the design intent. In the projects especially in technical buildings such as labs, hospitals, and the like, the design intent is often defined quantitatively, and this allows a building model to be used to check for these requirements. For qualitative requirements, the 3D model also can support automatic evaluations.[131]

In terms of project benefits, according to McGrawHill Construction (2010), the benefits which generated from applying BIM on project, can be seen as the 7 following aspects (Seen at Figure 13):

- Improved collective understanding of design intent;
- Improved overall project quality;
- Reduced conflicts during construction;
- Reduced changes during construction;
- Fast Client Approval Cycles;
- Better cost control/predictability;
- Reduced number of RFIs (Requests for Information).

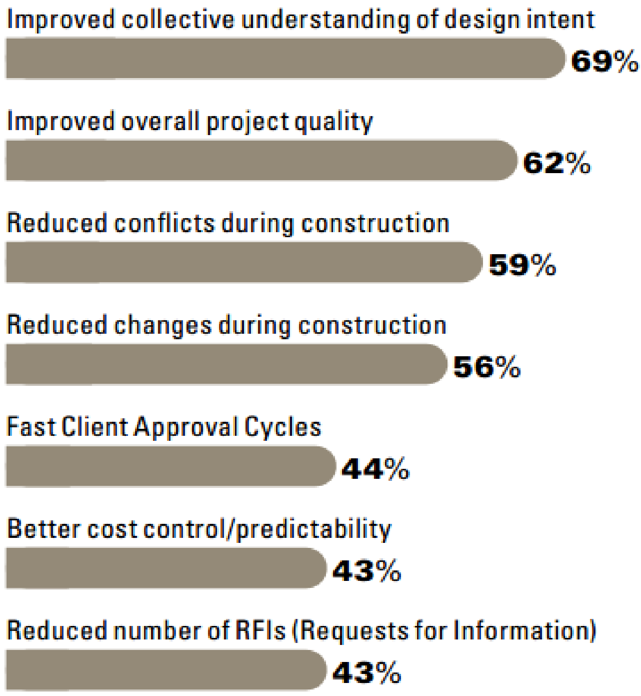

Figure 13: BIM Benefits Contributing the Most Value[132]

Dodge Data & Analytics (2015) also mentioned the aspects of BIM adoption on a project in the Chinese market as following factors[133].

- Better design solutions;
- Reduced errors and omissions in construction documents;

[131] Eastman et al., 2011, p.21, p.22, p.23.
[132] McGrawHill Construction, 2010, p.6.
[133] Dodge Data and Analytics, 2015, p.20.

- More client involvement and improved understanding;
- Reduced number of field coordination problems;
- Reduced rework;
- Better collaboration with other project team organizations;
- Reduced number and need for contractor; information requests to architect;
- Reduced construction cost;
- Better cost control/Predictability
- Improved safety;
- Reduced overall project duration

Dodge Data & Analytics (2015) also analyzed these factors in the two types of companies: architect and contractor. Contractors and architects were asked to rate the degree to which each of eleven BIM benefits was improving their projects on a scale of one (no benefit) to five (very high benefit). Figure 14 are shown the result of survey.

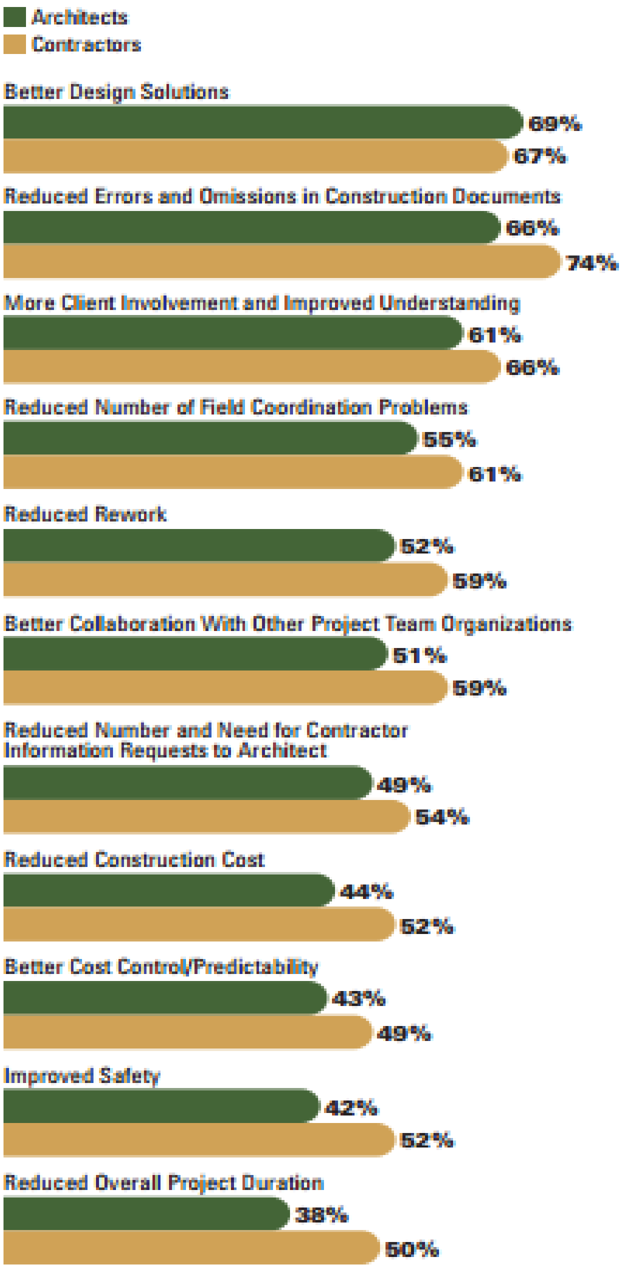

Figure 14: Project Benefits Generated by BIM (By Percentage of Chinese Respondents Receiving Benefit at High/Very High Level)[134]

From a business value perspective, the business value can be approached from the respective of the internal benefits of BIM adoption. The concepts of internal benefits could be understood as Internal benefits that accrue directly to the company deploying BIM (Dodge Data & Analytics, 2015).

In terms of Internal benefits, a research of McGrawHill Construction (2010), they used ROI (Return On Investment) as the KPI (Key Performance Indicator) to measure the

[134] Dodge Data and Analytics, 2015, p.20

success of BIM investment. According to Dodge Data & Analytics (2015), there was no single globally accepted method to calculate the return on investment (ROI) of BIM adoption. However, most users had a perception of the degree to which they are receiving values from their investment are the value of the time, money and effort [135]. Along with this method, the ROI is divided into three categories:

- Negative: The value they have received so far is less than the investments they have made.
- Break-Even: The value they have received is approximately equivalent to the investments they have made.
- Positive: They feel they are receiving greater value than the investments they have made[136]

According to report "the business value of BIM in Europe" of McGrawHill Construction (2010), the data revealed that three-quarters of Western Europe, equal 74% of BIM user, had a positive ROI report. It was a positive perceived return on their overall investment in BIM. This number of North America was at 64%. They also analyzed data from architects, engineer and constructor. The results showed that architects in both markets reported the greatest ROI, engineer and constructor also had positive report of ROI. The positive results of engineer in Western Europe was at 70% and at 46% in North America. Meanwhile nearly three-quarters of contractors report positive ROI versus Western Europe, where only 40% cite ROI above break-even. This report also pointed that, in both markets, the higher ROI is linked directly to the BIM users' experience level[137].

In other report of Dodge Data & Analytics (2015), in Chinese market, the perceived ROI for BIM was overall positive result. There was only 15% of architects and 14% of contractors report a negative on ROI in Chinese market. (Seen at Figure 15)[138]. Another finding was the payoff of ROI related to the BIM implementation level as well. Company adopted BIM on more projects, the greater ROI they can achieve (Dodge Data & Analytics, 2015) (Seen at Figure 16 below).

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[135] Dodge Data & Analytics, 2015, p.28.
[136] Dodge Data & Analytics, 2015, p.28; McGrawHill construction, 2010, p.4, p.5
[137] McGrawHill construction, 2010, p.4, p.5
[138] Dodge Data & Analytics, 2015, p.28.

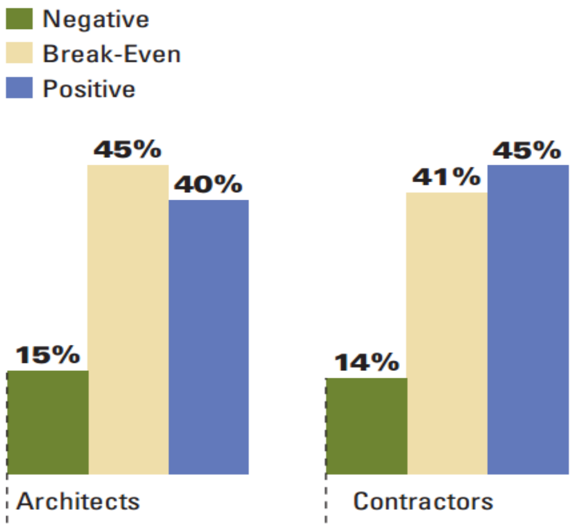

Figure 15: Perceived Return on Investment[139]

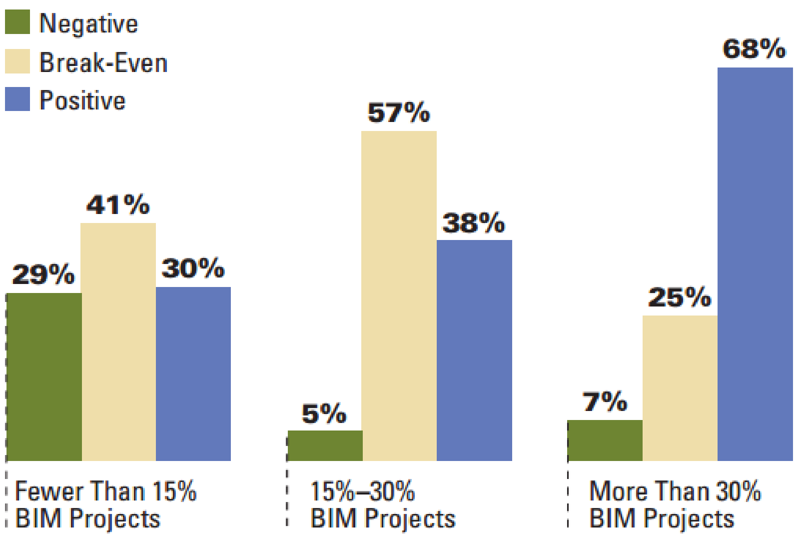

Figure 16: Perceived Return on Investment (ROI) for BIM Users in China (By Level of BIM Implementation) [140]

On other side of BIM adoption, according to McGrawHill Construction (2010), the internal business values could be seen as productivity gains and the enhanced ability to secure new work[141]. In the productivity gains aspects, three factors which were voted by BIM users in Western Europe can be seen as below:

- Reduced errors and omissions in construction documents.
- Reduced cycle time of specific workflows.
- Reduced rework.

[139] Dodge Data & Analytics, 2015, p.28.
[140] Dodge Data & Analytics, 2015, p.28.
[141] McGrawHill Construction, 2010, p.6.

Involving securing new work, both markets (North America and Western Europe) agreed that BIM were generating a positive impact on:

- Offering new services;
- Marketing new business to new clients;
- Maintaining repeat business with past clients.

McGrawHill Construction (2010) also found out the link between the level of advanced BIM skills and the internal benefits. The BIM user with more advanced BIM skills gains more benefits.

