BIM READINESS IN SRI LANKAN ARCHITECTURAL ENGINEERING AND CONSTRUCTION (AEC) INDUSTRY.

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DECLARATION

"I declare that this is my own work and this thesis does not incorporate without acknowledgement any material previously submitted for Degree or Diploma in any other University or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

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ABSTRACT

Construction industry highly influences on improving the infrastructure industry of a country. Architectural Engineering and Construction (AEC) industry always focuses on reducing inefficiencies, enhance the productivity and increasing the communication. Construction industry is highly turbulent and complex in nature as number of suppliers, employees, materials and machinery work in a construction site. One of the major challenges in the construction industry is communication and coordination between different disciplines involved in the industry like authorities, local & foreign governments, financial authorities & institutes, engineers, architect, lawyers, quantity surveyors, contractors, suppliers, community and trades. Building Information Modeling (BIM) is currently the most common denomination for a new way of approaching the design, construction, and maintenance of buildings. According to the literature and industrial reports BIM implementation is in primary stage in Sri Lanka. The researcher aims to develop suitable framework to assess BIM readiness of construction organizations.

The researcher followed both interpretivism and positivism to conduct this research study. Because BIM is currently on a radical development arround the world and also is a novel idea to Sri Lankan industry. The researcher identified several factors such as importance of management, importance of process, importance of people and importance of technology which infleunces on level of BIM readiness. Both qualitative and quantitative data were used to understand the practice of BIM in Sri Lanka and collect employees' view.

The research result stated that all the factors such as importance of management, importance of process, importance of people and importance of technology highly infleunces on BIM implementation in Sri Lanka in different perspectives.

DEDICATION

I dedicated this research to my loving wife and to my family members for their commitment and cooperation for the success of this thesis.

I dedicated this thesis to research supervisor, Ch.QS.(Mr.) Suranga Jayasena, pioneer Building Information Modeling researcher in Sri Lanka for his valuable guidance and valuable assistance towards the success of this thesis and also I dedicated this thesis to Programme Director, all of my lectures, programme coordinator and colleagues for their valuable support and guidelines.

And also I would like to dedicate this thesis for all professionals who had share their experience and knowledge regarding the Building Information Modelling in Sri Lanka and also for all professionals for their effort to delivering successful Building Information Modelling implementation in Sri Lanka.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATION

GDP	-	Gross Domestic Product
AEC	-	Architectural Engineering and Construction
R & D	-	Research and Development
IT	-	Information Technology
BIM	-	Building Information Modelling
ICT	-	Information Communication and Technology
ICTAD	-	Institute of Construction Training & Development
LAN	-	Local Area Network
CMMI	-	Capability Maturity Model Integrated
SPICE	-	Structured process improvement for construction enterprises
GPS	-	General Practitioner Information System
BIMMi	-	Building Information Maturity Index
CAD	-	Computer Aided Design
2D	-	Two Dimensional
CDE	-	Common Data Environment
ROI	-	Return Of Investment.

1. INTRODUCTION

1.1. Introduction

Most of the countries generate high economic value from the construction industry as it helps to enhance the infrastructure system of the country. Architectural Engineering and Construction (AEC) industry always focuses on reducing inefficiencies, enhance the productivity and increasing the communication (Alabdulqader, Panuwatwanich, & Doh, 2011). The nature of the construction industry is very complex and difficult to manage because of the large number of human resource, materials, and machines used in the construction process. One of the major challenges in the construction industry is communication and coordination between different disciplines involved in the industry like authorities, local & foreign governments, financial authorities & institutes, engineers, architects, lawyers, quantity surveyors, contractors, suppliers, communities, and trades (Alaloul, Liew, & Zawawi, 2016). Therefore, Information and Communication Technology (ICT) can be used to manage the employees efficiently and direct them towards their vision, mission effectively along with their strategic plans. Building Information Modeling (BIM) is currently the most common denomination for a new way of approaching the design, construction, and maintenance of buildings (Bryde, Broquetas, & Volm, 2013). The successful implementation of BIM technology is beneficial for project stakeholders throughout the project lifecycle. The first chapter of the research document aims to explain the research background, rationalize the research background and to explain the problem statement. Further, the researcher describes the aims and objectives of the research questions that can be used to solve the research problem of this study. In addition, the significance of the study is a more important section in this research document as it explains the importance of the study to the particular group of people.

1.2. Background of the Study

The construction industry is one of the largest industries around the world (Matarneh & Hamed, 2017). The construction projects are highly complex as it associates

different activities and difficult to manage changes in the middle, planning and gap between the design of the project and construction site (Alaloul, Liew, & Zawawi, 2016). Yet it is also known to be highly turbulent and complex, this industry contribute a huge amount to the Gross Domestic Product (GDP) in most of economies according to the Table 1-1.

Table 1-1: GDP of the countries and construction industry

Country	Contribution of Construction industry to GDP			GDP of country	
	Amount	Currency	Month / Year	Amount (USD Billion)	Month / Year
Sri Lanka	171,094.00	Sri Lankan Rupee Million	12 / 2018	87.17	12 / 2017
Canada	138,536.00	Canadian Dollar Million	02 / 2019	1,653.04	12 / 2017
China	10,528.60	Chinese Yuan in H undred Million	03 / 2019	12,237.70	12 / 2017
Australia	34,105.00	Australian Dollar	12 / 2018	1,323.42	12 / 2017
Japan	29,714.00	Japan Yen Million	12 / 2017	4,872.14	12 / 2017
Saudi Arabia	28,856.00	Saudi Arabian Riyal Million	12 / 2018	683.83	12 / 2017
United Kingdom	28,286.00	British Pound Million	12 / 2018	2,622.43	12 / 2017
Malaysia	13,695.00	Malaysian Ringgit Million	12 / 2018	314.71	12 / 2017

Source: (Trading Economics, 2019)

Gross domestic product is the total value of everything produced in a country. Contribution from the construction industry to GDP is explaining the value of the construction to the economy as a key industry.

According to the Cabinet Office, (2011 cited in Chen, 2015), construction industry does not fully utilize the advanced technology methods with their work. While considering Sri Lanka's economy along with the construction sector, we have to consider the Gross Domestic Product (GDP) from construction. Most of the countries consider construction industry as the most challenging industry as issues with profitability, poor productivity, skilled labor shortage, low investment in Research and Development (R & D) compare with other industries and clients tend to select the lowest bid for the work (Haron, 2013). The condition of construction industry is complex due to improper planning, lack of coordination and communication, subcontractor delay and non-selection of the correct procurement methods. The previous literature explains that most of the client complaints are due to the inefficiency of the construction sites and huge wastage of resources. When compared with other industries, the construction industry is not much efficient, behind the productivity level; most of the time cannot achieve the quality defined by the clients and less sustainability. All most all the industries adapt to the Information Technology (IT) but still, construction industry shows low progress with adapting new technology.

According to the Gray, Gray, Teo, Chi, & Cheung (2015) stated that Building Information Modeling (BIM) is considered as an evolutionary way of delivery projects in AEC. This BIM related softwares also named as n-D modeling or virtual prototyping technology (Azhar, Khalfa, & Maqsood, 2012). The literature revealed that BIM is the best solution to fill the gap between the construction industry and Information Technology (Alaloul, Liew, & Zawawi, 2016). Moreover, the concept of BIM allows the industry to improve the quality of projects, manage the schedule, cost-effectiveness, and sustainability of each project. They allow users to visualize the design and identify the construction issues or operationalization issues as this provides to view the design in 3-D format. This tool makes it easy to communicate with clients, construction companies, architectural companies and all other stakeholders in real time. In addition, by using this technology, engineers, facility managers, and other managerial parties can easily manage the building design and relevant data through the construction lifecycle. BIM related software includes

functions such as creating, storing and managing building-related information, identifying the relevant standards to complete the project and manage the project during the project life cycle.

The culture of Architectural Engineering and Construction (AEC) industry does not allow reusing and sharing the information. Most of the information regarding with the project is not reused during the project life cycle, and also poor communication between stakeholders create many issues in the AEC (De Silva , Rajakaruna , & Bandara , 2010).

Since this research is limited to Sri Lanka it is better to find the current status of construction industry in Sri Lanka. The construction market in Sri Lanka has been very active with the entire market size. De Silva , Rajakaruna , & Bandara (2010) explained how Sri Lankan construction industry highly contributes to the economics of the country. The construction industry faces many challenges and difficulties to continue their work effectively due to many reasons. The problems can be explained as socio-economic stress, resource shortage, weaknesses of institutes and inability to address the key issues (Fadeyi, 2017). Nagalingam, Jayasen, & Ranadewa (2013) explained that fluctuation of construction workload, competition from foreign companies, shortage of skills and having to invest huge costs on developing skills were main problems in Sri Lankan construction industry. Construction industry is the fourth highest contributor in developing the national economy of the country (Kugbeadjor , Suresh , & Renukappa, 2016). The construction industry of Sri Lanka has a wide range of products from individual houses to larger infrastructure buildings such as medium and high rise buildings, highways and road networks. According to the data, the construction industry provides employment for 4% to 5% of the labor force and contributes approximately 30 % to trade balance (De Silva , Rajakaruna , & Bandara , 2010). Raftery, (1991 cited in Weddikkara & Devapriya, 2015) stated that construction output can be used to explain the demand in the construction industry. In Sri Lanka, housing, industrial and infrastructure sector largely contributes to the construction output of the country.The Census department stated

several construction activities with their values. According to the survey of the construction industry was done in 2015 in Table 1-2