In research of Chinese market, Dodge Data & Analytics (2015) mentioned about the Internal business of BIM in the 7 following aspects:

- Enhancement of organization's image as an industry leader;
- Faster client approval cycles;
- Offering new services;
- Maintaining repeat business with past clients;
- Marketing new business to new clients;
- Increased profits;
- Reduced litigation and/or insurance claims.

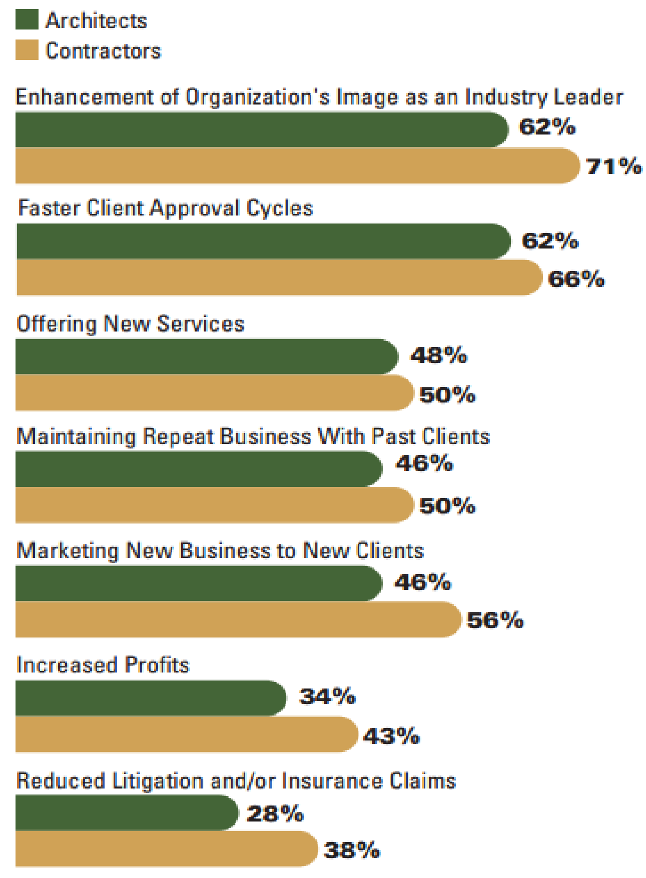

Figure 17: Internal Business Benefits Generated by BIM (By Percentage of Chinese Companies Receiving Benet at High or Very High Level) [142]

Chinese firms were asked to rate the degree to which they are receiving each of seven possible internal business benefits from BIM on a scale of one (no benefit) to five (very high benefit). In this results of this survey, the architecture company in China enjoyed the most in the aspect of faster client approval cycles. This rank was very closed to the

[142] Dodge Data & Analytics, 2015, p.17.

top among internal BIM benefits. In other aspects, the contractor engaged more than the architecture firm. (Seen at Figure 17)[143]

In conclusion, BIM adoption not only offers a greater return on investment (ROI), ensuring the ability to secure new work, and enhancing productivity gains for an organization but also brings more advantages in engineering value to a project.

2.8 Litterature review comments

Although all the above studies, to various extents, helped with the better understanding of the BIM concepts, how to apply BIM on QTO and estimation process, inhibiting factors of BIM deployment as well as considering factors for applying BIM, there are still some limitations in these studies:

1. Some of the studies are over 10 years old. There is a need for a more up-to-date study to expose any development in recent years.

2. The literature review does not reveal any comprehensive studies on inhibiting factors and feasible solutions for applying and developing QTO and Estimation process in construction consultant companies

3. Most of the studies were performed outside Vietnam. Although the construction industry worldwide shares some common characteristics, there are also some country-specific conditions. Therefore, a Vietnam-based study will help to identify issues most relevant to the current practice of BIM in QTO and estimation in this country.

4. Some of the reviewed surveys had relatively small sample sizes, which may affect the reliability of their results.

[143] Dodge Data & Analytics, 2015, p.17.

3 Research methodology

3.1 Research questions and hypotheses to test

The thesis will use a mixture of quantitative and qualitative research method using questionnaire survey. The objectives of the research include:

1. To review the existing methods which are used in order to define QTO and estimation in construction consultant company in Vietnam, focus on BIM methodology.

2. To point out objective and subjective reasons leading to limitation in applying BIM in QTO and estimation in construction consultant company in Vietnam.

This thesis, therefore, firstly presents findings of exploratory research questions

Research question 1 (RQ1): What are current methods and processes of calculating QTO and estimation in Vietnam? Do these methods include BIM application?

In order to find out the answer, the following sub-questions were designed:

- RQ1a: What methods are used in the QTO and Estimation process in your company?
- RQ1b: Which software is used to do these tasks?
- RQ1c: Commenting/valuing about this process?
- RQ1d: Does your company use BIM application in the construction project in general and in the QTO and Estimation process in particular?

Research question 2 (RQ2): What are the objective and subjective reasons leading to limitations in applying BIM in QTO and estimation in Vietnam?

Apart from identifying the reasons for limitations in the adoption of BIM on QTO and estimation process among consultant companies, the study also tested the following hypotheses:

Hypothesis 1: In non-BIM user group, some certain limitation factors of BIM adoption on QTO and estimation process will be more frequently received than others.

Hypothesis 2: In BIM user group, some certain limitation factors of BIM adoption on QTO and estimation process will be more frequently received than others

In this sector, Likert Scale was used to collect data, where respondents in two groups (non-BIM user group and BIM user group) ranked their levels of agreement with around fifteen statements relating to limit on BIM use in quantity take off and estimation process. The respondents were asked to rate each factor according to a 5-point Likert scale: 5= Strongly Agree; 4 = Agree; 3 = Neutral; 2= Disagree; 1= Strongly Disagree. The results will be ranked after in order to find out the top reasons for limitation in deploying BIM in construction project in general and in the QTO and estimation process in particular in Vietnam. Two ‘open-ended’ questions were introduced to collect additional data, which invited respondents to share opinions on particular aspects of limitation on BIM use, and to give any further comments.

The factors regarding non-BIM user hypothesis are:

Factor 1: Lack of client demand

Factor 2: Using the traditional methods for long and it is risky to invest in something new, which was not tested and proven

Factor 3: Time needed to train staff is long, cost to update hard software and buy BIM software are expensive

Factor 4: Believed that BIM is low or no importance in future

Factor 5: Believed that BIM is less efficient on smaller projects

Factor 6: Believed that no immediate competitive threat resulting from BIM non-use

Factor 7: Believed that no possible to carry out the project without the 2D CAD drawings

Factor 8: Think that chosen designer for a project are by lowest tender prices, thus it is not valued to invest time or quality on designer’s work with uncertain return

Factor 9: Company is just doing small project, therefore low chance for occurring errors in different stage of project

Factor 10: Lack of internal understanding of BIM

Factor 11: The resistance to change

Factor 12: Lack of appropriate legal framework

Factor 13: Lack of BIM expertise

Factor 14: Lack of BIM training program in school/ university

Factor 15: Concerns of BIM technology will replace quantity surveyors and estimators, no needs of their roles in futures

The factors regarding BIM user hypothesis are:

Factor 1: The factor “Confusing in choosing the software”

Factor 2: The factor **“**Software complexity”

Factor 3: The factor **“**The big amount of time and effort to build the BIM models from the beginning”

Factor 4: The factor **“**The company use BIM tools to do its certain functions such as building 3D models, no need to use it for QTO and estimation”

Factor 5: The factor **“**The missing data for QTO and estimation from Models”

Factor 6: The factor **“**Time to learn how to use the BIM tool to do QTO is long”

Factor 7: The factor **“**Defining the mistakes of calculation process”

Factor 8: The factor **“**Tracking the actual QTO”

Factor 9: The factor **“**Model is not corrects”

Factor 10: The factor **“**Lack of understanding workflow with BIM base QTO and estimation process”

Factor 11: The factor **“**The habit of using Standard Construction Codes in QTO and estimation process and Standard and this Standard Construction Codes cannot integrate with BIM software”

Factor 12: The factor **“**Difficulty in approving QTO and estimation from the checking parties if QTO and estimation are created by BIM tools”

Factor 13: The factor **“**Lack of resources both software and hardware regarding use of BIM tools”

Factor 14: Lack of context for construction methods and procedures, these material quantities cannot be used directly to generate labor and equipment quantities

Factor 15: The factor **“**Concerns of BIM technology will replace quantity surveyors and estimators, no needs of their roles in futures”

3.2 Methodology of survey

A quantitative methodology was used as the main method for author’s survey. First of all, a quantitative method using a questionnaire survey was conducted to generate information from a large sample population. Then, the second stage of the research was performed using a qualitative method through literature review in order to consolidate the final results.

3.3 E-mail survey

An online questionnaire was created by Google Forms application and sent to targeted people via e-mail. Another channel to approach this target group was publication of the URL link to the questionnaire on the Facebook groups such as Vietnam BIM network, English for construction field.

The questions were designed for everyone who works in the construction industry in Vietnam who has BIM experience or not, with a deeper focus on people work as estimator/ quantity surveyor. Although, the subject of this research was “applying BIM in the QTO and estimation process in Vietnamese construction consultant companies“. An overview opinion from the client, constructor, state construction management, and educational institutes were also considered in order to get a broader view of issues examined. The survey form was organized into 6 sections as described below:

Section 1: Introduction. The general information of survey question, the purpose of the survey, and the commits about the privacy of respondents from the researcher were established. There was not question in this section.

Section 2: Basic information. The background of respondents was collected in order to obtain responses’ information on respondents and their organization such as the year of working experience, type of their company, and their position in the company. This section also divided the respondents into two groups: respondents with estimating/quantity surveying background (people have experience in quantity take off and estimation process) and others (people have no experience with this process)

Section 3: Quantity takeoff and estimation process. This section was constructed for people with estimating/ quantity surveying background. The information about the current process of QTO and estimation was collected here. An open-ended’ question was also introduced to collect additional data, which invited respondents to share opinions on this process, and to give any further comments.

Section 4: BIM application. The main purpose of this section was to collect the information about BIM application in the organization of respondents and to drive the respondents into the sections of non-BIM users and BIM user.

Section 5: The reasons for the no application BIM. In this section, the reasons of the non-BIM user group which have been found in literature review was tested in Vietnamese environment and the personal opinions about this was collected as well.

Section 6: Reasons for limitation in deploying BIM. In this section, the limited reasons of the BIM user group which have been found in literature review was tested in Vietnamese environment and the personal opinions about this was collected as well.

The detail of questionnaire for survey can be seen at appendix D.

4 Survey data analysis

The results of the quantitative study using the survey are divided into three parts:

1. Section 1: Raw data analysis. It focuses on the profiles of the company and the profile of the respondents.
2. Section 2: Current method in use. It focuses on the current method of QTO and estimation process and BIM method in use in Vietnamese construction industry in general and in construction consultant company, in particular.
3. Section 3: Limitation factors. It focuses on identifying the reasons for limitation factors of deploying BIM in QTO and estimation process in two groups, BIM users, and Non-BIM users.

4.1 Response data description

In total 212 responses were received in Vietnamese AEC industry. One response was rejected because it came from someone who do not have the background in the construction industry. Finally, 211 answers were analyzed.