Table 1-2: Value of Construction activities on 2015(As per the latest statistics)

Type of Construction Activity	Value of work done (Rs. Mn)	%
Buildings (Residential)	52,078	13.1
Non-residential Buildings	51,930	13.1
Roads & Railways	192,559	48.4
Utility Projects	37,049	9.3
Other Civil Engineering Projects	16,364	4.1
Electrical, Plumbing and Other Construction Installation Activities	20,667	5.2
Building Completion & Finishing	1,278	0.3
Other Construction	25,845	6.5
Total	**397,770**	**100.0**

Source: (Department of Census and Statistics, 2015)

According to Table 1-2, the total value of work covering all the different construction activities in Sri Lanka was Rs. 397, 770 million. Further, the highest contribution has been done by road and railway construction sector in Sri Lanka which is 192,559 million. Second, highest contribution to the total construction value has been done by resident building constructions. The data revealed that three types of entities carried out the construction work in Sri Lanka namely; registered contractors under the Institute of Construction Training & Development (ICTAD), unregistered local contractors and international contractors. The safety is very important in any sector and construction industry needs to be more concerned about the safety as it involves complex activities and a larger number of human workforce. Hettiarachchie Don (2012) explained that most of the accidents happen due to human which is reported to be 80 %. Further, this report explained that even Sri Lanka earns high income from construction industry the safety and accidents in the

construction industry can show in the upward diagram. The Sri Lankan safety standards are lower than most of the other countries in the world.

1.3. Rationale

Small and Medium-size Enterprise (SME) in developed countries have still not adopted BIM for their work (Rodgers, Hosseini, Chileshe, & Rameezdeen, 2015). Most of the Small and Medium-size Enterprise (SME) have less awareness and knowledge of BIM in Australia. Therefore, the SMEs have a negative perception towards the requirement of BIM and BIM implementation. Sri Lanka is still developing country and Rodgers, Hosseini, Chileshe, & Rameezdeen (2015) statement can be used as strong evidence to explan the inability of SME in Sri Lanka to adapt to BIM in construction industry. Azhar, Khalfa, & Maqsood (2012) explained BIM has changed the building design, and operation of each project. The main advantage of the BIM as explained by Rodgers, Hosseini, Chileshe, & Rameezdeen (2015) was to increase the profitability of the project, reduce cost, better time management and improve the relationship between clients, the company and other stakeholders. According to the literature, most of the construction companies around the world have less motivation to use BIM in their organization due to the challenges of the new module implementation in their organization and interacting with it. Nagalingam, Jayasen, & Ranadewa (2013) stated that BIM helps to achieve the triple bottom line named economic, social and environment successfully. However, Sri Lanka does not use BIM in project management lifecycle in construction industry though it differentiates the project lifecycle in traditional procurement systems (Epasinghe, Jayasena, Kolugala, & Wijewickrama, 2018). Therefore, the research area has high value in Sri Lankan construction industry and framework developed through this study helps to implement the BIM successfully and face the challenges during the implementation successfully.

1.4. Problem Statement

The Information Communication Technology (ICT) plays very important role in most of the industries now to improve the performances of the companies (Alabdulqader, Panuwatwanich, & Doh, 2013). When compared with other

industries, there is less motivation to use technology and adapt to the technology in the construction industry even if the industry is highly complex. It is essential to investigate the impact of Information Technology (IT) in construction industry to realize the benefits of IT related models. BIM implementation moves from technology and has added management, the process of the industry, people and policy (Azhar, Khalfa, & Maqsood, 2012). This enhances the complexity of BIM which minimizes the interest of construction companies towards the system.

LMD (2018) explained that the construction industry contributed Rs. 200,970 by the end of the fourth quarter in the year 2016 to Sri Lankan GDP. This is considered as an improvement in the construction industry when comparing with the statistics of the year 2010. Further, the statistics proved that the improvement in annual contribution to the GDP from the year 2009 which was 6.6 %, was 8.7 % in 2013 and that of the year 2014 was 9.6 %. According to the construction industry related reports, it is stated that there is a boom in the industry. The main challenges currently faced by the construction segment in Sri Lanka is; inability to carry out operations efficiency and effectively and obtaining the approval at the right time. As an example LMD (2018) stated that Shangri La hotel had to face so many administrative delays as it is the first mixed development in Sri Lanka. In addition, the lack of skilled labor highly causes delays on the projects (Weddikkara & Devapriya , 2015). Most of the construction companies stated that due to the health hazard and high risk in the construction segment most of the young people do not like to engage with the industry now and other skilled labors increase their values by considering all the fact. The construction industry totally depends on the resources such as cement, sand, and metal and now it is questionable to find quality materials as the durability of a building depends on the quality of materials (Nagalingam, Jayasen, & Ranadewa, 2013). Therefore, it is essential to find alternative resources by using modern technology. Also, currently all the industries focus on sustainability and this is one of the main barriers in the industry now.AEC industry consists of various activities and the long process from the beginning to close out the project. In various stages, various professionals with different backgrounds involve in the project. As an example, in the initial phase the architect needs to check with the land and come up