There were 63 respondents from construction consultant company (with 31 people having estimating and quantity surveying background); 48 respondents work for the construction investment company, clients, (with 32 people working as quantity surveyor/estimator); 53 people came from constructors (with 37 people working in quantity surveying/ estimating field); There were 10 person working in the educational field; and 4 persons came from BIM consultant company; In state construction management units, there were 33 people working for there. The following table describe the distribution of the collected sample:

No	**Type of organization**	**Frequency**	**Percent**
1	Construction consultant company	63	29.86%
2	Construction investment company, clients	48	22.75%
3	Contractors/Subcontractors	53	25.12%
4	State construction management units	33	15.64%
5	BIM consultant company	4	1.90%
6	Educational institutes in construction field	10	4.74%
	Total	211	100.00%

Table 7: The distribution of the collected sample[144]

[144] Own tabulation

The responses obtained from the clients, contractors, state construction management units were analyzed separately from the consultant's responses. The reasons for this action are as follows:

- Firstly, the main subject of this survey is consultants, and responses from contractors, clients and state construction management units are only used as supportive information.
- Secondly, the works of contractors, clients, and state construction management are done on co-corporate with consultants. Thus, they can join in the supporting information group in order to solidify the survey's results.

Other groups (Educational field; BIM consultant company) were considered only in the analysis of the responses on the question of limiting factors of BIM use in order to support the results of respondents from consultant company.

At the end, three groups will be analyzed for information. The first group is only consultants companies, the second group includes clients, investors, contractors, subcontractor, state management units. The last group is the responses from BIM consultant company, educational institutes in construction field. The distribution of the collected sample of each group can be seen at Table 8 below:

No	**Type of organization**	**Frequency**	**Percent**
1	Construction consultant company	63	29.86%
2	Investors, clients, contractors/subcontractors, state construction management units	134	63.51%
3	BIM consultant company, educational institutes in construction field	14	6.64%
	Total	211	100.00%

Table 8: The distribution of the collected sample and will be analyzed [145]

A specific analysis of quantity surveyors/estimators' group were taken. In this section, only data coming from respondents who work as quantity surveyor/estimators were analyzed. The reason for this action was because one of the main quantity surveyor/ estimators' tasks is cost estimate. It means they must work with all QTO and estimation process. This data was then used to find out the current method in use on QTO and estimation process in Vietnamese consultant company. The data collected in this sector: 211 responses were collected from the survey which included 123 of responses

[145] Own tabulation

of quantity Surveyor / estimators. A total 31 people out of the 123 quantity Surveyor / estimators work for construction consultant company.

Another specific analysis of non-BIM user and BIM user group was analyzed as well. The reasons for this division are to easily access the limitation reasons of BIM adoption. Those data were used to figure out the findings of limitation reasons factors for BIM adoption in Vietnam. The total 211 responses were divided into 2 group: BIM user and Non-user. The collected data can be seen at Table 9 below and will be analyzed in the subsections 4.3.1 Non-BIM user group and 4.3.2. BIM user group.

No	Groups	Frequency	Percent
1	Non-BIM user	153	72.51%
2	BIM user	58	27.49%
	Total	**211**	**100.00%**

Table 9: Collected data of BIM user and Non-BIM user group[146]

In order to specify reasons for limited use of BIM in construction consultant companies, the data was analyzed in two parts. One is the data collected from consultant company, another is the data came from other types of companies (clients, contractor, investors, BIM consultants, etc.). The divided data can be seen at Table 10, and Table 11 below:

No	Groups	Frequency	Percent
1	Non-BIM user	41	19.43%
2	BIM user	22	10.43%
	Total	**63**	**29.86%**

Table 10: Collected data of BIM user and Non-BIM user group in construction consultant company[147]

No	Groups	Frequency	Percent
1	Non-BIM user	112	53.08%
2	BIM user	36	17.06%
	Total	**148**	**70.14%**

Table 11: Collected data of BIM user and Non-BIM user group in other types of companies[148]

[146] Own tabulation
[147] Own tabulation
[148] Own tabulation

Profile of respondents from consultant companies:

No	Job roles of the respondents	Frequency	Percent
1	Quantity surveyor/ estimators	31	49.2%
2	Architect	9	14.3%
3	Structure engineer	7	11.1%
4	Civil engineer	16	25.4%
5	MEP engineer	0	0.0%
	Total	**63**	**100%**

Table 12: Job roles of the respondents from consultant company[149]

The data from Table 12 shows that quantity surveyor/estimators participated more in the survey with an overall percentage of 49.2%, this is followed by the Civil engineer at 25.4%. At 14.3% and 11.1% for architect and structure engineer respectively. No MEP engineer took part in the survey.

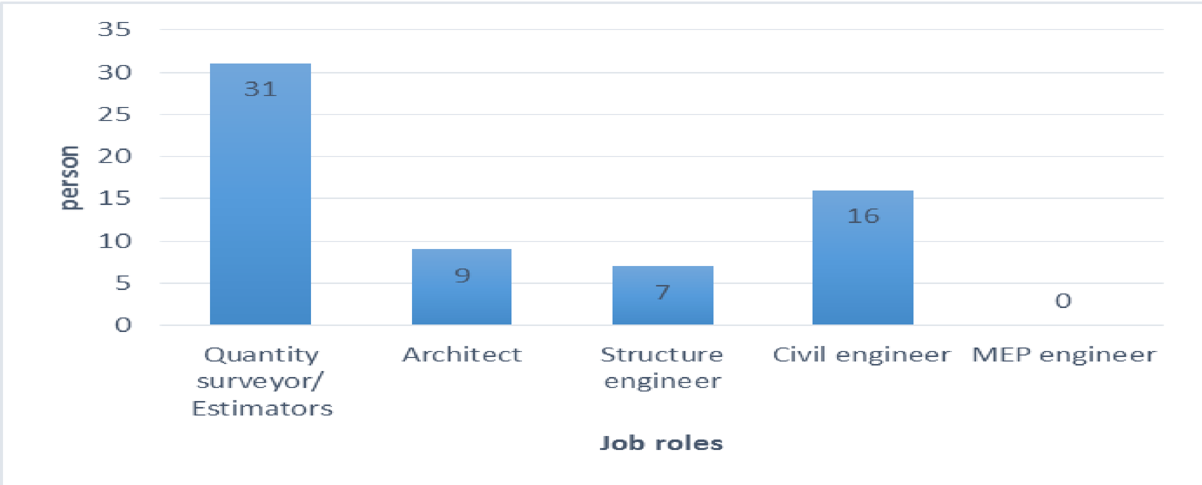

Figure 18: Job roles of the respondents from consultant company[150]

Besides that, from data in Table 13 and Figure 19, these respondents also had a relative significant years of experience in construction industry. In detail, 23.81% of respondents from consultants have 10 to 15 years of experience and 20.63% of respondents have more than 15 years of experience. Respondents having from 3 to 5 years and from 5 to 10 years experience are at 17.46% and 15.87% respectively. The remaining is at 22.22% for respondents have from 0 to 3 years of working experience. From this analysis, it is a balance among group of experience. However, the total of number of respondents with more than 5 years of working experience are dominant around 61%.

[149] Reference: own tabulation
[150] Reference: own figure

No	Years of work experience	Frequency	Percent
1	From 0 to 03 years	14	22.22%
2	From 03 to 05 years	11	17.46%
3	From 05 to 10 years	10	15.87%
4	From 10 to 15 years	15	23.81%
5	From 15 to 20 years	13	20.63%
6	More than 20 years	0	0.00%
	Total	**63**	**100.00%**

Table 13: Years of work experience in the construction industry of the respondents from consultant company[151]

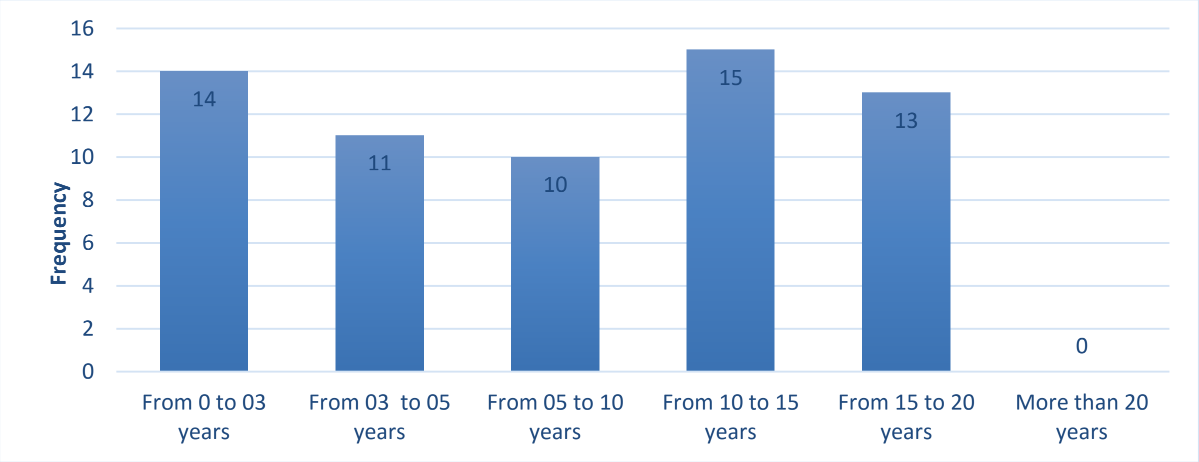

Figure 19: Years of work experience in the construction industry of the respondents from consultant company[152]

Profile of respondents from contactors, clients and state management units

As can be seen from Table 14, the significant number of people working as quantity surveyor / estimators was at 61.94 % of the total respondents. This group was followed by Civil engineer at 27.61%. For architect, structure engineer and project engineer, the percentage was the same at 2.99%. The smallest group was MEP engineer at 1.49%.

No	Job roles of the respondents	Frequency	Percent
1	Quantity surveyor/ Estimators	83	61.94%
2	Architect	4	2.99%
3	Structure engineer	4	2.99%
4	Civil engineer	37	27.61%
5	MEP engineer	2	1.49%
6	Others (Project engineer)	4	2.99%
	Total	**134**	**100%**

Table 14: Job roles of the respondents from clients, contractors, state management units[153]

151 Reference: own tabulation
152 Reference: own figure
153 Reference: own tabulation

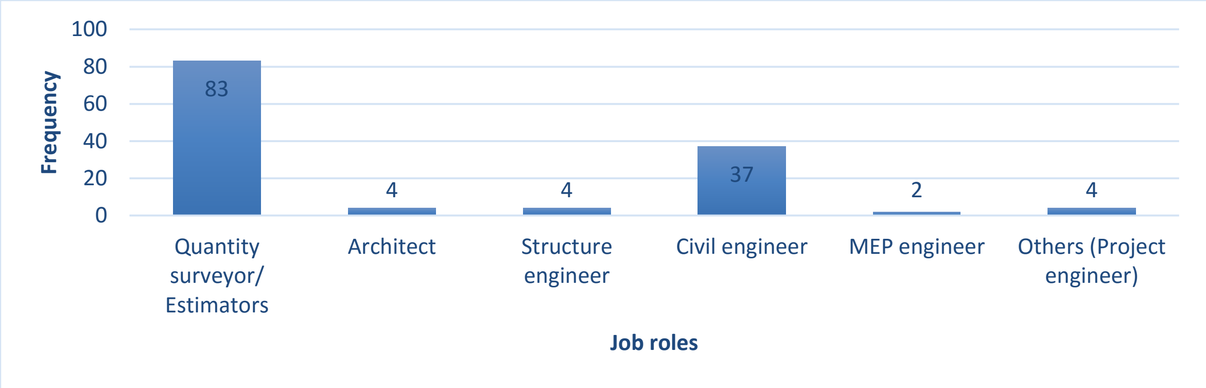

Figure 20: Job roles of the respondents from clients, contractors, state management units[154]

As can be seen in Table 15 and Figure 21, 24.63% of respondents have 5 to 10 years of experience. The same figure was at 20.15% for the groups has less than 3 years of experience and has 3 to 5 years .The group of 10 to 15 years was at 24.63%. For the group of 15 to 20 years of experience was at 9.7%.The remaining was at 1.49 % for respondents have more than 20 years of working experience.

No	Years of work experience	Frequency	Percent
1	From 0 to 03 years	27	20.15%
2	From 03 to 05 years	27	20.15%
3	From 05 to 10 years	32	23.88%
4	From 10 to 15 years	33	24.63%
5	From 15 to 20 years	13	9.70%
6	More than 20 years	2	1.49%
	Total	**134**	**100%**

Table 15: Years of work experience in the construction industry of the respondents from clients, contractors, state management units[155]

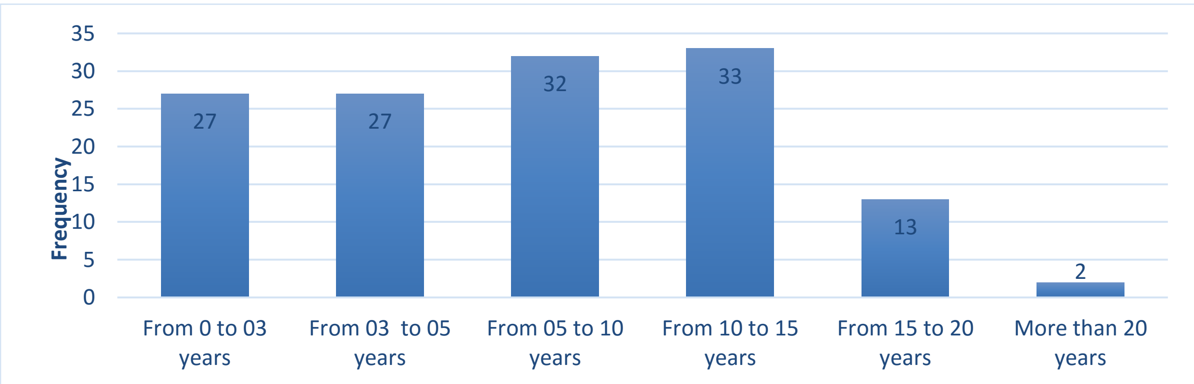

Figure 21: Years of work experience in the construction industry of the respondents from clients, contractors, state management units[156]

[154] Own Figures
[155] Own tabulation
[156] Own Figures

4.2 Survey findings of method in use

Current method of QTO and estimation in Vietnamese construction consultant companies

As figure can be seen in Table 16 and Figure 22, the common method in use was the traditional one (paper-based method) with a 93.55% of responses in the survey were confirmed. The rest, 6.45% of responses, was the BIM method.

No	Current method of QTO and estimation	Frequency	Percent
1	Traditional method (paper - based method)	29	93.55%
2	BIM method	2	6.45%
	Total	**31**	**100.00%**

Table 16: Current method of QTO and estimation in construction consultant companies in Viet Nam[157]

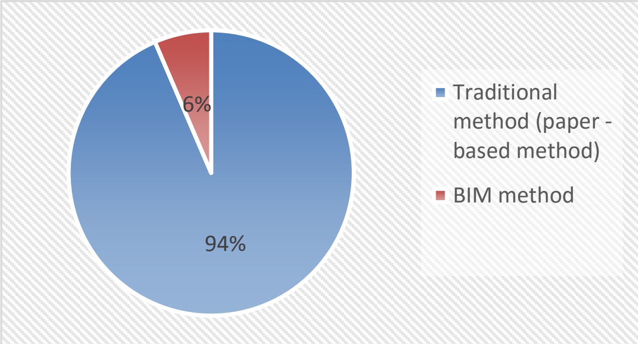

Figure 22: Current method of QTO and estimation in construction consultant companies in Viet Nam[158]

Software packages in use: The common software in use within the traditional method was MS excel, and common cost estimating software such as GXD, G8, F1, Acitt (25 responses). There were some mentions about Cost X, Revit software which were used in BIM method.

Current method of QTO and estimation in contactors, clients and state management units

No	Current method of QTO and estimation	Frequency	Percent
1	Traditional method (paper -based method)	86	93.48%
2	BIM method	6	6.52%
	Total	**92**	**100.00%**

Table 17: Current method of QTO and estimation in contactors, clients and state management units[159]

[157] Own tabulation
[158] Own Figures
[159] Own tabulation

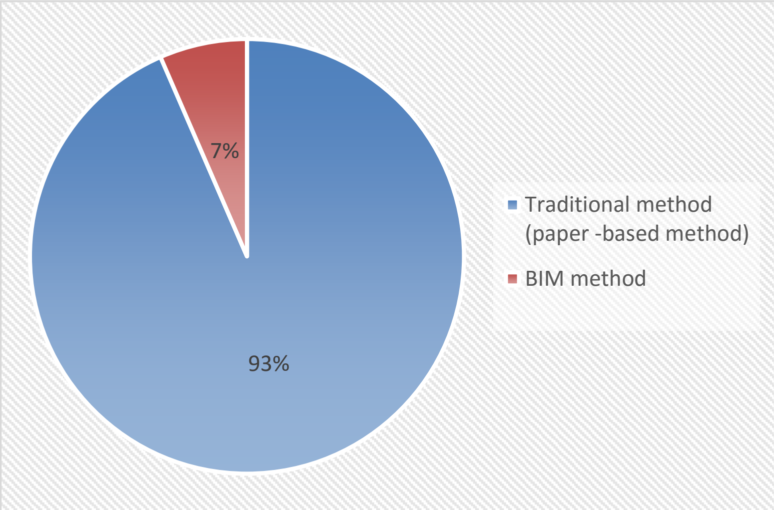

Figure 23: Current method of QTO and estimation in contactors, clients and state management units[160]

As figure can be seen in Table 17 and Figure 23, the current method in use in other companies/ other organization was also the traditional method. The similar percent was at 93.48% in comparison to the current method in use in consultant companies. The BIM method was just at 6.52% in total percentage.

Software packages in uses: The common software in use within the traditional method was MS excel, and cost estimating software such as GXD, G8, F1, Acitt, Delta Some respondents mentioned CostX, Revit, Tekla Structural and the BIM-based cost estimating software such as Autodesk Quantity take off, which were used in BIM method.

4.3 Survey findings of limitation factors

4.3.1 Non-BIM user group

Non-BIM user in construction consultant companies: The mean value of this questionnaire was 3.29 and the range was 3.93 to 2.54. The most influenced factors for limiting BIM usage in consultant companies were the factor 1 "the lack of client's demand (3.93), the factor 3 "Time needed to train staff is long, cost to update hard software and buy BIM software are expensive", and the factor 9 "Think that chosen designer for a project are by lowest tender prices, thus it is not valued to invest time or quality on designer's work with uncertain return". Placed at the top 4 and 5 are the beliefs about no posibility to carry out a project without 2D drawings (factor 8) and doing the small project will not be created mistake (factor 10).

160 Own Figures

No	Factor	n	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total	Ave	SD	Rank
1	Lack of client demand	41	31.71%	36.59%	26.83%	2.44%	2.44%	100%	3.93	0.164	1
3	Time needed to train staff is long, cost to update hard software and buy BIM software are expensive.	41	29.27%	41.46%	19.51%	2.44%	7.32%	100%	3.83	0.159	2
9	Think that chosen designer for a project are by lowest tender prices, thus it is not valued to invest time or quality on designer's work with uncertain return;	41	26.83%	48.78%	7.32%	9.76%	7.32%	100%	3.78	0.180	3
8	Believed that no possible to carry out the project without the 2D CAD drawings;	41	24.39%	48.78%	9.76%	9.76%	7.32%	100%	3.73	0.175	4
10	Company is just doing small project, therefore low chance for occurring errors in different stage of project.	41	19.51%	46.34%	17.07%	12.20%	4.88%	100%	3.63	0.158	5
2	Using the traditional methods for long and it is risky to invest in somethings new, which was not tested and proven.	41	24.39%	34.15%	19.51%	17.07%	4.88%	100%	3.56	0.107	6
7	Lack of appropriate legal framework.	41	21.95%	21.95%	34.15%	9.76%	12.20%	100%	3.32	0.097	7
11	Lack of internal understanding of BIM.	41	19.51%	21.95%	39.02%	7.32%	12.20%	100%	3.29	0.121	8
14	Lack of BIM training program in school/ universit	41	19.51%	29.27%	19.51%	21.95%	9.76%	100%	3.27	0.070	9
12	The resistance to change	41	14.63%	14.63%	43.90%	19.51%	7.32%	100%	3.10	0.141	10

Table 18: Results of the questionnaire regarding limitation factors for BIM adoption among Non-BIM users in construction consultant companies (a)[161]

[161] Own tabulation

No	Factor	n	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total	Ave	SD	Rank
5	Believed that BIM is less efficient on smaller projects	41	17.07%	12.20%	31.71%	21.95%	17.07%	100%	2.90	0.074	11
6	Believed that no immediate competitive threat resulting from BIM non-use.	41	9.76%	14.63%	43.90%	17.07%	14.63%	100%	2.88	0.136	12
13	Lack of BIM expertise	41	12.20%	14.63%	34.15%	24.39%	14.63%	100%	2.85	0.092	13
15	Concerns of BIM technology will replace quantity surveyors and estimators, no needs of their roles in futures.	41	12.20%	9.76%	31.71%	26.83%	19.51%	100%	2.68	0.094	14
4	Believed that BIM is low or no importance in future	41	12.20%	4.88%	29.27%	31.71%	21.95%	100%	2.54	0.114	15
	Average								**3.29**		

Table 19: Results of the questionnaire regarding limitation factors for BIM adoption among Non-BIM users in construction consultant companies (b)[162]

<u>Non-BIM user in contactors, clients, state management units, BIM consultant company, and educational institutes:</u> The mean value of this questionnaire was 3.23 and the range was 3.84 to 2.53. “Lack of client’s demand” with a 3.84 mean value is a major factor to limit BIM usage among contactors, clients, state management units, BIM consultant company, and educational institutes. The followings are the factor 3 “Time needed to train staff is long, cost to update hard software and buy BIM software are expensive” (3.68), and the factor 10 ” Company is just doing small project, therefore low chance for occurring errors in different stage of project”(3.69).

No	Factor	n	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total	Ave	SD	Rank
1	Lack of client demand	112	24.11%	47.32%	19.64%	6.25%	2.68%	100%	3.84	0.18	1
10	Company is just doing small project, therefore low chance for occurring errors in different stage of project	112	17.86%	45.54%	26.79%	7.14%	2.68%	100%	3.69	0.17	2
3	Time needed to train staff is long, cost to update hard software and buy BIM software are expensive	112	19.64%	41.96%	26.79%	9.82%	1.79%	100%	3.68	0.16	3

Table 20: Results of the questionnaire regarding limitation factors for BIM adoption among Non-BIM users in contactors, clients , state management units , BIM consultant company, and educational institutes (a) [163]

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162 Own tabulation
163 Own tabulation

No	Factor	n	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total	Ave	SD	Rank
9	Think that chosen designer for a project are by lowest tender prices, thus it is not valued to invest time or quality on designer's work with uncertain return	112	20.54%	43.75%	22.32%	8.93%	4.46%	100%	3.67	0.15	4
2	Using the traditional methods for long and it is risky to invest in somethings new, which was not tested and proven.	112	19.64%	39.29%	23.21%	14.29%	3.57%	100%	3.57	0.13	5
8	Believed that no possible to carry out the project without the 2D CAD drawings;	112	16.96%	44.64%	18.75%	14.29%	5.36%	100%	3.54	0.15	6
14	Lack of BIM training program in school/ universit	112	14.29%	35.71%	33.04%	12.50%	4.46%	100%	3.43	0.14	7
7	Lack of appropriate legal framework.	112	9.82%	33.04%	40.18%	11.61%	5.36%	100%	3.30	0.16	8
11	Lack of internal understanding of BIM.	112	7.14%	30.36%	41.07%	12.50%	8.93%	100%	3.14	0.15	9
12	The resistance to change	112	6.25%	16.96%	50.00%	18.75%	8.04%	100%	2.95	0.18	10
13	Lack of BIM expertise	112	5.36%	26.79%	36.61%	19.64%	11.61%	100%	2.95	0.12	11
6	Believed that no immediate competitive threat resulting from BIM non-use.	112	4.46%	11.61%	52.68%	22.32%	8.93%	100%	2.80	0.19	12
15	Concerns of BIM technology will replace quantity surveyors and estimators, no needs of their roles in futures.	112	6.25%	10.71%	45.54%	24.11%	13.39%	100%	2.72	0.16	13
5	Believed that BIM is less efficient on smaller projects	112	3.57%	9.82%	45.54%	25.89%	15.18%	100%	2.61	0.16	14
4	Believed that BIM is low or no importance in future	112	4.46%	7.14%	43.75%	25.89%	18.75%	100%	2.53	0.16	15
	Average								**3.23**		

Table 21: Results of the questionnaire regarding limitation factors for BIM adoption among Non-BIM users in contactors, clients , state management units , BIM consultant company, and educational institutes (b) [164]

[164] Own tabulation

Following the analysis of the results among Non- BIM users, it can be seen that the most common limitation reason for applying BIM in consultant companies is the lack of client's demand in construction market. Other reasons are needed time to train staff is too long, the initial investment is high.

4.3.2 BIM user group

<u>BIM user in construction consultant companies:</u> The mean value of this questionnaire was 3.22 and the range was 3.64 to 2.64. The most influenced factors for limiting BIM usage in consultant company is the factor 3 " The big amount of time and effort to build the BIM models from the beginning (3.64), the factor 11 " The habit of using Standard Construction Codes in QTO and estimation process and Standard and this Standard Construction Codes cannot integrate with BIM software"(3.64), and the factor 10 " Lack of resources both software and hardware regarding use of BIM tools"(3.5). The factor 16 "Concerns of BIM technology will replace quantity surveyor/ estimators, no needs of their roles in futures" was the less important factor" (2.64).

No	Factor	n	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total	Ave.	SD	Rank
3	The big amount of time and effort to build the BIM models from the beginning	22	13.64%	50.00%	27.27%	4.55%	4.55%	100%	3.64	0.192	1
11	The habit of using Standard Construction Codes in QTO and estimation process and Standard and this Standard Construction Codes cannot integrate with BIM software	22	22.73%	36.36%	27.27%	9.09%	4.55%	100%	3.64	0.131	1
13	Lack of resources both software and hardware regarding use of BIM tools	22	18.18%	36.36%	27.27%	13.64%	4.55%	100%	3.50	0.123	3
7	Defining the mistakes of calculation process	22	13.64%	31.82%	40.91%	9.09%	4.55%	100%	3.41	0.156	4

Table 22: Results of the questionnaire regarding limitation factors for BIM adoption among BIM users in construction consultant companies (a)[165]

[165] Own tabulation

No	Factor	n	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total	Ave.	SD	Rank
10	Lack of understanding workflow with BIM base QTO and estimation process	22	9.09%	40.91%	36.36%	9.09%	4.55%	100%	3.41	0.172	4
12	Difficulty in approving QTO and estimation from the checking parties if QTO and estimation are created by BIM tools	22	18.18%	31.82%	31.82%	9.09%	9.09%	100%	3.41	0.114	4
14	Lack of context for construction methods and procedures, these material quantities cannot be used directly to generate labor and equipment quantities	22	18.18%	22.73%	40.91%	13.64%	4.55%	100%	3.36	0.135	7
4	The company use BIM tools to do its certain functions such as building 3D models, no need to use it for QTO and estimation	22	4.55%	40.91%	31.82%	18.18%	4.55%	100%	3.23	0.163	8
5	The missing data for QTO and estimation from Models	22	4.55%	36.36%	31.82%	22.73%	4.55%	100%	3.14	0.149	9
8	Tracking the actual QTO	22	13.64%	18.18%	40.91%	22.73%	4.55%	100%	3.14	0.135	9
1	Confusing in choosing the software	22	0.00%	40.91%	31.82%	18.18%	9.09%	100%	3.05	0.166	11
6	Time to learn how to use the BIM tool to do QTO is long	22	13.64%	18.18%	27.27%	36.36%	4.55%	100%	3.00	0.123	12
2	Software complexity	22	9.09%	27.27%	27.27%	27.27%	9.09%	100%	3.00	0.100	13
9	Model is not corrects	22	0.00%	18.18%	45.45%	31.82%	4.55%	100%	2.77	0.189	14
15	Concerns of BIM technology will replace quantity surveyors and estimators, no needs of their roles in futures	22	4.55%	9.09%	40.91%	36.36%	9.09%	100%	2.64	0.172	15
	Average								**3.22**		

Table 23: Results of the questionnaire regarding limitation factors for BIM adoption among BIM users in construction consultant companies (b) [166]

[166] Own tabulation

<u>BIM user in contactors, clients, state management units, BIM consultant company, and educational institutes:</u>

The mean value of this questionnaire in this sector was 3.24 and the range was 3.81 to 2.5. The most influenced factors for limiting BIM use in contactors, clients, state management units, BIM consultant company, and educational institutes were the factor 11 " The habit of using Standard Construction Codes in QTO and estimation process and Standard and this Standard Construction Codes cannot integrate with BIM software"(3.81), the factor 10 " Lack of understanding workflow with BIM base QTO and estimation process (3.61), and the factor 12 " Difficulty in approving QTO and estimation from the checking parties if QTO and estimation are created by BIM tools"(3.58). The factor 16 "Concerns of BIM technology will replace quantity surveyor/ estimators, no needs of their roles in futures" (2.81) and the factor 9 "Model in not corrects" (2.5) were the least important factor".

No	Questions	n	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total	Ave	SD	Rank
11	The habit of using Standard Construction Codes in QTO and estimation process and Standard and this Standard Construction Codes cannot integrate with BIM software	36	16.67%	55.56%	22.22%	2.78%	2.78%	100%	3.81	0.249	1
10	Lack of understanding workflow with BIM base QTO and estimation process	36	11.11%	52.78%	25.00%	8.33%	2.78%	100%	3.61	0.225	2
12	Difficulty in approving QTO and estimation from the checking parties if QTO and estimation are created by BIM tools	36	16.67%	41.67%	25.00%	16.67%	0.00%	100%	3.58	0.173	3
14	Drawings must produce in a BIM software, and must be available to the estimator	36	8.33%	52.78%	27.78%	11.11%	0.00%	100%	3.58	0.229	3

Table 24: Results of the questionnaire regarding limitation factors for BIM adoption among BIM users in contactors, clients , state management units , BIM consultant company, and educational institutes (a)[167]

[167] Own tabulation

No	Questions	n	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Total	Ave	SD	Rank
3	The big amount of time and effort to build the BIM models from the beginning	36	13.89%	47.22%	22.22%	16.67%	0.00%	100%	3.58	0.196	5
5	The missing data for QTO and estimation from Models	36	11.11%	47.22%	30.56%	8.33%	2.78%	100%	3.56	0.205	6
4	The company use BIM tools to do its certain functions such as building 3D models, no need to use it for QTO and estimation	36	2.78%	63.89%	11.11%	19.44%	2.78%	100%	3.44	0.273	7
13	Lack of resources both software and hardware regarding use of BIM tools	36	11.11%	38.89%	25.00%	22.22%	2.78%	100%	3.33	0.149	8
15	Lack of context for construction methods and procedures, these material quantities cannot be used directly to generate labor and equipment quantities	36	5.56%	36.11%	38.89%	16.67%	2.78%	100%	3.25	0.170	9
6	Time to learn how to use the BIM tool to do QTO is long	36	0.00%	38.89%	38.89%	19.44%	2.78%	100%	3.14	0.174	10
2	Software complexity	36	5.56%	27.78%	30.56%	36.11%	0.00%	100%	3.03	0.161	11
7	Defining the mistakes of calculation process	36	0.00%	25.00%	47.22%	22.22%	5.56%	100%	2.92	0.171	12
1	Confusing in choosing the software	36	5.56%	22.22%	33.33%	33.33%	5.56%	100%	2.89	0.131	13
8	Tracking the actual QTO	36	0.00%	30.56%	27.78%	36.11%	5.56%	100%	2.83	0.134	14
16	Concerns of BIM technology will replace quantity surveyors and estimators, no needs of their roles in futures	36	5.56%	27.78%	19.44%	36.11%	11.11%	100%	2.81	0.108	15
9	Model is not corrects	36	0.00%	19.44%	27.78%	36.11%	16.67%	100%	2.50	0.088	16
	Average								**3.24**		

Table 25: Results of the questionnaire regarding limitation factors for BIM adoption among BIM users in contactors, clients , state management units , BIM consultant company, and educational institutes (b)[168]

[168] Own tabulation

There is the complete consensus between two part of BIM user group about the reasons for limiting deploying BIM in QTO and estimation process. Although the ranking in the two groups is a slight difference, the reasons of the habit of using Standard Construction Codes in QTO and estimation process was placed at the top reasons. Besides, the amount of time have to spend to build the model from beginning and concern of the difficulty in prove estimation were also critical limitation reasons for deployment of BIM among BIM user group.

5 Possible solutions to overcome the limitations and barriers

Lack of client demand

“Lack of client demand is biggest barrier to adoption of BIM”, Crowther (2013) cited from RICS’BIM survey that limited client’s demand is standing in the way of industry-wide adoption of BIM. However, he also pinpointed that education is critical to change the needs. The greater recognition of the benefits it can bring, and ultimately heightened demand for its usage.

According to Chan (2014), being the largest client in the construction industry was government and they should take the lead to increase the demand for BIM implementation in their projects. Government departments should encourage the use of BIM starting from design stage, even if the design is prepared by in-house designers. When the benefits of BIM are widely recognized by different professionals, private clients will demand BIM in their project design and construction.[169]

Time needed to train staff is long, cost to update hardware and buy BIM software are expensive

According to Eastman et al. (2011), if the company just considers the initial cost such as costs of purchasing new systems, retraining staff, and developing new procedures, it is easy to rationalize that the benefits do not seem worthwhile.[170] However, if it is considering the long-term benefits, the return on investment on BIM is high. Thanks to the potential of BIM adoption, the design company can offer new services to the clients.[171] The details of new services and fee can be seen at subtitle 2.6. Considering

[169] Chan,2014, p.035.
[170] Eastman et al., 2011, p.253.
[171] Eastman et al., 2011, p.254.

the factors. Furthermore, the positive results of the ROI indicator show that the initial investment on BIM is worthwhile. (McGrawHill Construction, 2010) (Dodge Data & Analytics, 2015)[172].

Using the traditional methods for long time and it is risky to invest in something new, which was not tested and proven

According to McGraw Hill (2010) and Dodge Data & Analytics (2015), in terms of internal benefits, they use ROI (Return On Investment) as the KPI (Key Performance Indicator) to measure the success of BIM investment. Although there is no single globally accepted method to calculate the return on investment (ROI) for BIM, most users have a perception of the degree to which they are receiving value for the time, money and effort they have invested. The results of their researches show that the positive return on investment are dominant in survey markets. This positive ROI return is proven for the BIM investment. (McGrawHill Construction, 2010)[173]. (Dodge Data & Analytics, 2015)[174].

The habit of using Standard Construction Codes in QTO and estimation process and this Standard Construction Codes cannot integrate with BIM software**.**

According to Eastman et al (2011), there are three options to support the estimating process. One of them is extract quantity from BIM model to the spreadsheet like MS excel. The estimators can use this data to support the estimation process. The users can take this BIM option and use the advantages of BIM model as well as BIM adoption in the QTO and estimation process. For other options, it seems difficult from beginning to intergrate the Standard Construction Codes with BIM software. However, the developing of BIM based cost estimating software with the manual intervention capability features allows users perform manual modifications and customization. BIM components can be restructured to the right level of estimating detail. It means that the users can create their own dimension groups based on their standards and indicate the measurement type for the objects they required to measure. (Wu, et al., 2014)[175].

Difficulty in approving QTO and estimation from the checking parties if QTO and estimation are created by BIM tools

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[172] Dodge Data & Analytics, 2015, p.28, McGrawHill construction, 2010, p.4,p.5
[173] McGrawHill construction, 2010, p.4,p.5
[174] Dodge Data & Analytics, 2015, p.28.
[175] Wu et al, 2014, p.60.

One of the reasons for this obstacle is the Standard Construction Codes can not integrate with BIM software. It leads to the missing standard to check and monitor the cost estimate. If the users can use some suggestion above on how to integrate Standard Construction Codes with BIM-based cost estimating software, users can come over this obstacle.

<u>The big amount of time and effort to build the BIM models from the beginning</u>

This issue is related to the level of information in BIM models. It will take time and a lot of attempts to build a 3D model with full of information from beginning of project It is obvious that more information in BIM model from beginning yields more benefits. (Eastman , et al., 2011). However, requiring all information from the beginning of building 3D BIM model is not advisable. A lot of information at the wrong time in the BIM project would end up in incorrect decision making and unrealistic project planning. (Wu, et al., 2014)[176]. Therefore, it is important to understand which level of information should be in the requirement for BIM model during each stage of a project and what information needs to be included in BIM model for the benefit of quantity surveyors.

<u>Lack of understanding workflow with BIM base QTO and estimation process</u>

From the literature review, some suggestions to understanding workflow as well as the steps to build a BIM workflow for QTO and estimation process are:

- Building a BIM workflow for QTO and estimation process based on each design phase.
- Defining the cost target requirements and the design features of projects.
- Defining the compatibility system between BIM design software and BIM based-cost estimating software.
- Defining whether the part of total quantity takeoff has to be taken by the manual method.
- Building a collaboration team from the early stage of the project. The recommended team for this process should include three professionals in their field: Architect, estimator, and BIM engineer.

[176] Wu et al.,2014, p.27.

6 Conclusion

6.1 Main results and discussion

This research has tried, on one hand, to describe the current status of BIM implementation in QTO and estimation process in Viet Nam, focusing on BIM method and, on the other hand, to pinpoint the inhibiting factors of BIM usage and to develop mitigation measures for these inhibiting factors. This is done by analyzing data from the questionnaire survey. The following main issues have been revealed and discussed:

Traditional method is used for QTO and estimation process at consultant companies in Vietnam. In general, this method does not function efficiently. BIM method is being implemented and it is in the early phase. However, it is not being adopted by all departments rather they are focusing to implement BIM mostly in the design area.

Regarding the BIM implementation in QTO and estimation process, despite its outstanding benefits, is not a common choice of consultant company in Vietnam. This above-indicated non-diffusion of BIM can be explained by many limiting factors that stem from the Non-BIM user and BIM user group. Similar to the literature review, lack of client's demand is the biggest barrier to adopt BIM in construction consultant companies in Vietnam. Other common reasons are the high cost for the initial investment on BIM adoption such as the cost for hardware up gradation and software license, and risks involved in investing on new technology. These barriers are being considered over the advantages as there is the lack of recognition of the benefits which BIM can bring and also the disinterest by government in terms of the new technology adoption. Despite BIM is deployed in the design rapidly in comparison to the adoption of BIM in QTO and estimation process. It can be seen that the significant reasons for that are the perception of inability to integrate the Vietnamese Standard Construction Codes with BIM-based estimating software and difficulty in approving estimation if it is generated from BIM application. The sense behind that leads to these perceptions is a gap in the knowledge of the capability of BIM tools as well as understanding the potential limitations of the automatic measurement of BIM usage, and it could be also the reflection of the reasons "lack of understanding workflow with BIM based-QTO and estimation process". This research has shown the last reason for the slowdown of BIM adoption on QTO and estimation process is the factor "the big amount of time and effort to build the BIM models from the beginning". It is also reflected by a lack of skill in working with the 3D digital model and a lack of understanding of required information in the model which are needed to generate the estimation during each stage of development of a project.

Following the analysis of the findings, the possible solutions to overcome these limitations are developed. The education solution is critical to change the needs and the BIM implementation scope. The further look at the long-term benefits of BIM adoption in an organization is beneficial. The understanding about BIM tools as well as its potential functions is necessary.

In conclusion, this research, with a deep view into the current status of BIM application of QTO and estimation process in construction consultant companies in Vietnam, the inhibiting factors and the developed mitigation measures, will help to overcome the lack of literature and facilitate the consultants and other practitioners in Vietnamese construction industry to further use BIM in the construction projects in general and in QTO and estimation process in particular.

6.2 Limitation and recommendation for further research

In spite of these contributions allowing to cover several gaps in the literature or to deepen scientific knowledge, the research suffers from certain limitations that could be avoided in future research works:

Regarding the samples, the sample of 63 consultants; 148 of others (clients, contractors/, state construction management units etc..) can be considered too small for the statistical analyses to extract significant results.

Regarding the nature of research methodology, it should be noted that the questionnaire survey might have collected bias data because of the personal bias or lack of knowledge of the respondents. No interviews are taken and this also creates limitation on survey results.

Finally, the continuation of the study of BIM implementation in Vietnam construction industry can be a deep investigation into standardization and appropriate pricing format in practice of BIM deployment in QTO and estimation process as well as expansion of the research into other subjects such as the clients and contractors.

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Declaration of authorship

I hereby declare that the attached Master’s thesis was completed independently and without the prohibited assistance of third parties, and that no sources or assistance were used other than those listed. All passages whose content or wording originates from another publication have been marked as such. Neither this thesis nor any variant of it has previously been submitted to an examining authority or published.

Location, Date	Signature of the student

Appendix

Appendix A

Group Element	Element	Unit	Required Information from BIM	Autodesk Revit Model information
0 Facilitating works		m²	N/A	It is usually not included in the BIM model. Site Area can be obtained if the site design is included in the model
1 Substructure	**1 Substructure**	m²	• Area of the lowest floor • Areas of basements	Floor element in Revit. Dimensions included in Floor element: • Slope Angle • Perimeter • Area • Volume • Thickness If area is defined in basement, area property can be used. Dimensions included in area element: • Area • Perimeter
2 Superstructure	**1 Frame**	m²	• Area of the floors related to the frame.	Floor element in Revit. Dimensions included in Floor element: • Slope Angle • Perimeter • Area • Volume • Thickness If areas are defined in upper floor, area property can be used. Dimensions included in area element: • Area • Perimeter
	2 Upper floors	m²	• Area of upper floor(s) • Areas for balconies, galleries, tiered terraces, service floors, walkways, internal bridges, external links, and roofs to internal buildings.	Floor element in Quantity information needed in Floor element: • Slope Angle • Area

Table 26: Information Requirement (a)[177]

[177] Wu, et al., 2014, p.34

Group Element	Element	Unit	Required Information from BIM	Autodesk Revit Model information
2 Superstructure (continued)	3 Roof	m²	• Area of the roof on plan	Quantity information needed in Roof element: (please note, the area in roof element is the actual area of the roof element, not the roof on plan). • Area
	4 Stairs and ramps	nr	• Total number of storey flights • Total vertical rise of each staircase or ramp	Stair tool / element
	5 External walls	m²	• Area of the external wall • Area of windows	Wall element in Revit. Dimensions included in Floor element: • Length • Area • Thickness Window element in Revit. Dimensions included in Floor element: • Height • Width
	6 Windows and external doors	m²	• Area of windows and external doors	Window element in Revit. Dimensions included in Floor element: • Height • Width Door element in Revit. Dimensions included in Floor element: • Height • Width • Thickness
	7 Internal walls and partitions	m²	• Area of internal walls and partitions	Wall element in Revit. Dimensions included in Floor element: • Length • Area • Thickness
	8 Internal doors	nr	• Total number of internal doors	Classification according to the door type is not necessary at this stage
3 Internal finishes	1 Wall finishes	m²	• Total area of wall to which finishes are applied	Room element, definition of the finishes and dimension in wall elements
	2 Floor finishes		• Total area of floor to which finishes are applied	Room element, definition of the finishes and dimension in floor elements
	3 Ceiling finishes		• Total area of ceiling to which finishes are applied	Room element, definition of the finishes and dimension in ceiling elements
4 Fittings, furnishings and equipment		m²	• Gross internal floor area (GIFA)	If area/ area plan is defined in the model, area property can be used. (please check if the definition of the area plan is comply with RICS GIA definition.) Dimensions included in area element: • Area • Perimeter
5 Services			Not include in the scope of the study	

Table 27: Information Requirement (b)[178]

[178] Wu, et al., 2014, p.34

Group Element	Element	Unit	Required Information from BIM	Autodesk Revit Model information
6 Prefabricated buildings and building units	**1 Prefabricated buildings and building units**	m²	• Gross internal floor area (GIFA) of the complete buildings or prefabricated room units	If area/ area plan is defined in the model, area property can be used. (please check if the definition of the area plan is comply with RICS GIA definition.) Dimensions included in area element: • Area • Perimeter
7 Work to existing buildings	**1 Minor demolition and alteration works**	m²	N/A	This information is not included in BIM
8 External works	**1 Site preparations works**	m²	N/A	This information is not included in BIM
9 Main contractor's preliminaries		%	N/A	This information is not included in BIM
10 Main contractor's overheads and profit		%	N/A	This information is not included in BIM

Table 28: Information Requirement (c)[179]

[179] Wu, et al., 2014, p.34

Appendix B

Building Elements	Description	Quantity information
Wall	Architectural wall or structural wall	Length of the wall, area of the wall, the volume of the wall
Doors	Door [hosted component] can be added on any wall, it can be external or internal.	Thickness of the door, height of the door, width of the door,
Windows	Windows [hosted component] can be added on any wall or roof	Height of the opening of the windows, width of the windows,
Roofs	Standard roof elements, can't cut through windows or doors	Slope, thickness of the roof, volume of the roof and area of the roof, please note, this is the actual area, not the area on plan.
Ceilings	Ceiling are level based elements, created at a specified distance above the level which they reside	Slope, Perimeter of the ceiling, area of the ceiling and volume of the ceiling
Floors	Floor element, can be a structural element	Slope Angle, perimeter of the floor, area of the floor, volume of the floor and thickness of the floor
Stairs by components	Stair is assembled with common components, such as run, landing and support	Desired number of risers, actual number of risers, rise height and tread depth
Stairs by sketch	Stair is created by defining the run of the stairs	Width of the stairs, Desired number of risers, actual number of risers, rise height and tread depth
Curtain Elements	Curtin element is used to create building façades, such as curtain wall.	Length of the curtain wall and area of the curtain wall
Column	Architectural columns and structural columns	Column width, column depth and column volume.
Beam	Beams are structural elements for load bearing applications.	Length of beam, volume of beam Steel Beam Section area, nominal weight, Flange width, depth of section, k distance, k2 distance, Flange thickness, web thickness
Foundation	Wall Foundations Isolated Foundations Foundation Slabs	Elevation at bottom for all foundations: Length, width and volume of the wall foundation Width, length and thickness of isolated foundations Slope, perimeter, area, volume of the foundation slab

Source: Autodesk, 2013

Table 29: Building elements in Autodesk Revit 2013[180]

[180] Wu, et al., 2014, p.36

Appendix C

Group element 2: Superstructure					
Element	**Sub-element**	**Component**	**Unit**	**Required Quantity Information from BIM** (in accordance with the rules of measurement)	**Notes/remarks**
2.1 Frame	1 Steel frames	1 Structural steel frame	t	The total mass of the steel frame including, • Structural components - columns, beams, composite columns and beams, lattice beams, braces, struts and the like • Fittings and Fixtures • Roof trusses which are an integral part of the frame • Floor and roof members or decks forming an integral part of the frame	It will be modelled in structural element with steel as the property type and the nominal weight of the element is available from the element quantity information
	2 Space frames/ decks	1 Space frames/decks	m²	• Area of the upper floors	Quantity information from area / area plan
	3 Concrete casings to steel frames	1 Column casings	m	• Number and size of columns • Type of formwork finish	Quantity information is available from column element, formwork finish is not usually in the model
		2 Beam casings		• Number and size of beams • Type of formwork finish	Quantity information is available from column element, formwork finish is not usually in the model
	4 Concrete frames	1 Columns	m	• Number and size of columns • Type of formwork finish	Quantity information is available from column element, formwork finish is not usually in the model
		2 Beams		• Number and size of beams • Type of formwork finish	Quantity information is available from beam element, formwork finish is not usually in the model
		3 Walls		• Area and thickness of walls	Quantity information is available from wall element, formwork finish is not usually in the model
		4 Extra over walls for forming openings in walls for doors, windows, screens and the like	nr	• Sizes and number of openings	Quantity information from opening object or doors and window object
		5 Designed joints	m		
	5 Timber frames	1 Timber frames	m²	• Area of the upper floors	Quantity information from area / area plan
	6 Specialist frames	1 Specialist frame	m²	• Area of the upper floors	Quantity information from area / area plan
2.2 Upper floors	1 Floors	Concrete floors: 1 Suspended floor slabs	m²	• Area of the upper floors • Area of each floor construction type • Areas for balconies, galleries, tiered terraces, service floors, walkways, internal bridges, external links and roofs to internal buildings	Quantity information from floor element with different type information
		2 Edge formwork	m	• Length of edge formwork	Quantity information from floor element (perimeters)
		3 Designed joints		N/A	
		4 Surface treatments	m²	• Area of the upper floors	Quantity information from area / area plan or floor element

Table 30: The information requirements for BIM element cost planning (a)[181]

[181] Wu, et al., 2014, p.36,p.37, p.38, p.39.

Group element 2: Superstructure					
Element	**Sub-element**	**Component**	**Unit**	**Required Quantity Information from BIM** (in accordance with the rules of measurement)	**Notes/remarks**
2.2 Upper floors *(continued)*	1 Floors *(continued)*	Precast/composite decking systems: 5 Suspended floor slabs	m²	• Area of the upper floors • Area of each floor construction type • Areas for balconies, galleries, tiered terraces, service floors, walkways, internal bridges, external links and roofs to internal building	Quantity information from area / area plan or floor element
		Timber Floors: 6 Timber Floors	m²	• Area of the upper floors • Where more than one type of floor construction type, area of each floor construction type • Areas for balconies, galleries, tiered terraces, service floors, walkways, internal bridges, external links and roofs to internal buildings	Quantity information from area / area plan or floor element
		Structural screeds: 7 Structural screeds		• Area to which screed is applied	Quantity information from floor element with different type information
	2 Balconies	1 Balconies	nr	• Number and area of balconies	Quantity information from the actual object if it is modelled separately.
	3 Drainage to balconies	1 Rainwater pipes	m	• Length of rainwater pipes	Quantity information from the actual object if it is modelled separately.
		2 Floor outlets	nr	• Number of floor outlets	Quantity information from the actual object if it is modelled separately.
		3 Testing of installations	%	N/A	
		4 Commissioning of installations			
2.3 Roof	1 Roof structure	1 Roof structure-pitched roofs	m²	• Area of the roof on plan • Design load, span, and angle of pitch	Quantity information from roof element, please note the area information from the element is the actual roof area, not the area on plan.
		2 Extra over roof structure- pitched roofs for forming dormer			
		3 Prefabricated dormers	nr		
		4 Roof structure-flat roofs	m²		
	2 Roof covering	1 Roof coverings, non-structural screeds, thermal insulation, and surface treatments	m²	• Surface area of the roof covering • Where more than one type of roof covering, area of each roof covering system	Detailed roof element can be added in the overall roof element, quantity information is available from the individual elements
		2 Extra over roof coverings for coverings to dormers, including cladding to dormer cheeks		• Area of rooflights, skylights and openings • Surface area of the dormer roof coverings	
		3 Eaves, verge treatment to pitched roofs	m	• Lengths of eaves, verge, edges	

Table 31: The information requirements for BIM element cost planning (b)[182]

[182] Wu, et al., 2014, p.36,p.37, p.38, p.39.

Group element 2: Superstructure					
Element	**Sub-element**	**Component**	**Unit**	**Required Quantity Information from BIM** (in accordance with the rules of measurement)	**Notes/remarks**
2.3 Roof *(continued)*	2 Roof covering *(continued)*	4 Edge treatment to flat roofs	m	• Lengths of eaves, verge, edges	Detailed roof element can be added in the overall roof element, quantity information is available from the individual elements
		5 Flashings			
	3 Specialist roof systems	1 Specialist roof systems	m²	• Area of the glazed roof on plan	
	4 Roof drainage	1 Gutters	m	• Length of gutters • Length of pipes	
		2 Rainwater pipes			
		3 Testing of installations	%	N/A	
		4 Commissioning of installations			
	5 Rooflights, skylights and openings	1 Rooflights, skylights and openings	nr/ m²	• Number of rooflights, skylights and openings • Area of rooflights, skylights and openings	
	6 Roof features	1 Roof features	nr	• Number of components	
2.4 Stairs and ramps	1 Stair/ramp structures	1 Stair structures	nr	• Number of storey flights • Vertical rise	Quantity information from the stair element.
		2 Ramp structures			
	2 Stair/ramp finishes	1 Stair finishes	nr	• Number of storey flights • Vertical rise	
		2 Ramp finishes			
	3 Stair/ramp balustrades and handrails	1 Wall handrails	nr	• Number of storey flights • Vertical rise	
		2 Combined balustrades and handrails			
	4 Ladders/ chutes/ slides	1 Ladders	nr	• Number of ladders/chutes/slides	Quantity information from the actual object if it is modelled separately
		2 Chutes			
		3 Slides			
2.5 External walls	1 External enclosing walls above ground level	1 External walls	m²	• Area of the external wall • Where more than one external wall system is employed, area of each external wall system	Quantity information from wall element with different type
		2 Extra over external walls for plinths, cornices, ornamental bands and the like		• Details of plinths, cornices, ornamental bands and the like	Quantity information from the actual object if it is modelled separately.
		3 Extra over external walls for quoins	m	• Length of quoins	
		4 Extra over external walls for forming openings for windows	nr	• Number and dimensions of windows • Number and dimensions of external doors	Quantity information from the relevant door and window element
		5 Extra over external walls for forming openings for external doors			

Table 32: The information requirements for BIM element cost planning (c)[183]

[183] Wu, et al., 2014, p.36,p.37, p.38, p.39.

Group element 2: Superstructure					
Element	**Sub-element**	**Component**	**Unit**	**Required Quantity Information from BIM** (in accordance with the rules of measurement)	**Notes/remarks**
2.5 External walls *(continued)*	1 External enclosing walls above ground level *(continued)*	6 Extra over cladding or curtain walling system for integral photovoltaic panels	nr	• Number integral photovoltaic panels	Quantity information from the actual object if it is modelled separately.
		7 Extra over cladding or curtain walling system for integral opening vents and panels	nr/ m²	• Area of cladding or curtain walling system • Number and dimensions of integral opening vents and panels	
		8 Projecting fins to cladding or curtain walling system	nr	• Number of projecting fins	Quantity information from the actual object if it is modelled separately
		9 Extra over projecting fins for applied artwork	item	• Details of applied artwork	
		10 Safety barriers, handrails or combined balusters and handrails to facetted glazing or cladding systems	nr/m	• Number of safety barriers, handrails or combined balusters and handrails • Length of facetted glazing or cladding systems	
		11 Finishes applied to external walls	m²	• Surface area of the external wall finishes	Quantity information from the relevant wall element
	2 External enclosing walls below ground level	1 External walls	m²	• Area of the external wall • Where more than one external wall system is employed, area of each external wall system	Quantity information from wall element with different type
		2 Extra over external walls for plinths, cornices, ornamental bands and the like	m	• Details of plinths, cornices, ornamental bands and the like	Quantity information from the actual object if it is modelled separately
		3 Extra over external walls for quoins		• Length of quoins	
		4 Extra over external walls for forming openings for windows	nr	• Number and dimensions of windows • Number and dimensions of external doors	
		5 Extra over external doors walls for forming openings for external doors			
		6 Finishes applied to external walls		• Surface area of the external wall finishes	Quantity information from wall element
	3 Solar/rain screening	1 Vertical solar/rain screening	m²	• Area of the overcladding system • Where more than one type of overcladding system is employed, the area for each overcladding system	Quantity information from the actual object if it is modelled separately.
		2 Horizontal solar/rain screening	m	• Length of horizontal solar/rain screening	
	4 External soffits	1 External soffit	m²	• Area of each type of external soffit	
		2 Cornices, covings and the like	m	• Length of cornices, covings and the like with details	

Table 33: The information requirements for BIM element cost planning (d)[184]

[184] Wu, et al., 2014, p.36, p.37, p.38, p.39.

Group element 2: Superstructure					
Element	**Sub-element**	**Component**	**Unit**	**Required Quantity Information from BIM** (in accordance with the rules of measurement)	**Notes/remarks**
2.8 Internal doors *(continued)*	1 Internal doors *(continued)*	2 Fire resisting doors	nr	• Number of fire resisting doors • Dimensions of each type of door leaf • Dimensions of overall openings	Quantity information from door element with different type information and door property set as interior
		3 Door sets		• Number of door sets • Dimensions of each type of door leaf • Dimensions of overall openings	
		4 Composite door and sidelights/over panel units		• Number of door composite door and sidelights/over panel units • Dimensions of each type of door leaf • Dimensions of overall openings	
		5 Roller shutters, sliding shutters, grilles and the like		• Number of Roller shutters, sliding shutters, grilles and the like • Dimensions of overall openings	
		6 Architraves	m	• Length of architraves	
				of each type of internal walls	
		2 Extra over internal walls for forming openings in walls for internal doors and the like	nr	• Number of openings in walls for internal doors and the like • Overall size of openings	
		3 Fixed partitions	m²	• Area of partitions • Where more than one type of partitions is employed, area of each type of partitions	
		4 Extra over fixed partitions for forming openings in partitions for internal doors and the like	nr	• Number of openings in partitions • Overall size of openings	
	2 Balustrades and handrails	1 Combined balustrades and handrails	m	• Length of internal balustrades/ handrails/ other fixed non-storey height divisions • Where more than one component is used, length of each component	Quantity information from the actual object if it is modelled separately
	3 Moveable room dividers	1 Moveable room dividers and partitions	m	• Length of moveable room dividers/ partitions • Where more than one component is used, length of each component	
	4 Cubicles *(continued)*	1 Cubicles	nr/ m/m²	• Number of cubicles • Dimensions	
		2 Fixed partitions		• Number of fixed partitions • Dimensions	
2.8 Internal doors	1 Internal doors	1 Internal doors	nr	• Number of internal doors • Dimensions of each type of door leaf • Dimensions of overall openings	Quantity information from door element with different type information and door property set as interior

Table 34: The information requirements for BIM element cost planning (e)[185]

[185] Wu, et al., 2014, p.36, p.37, p.38, p.39.

Appendix D

Ứng dụng BIM (Building Information Modeling) trong quá trình tính tiên lượng và dự toán/Implementation of BIM in terms of quantity take-offs (QTO) and Estimation

Trong khuôn khổ luận văn thạc sĩ nghiên cứu về ứng dụng BIM (Building Information Modeling) trong quá trình tính tiên lượng và dự toán ở Việt Nam, tại trường đại học Khoa học ứng dụng HTW Berlin Đức, tôi xin gửi tới Quý Anh/Chị bảng câu hỏi với mong muốn nhận được thông tin đánh giá của Anh/Chị trên quan điểm cá nhân về nội dung trên. Tôi xin cam kết mọi thông tin do Anh/Chị cung cấp được giữ bí mật, chỉ phục vụ cho mục đích nghiên cứu điều tra khảo sát, không sử dụng cho bất kỳ mục đích nào khác.

Mọi thông tin và câu hỏi liên quan đến Bảng Điều tra này xin Anh/Chị vui lòng liên lạc với tôi Ngô Thị Vân Nhạn. Email: ngovannhan55@gmail.com.

Rất mong nhận được sự hợp tác, giúp đỡ của Quý Anh/Chị!
Tôi xin chân thành cảm ơn!

NEXT

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Table 35: Online questionnaire - Google Forms [186]

[186] Own tabulation

Ứng dụng BIM (Building Information Modeling) trong quá trình tính tiên lượng và dự toán/Implementation of BIM in terms of quantity take-offs (QTO) and Estimation

* Required

Thông tin chung/Basic information

1. Họ và tên Anh/Chị? What is your full name? *

Your answer

2. Chuyên ngành làm việc của Anh/Chị? What is your major? *

- ○ Kỹ sư kinh tế xây dựng; dự toán/Quantity surveyor; Estimator
- ○ Kiến trúc sư/Architect
- ○ Kỹ sư kết cấu/ Structure engineer
- ○ Kỹ sư MEP/MEP engineer
- ○ Kỹ sư xây dựng/Civil engineer
- ○ Other: ____

3. Anh/Chị có bao nhiêu năm kinh nghiệm làm việc với chuyên ngành của mình? How many years have you been working in your field? *

- [ ] 0 đến 03 năm/0 to 03 years
- [ ] 03 đến 05 năm/03 to 05 years
- [ ] 05 đến 10 năm/05 to 10 years
- [ ] 10 đến 15 năm/10 to 15 years
- [ ] 15 đến 20 năm/15 to 20 years
- [ ] Trên 20 năm/More than 20 years
- [ ] Other: ____________

4a. Anh/Chị đang làm việc cho loại hình công ty nào? What kind of company are you working for? *

- ○ Công ty đầu tư xây dựng (chủ đầu tư)/Construction Investment company(Investor)
- ○ Công ty tư vấn xây dựng /Construction consultant company
- ○ Công ty xây dựng (nhà thầu)/Constructor
- ○ Công ty tư vấn và ứng dụng BIM/BIM consultant company
- ○ Công ty quản lý và vận hành dự án (công trình)/Owner
- ○ Trường đại học, cao đẳng, trường dạy nghề/University/ School, Vocational school
- ○ Công ty quản lý xây dựng nhà nước (Ví dụ: Bộ xây dựng, Viện kinh tế bộ xây dựng..)/State company (example: Ministry of Construction, Institute of Construction Economics..)
- ○ Other:

4b. Tên đơn vị công tác (công ty) Anh/Chị hiện đang làm việc?

Câu hỏi tùy chọn không bắt buộc/ optional question

Your answer

5. Vị trí công tác của Anh/Chị tại công ty? What is your position in the company? *

- [ ] Lãnh đạo doanh nghiệp/Top manager; Director; Vice Director
- [ ] Lãnh đạo bộ phận/Manager of Department
- [ ] Quản lý/ điều hành dự án/ Manager; Project manager
- [ ] Trưởng nhóm/Team leader
- [ ] Nhân viên/Staff
- [ ] Other: ____________

BACK NEXT

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Thời gian để đào tạo nhân viên là quá lâu, chi phí cho nâng cấp phần cứng, mua phần mềm BIM là quá cao/Time needed to train staff is long, cost to update hard software and buy BIM software are expensive	○	○	○	○	○
BIM ít hoặc không quan trọng trong tương lai/Believed that BIM is low or no importance in future	○	○	○	○	○
BIM là không hiệu quả trong dự án nhỏ/Believed that BIM is less efficient on smaller projects	○	○	○	○	○
Không có cạnh tranh thương mại ngay khi sử dụng BIM trong dự án/ no immediate competitive threat resulting from BIM non-use	○	○	○	○	○
Không có quy định luật pháp thích hợp để hỗ trợ quá trình ứng dụng BIM/Lack of appropriate legal framework	○	○	○	○	○
Thiếu chương trình đào tạo về BIM/Lack of BIM training program	○	○	○	○	○
Thiếu chuyên gia BIM/Lack of BIM expertise	○	○	○	○	○
Không có hiểu biết nội bộ về BIM/Lack of internal understanding of BIM	○	○	○	○	○

11. Ngoài những nguyên nhân được đưa ra ở trên, theo Anh/Chị còn có những nguyên nhân khác khiến ứng dụng của BIM không (chưa) áp dụng ở Việt Nam? Other reasons for limiting in deploying BIM in Viet Nam?
Câu hỏi tùy chọn không bắt buộc/ optional question

Your answer

12. Lý do Anh/Chị chọn "không đồng ý" hoặc "hoàn toàn không đồng ý" với những nguyên nhân nêu ở câu hỏi số 10? Could you give some reasons for choosing "strongly disagree" or "disagree" with question 10?
Câu hỏi tùy chọn không bắt buộc/Optional question

Your answer

Ứng dụng BIM (Building Information Modeling) trong quá trình tính tiên lượng và dự toán/Implementation of BIM in terms of quantity take-offs (QTO) and Estimation

* Required

Lý do hạn chế triển khai BIM/Reasons for limiting in deploying BIM

13. Theo Anh/Chị nguyên nhân nào dẫn đến việc hạn chế triển khai BIM trong dự án xây dựng hoặc trong quá trình tính tiên lượng, dự toán? What are reasons for limiting in deploying BIM in the construction project or in the QTO and Estimation process? *

Anh/Chị cho ý kiến theo nguyên nhân được liệt kê dưới đây.

	Hoàn toàn đồng ý/ Strongly Agree	Đồng ý/Agree	Không có ý kiến/ Neutral	Không đồng ý	Hoàn toàn không đồng ý/ Strongly Disagree
Khó chọn phần mềm BIM (công cụ BIM)/Choosing the BIM tools	○	○	○	○	○
Phần mềm BIM phức tạp /Software complexity	○	○	○	○	○
Mất quá nhiều thời gian cho việc tạo mô hình BIM với đầy đủ thông số từ đầu/The big amount of time and effort to build the BIM models from the beginning	○	○	○	○	○

Mất quá nhiều thời gian cho việc tạo mô hình BIM với đầy đủ thông số từ đầu/The big amount of time and effort to build the BIM models from the beginning	○	○	○	○	○
Công ty chỉ sử dụng BIM để thực hiện một số chức năng nhất định như xây dựng mô hình 3D mà không cần dùng để tính khối lượng hay lập dự toán/The company use BIM tools to do its certain functions such as building 3D models, no need to use it for QTO and estimation	○	○	○	○	○
Thiếu dữ liệu/thông tin từ mô hình BIM để triết xuất tiên lượng và tính dự toán / The missing data for QTO and estimation from Models	○	○	○	○	○
Thời gian để học cách sử dụng phầm mềm BIM quá lâu/Time to learn how to use the BIM tool to do QTO is long	○	○	○	○	○
Khó xác định lỗi trong quá trình chiết xuất tiên lượng bằng phương pháp BIM/Defining the mistakes of calculation process	○	○	○	○	○
Khó theo dõi (kiểm tra) khối lượng thực tế từ mô hình/Tracking the actual QTO	○	○	○	○	○

Mô hình BIM không đúng/BIM Model is not corrects	○	○	○	○	○
Thiếu hiểu biết về quy trình làm việc khi sử dụng phương pháp BIM để tính tiền lượng và hỗ trợ quá trình lập dự toán/Lack of understanding workflow with BIM base QTO and estimation process	○	○	○	○	○
Thói quen hoặc quy định sử dụng bộ định mức và đơn giá xây dựng khi lập dự toán và bộ định mức/đơn giá này khó có thể tích hợp với phần mềm BIM	○	○	○	○	○
Khó bảo vệ khối lượng, giá trị dự toán với đơn vị thẩm tra nếu sử dụng BIM để tính khối lượng, dự toán	○	○	○	○	○
Thiếu phần mềm dự toán BIM/Lack of BIM estimating software	○	○	○	○	○
Bản vẽ phải thực hiện trên phần mềm BIM thì sau đó mới có thể dùng để chiết xuất tiên lượng và lập dự toán theo phương pháp BIM được/Drawings must produce in a BIM software, and must be available to the estimator	○	○	○	○	○

Khối lượng chiết xuất từ mô hình BIM không thể dùng trực tiếp để tính nhân công và thiết bị do thiếu phương pháp thi công kèm theo/lack of context for construction methods and procedures, these material quantities cannot be used directly to generate labor and equipment quantities	○	○	○	○	○
Lo ngại về phương pháp BIM có thể thay thế vai trò của kỹ sư dự toán trong tương lai/Concerns of BIM technology will replace quantity surveyors and estimators, no needs of their roles in futures	○	○	○	○	○

14. Ngoài những nguyên nhân được đưa ra ở trên, theo Anh/Chị còn có những nguyên nhân khác khiến ứng dụng của BIM còn hạn chế ở Việt Nam? Other reasons for limiting in deploying BIM in Viet Nam?

Câu hỏi tùy chọn không bắt buộc/ optional question

Your answer

15. Lý do Anh/Chị chọn "không đồng ý" hoặc "hoàn toàn không đồng ý" với những nguyên nhân nêu ở câu hỏi số 13? Could you give some reasons for choosing "strongly disagree" or "disagree" with question 13?

Câu hỏi tùy chọn không bắt buộc/ optional question

Your answer