with a suitable design and structural engineers and many other professionals join in order to implement the project (Azhar, Khalfa, & Maqsood, 2012). Therefore, most of the time conflicts arise between stakeholders due to the difference in interests, benefits, risk and maturity levels based on their backgrounds and discipline. It is difficult to take the best decision due to the professional to represent a wider range of knowledge areas. Different people have different ideas regarding BIM implementation due to their varied levels of experience and knowledge. This highly impacts on BIM usage level and performances within the project. Azhar, Khalfa, & Maqsood (2012) stated that in the initial stage of BIM implementation, the companies have to invest the cost of risk and the cost of resources such as training, upgrading hardware and software with license and etc.

Most of the research explained that BIM implementation is re-engineering the business or organization as it needs to have skilled people to work with BIM, hardware to install the BIM and associated software and new services (Bryde, Broquetas, & Volm, 2013). This leads to enhance the risk of the organization as the actual return on investment is lower than expected before implementing the system.

Interoperability issue becomes increasingly important within the construction industry as it will affect the productivity and quality of a project. BIM is currently a trend in construction industry which can be used for solving problems in the industry. But still it shows low adaptation to BIM in Sri Lanka. The barriers in construction industry enhance the barriers that impact of BIM usage. According to the industrial experts, most of the countries show low usage of BIM due to the high cost associated with BIM implementation (Fadeyi, 2017). Currently, most of the companies are aware of modern technology but most of the smaller companies refuse to change as they cannot afford it (Star, 2009).

As BIM is an emerging research area, most of the Sri Lanka scholars have focused on this phenomenon. (Jayasena & Weddikkara, 2012) conducted his study in building information modelling for Sri Lankan construction industry. This study was conducted using literature to understand the industry's potential to develop strategies

for BIM integration. Siriwardhana, Jayasena, Wijewickrama, & Kolugala (2018) focused their study in identify a suitable government initiative strategy that can be adapted to implement BIM in Sri Lanka. But Sri Lankan scholars not focus on BIM readiness, BIM realization and establishing a suitable framework to implement BIM in Sri Lanka by identifying the factors associate with BIM implementation. Hence identify the BIM realization and readiness in Sri Lanka is very important. Therefore, this study fills the current research gap in this industry.

Thus, the researcher problem of this study is;
What factors have an impact on implementing Building Information Modeling (BIM) in Sri Lankan architectural engineering and construction (AEC) industry?

1.5. Aims and Objectives of the Study

The aim of the study is to identify the current status of BIM realization and the readiness of the Sri Lankan construction industry to implement BIM. To achieve the aim of this study the researcher derived the following objectives;

- To identify the framework for the assessment of the status of BIM realization
- To Find the status of BIM realization in Sri Lanka
- To identify a suitable framework to assess BIM readiness of construction organizations
- To find the BIM readiness of Sri Lankan construction organizations.

1.6. Research Questions

The researcher creates the following questions to answer throughout the study and to achieve the objectives of the study.

- What are the frameworks used in literature to analyze the BIM realization?
- What is the current BIM realization in Sri Lanka?
- What is the suitable framework to assess the status of BIM readiness?
- What is the level of BIM readiness of Sri Lankan Construction organization?

1.7. The significance of the Study

The significance of this study can be categorized into two sections as practical significance and academic significance. The researcher needs to develop a framework suitable for BIM implementation in Sri Lankan AEC industry. Therefore, this study contributes to existing knowledge in BIM implementation in AEC as it emphasizes the needs of the industry, necessary criteria of the organizations and necessary factors which are considered more in implementing BIM system in AEC. Also, this study helps to enhance the BIM practical usage in Sri Lanka's AEC. The framework which is explained by the researcher in this study helps to evaluate and improve the BIM implementation in the construction industry. Most of the researchers focus on the BIM industry in their researches as it is a very important area to enhance the efficiency of the industry. Most of the researchers focus on understanding the benefit of BIM in the construction industry as advanced technology helps to enhance the effectiveness and efficiency of different industries. This study tries to develop a framework which is suitable for Sri Lanka's AEC industry as there is less research focusing on this area in the academic background in Sri Lanka. Therefore, this study fills the gap in the academic research in BIM and AEC industry in Sri Lanka.

1.8. Document Outline

The research is a formal effort to find at the suitable solution for the identified problem in a particular subject area (Saunders, Lewis, & Thornhill, 2007). This research document consists of five chapters which explain the different stages of the research process named introduction, literature review, research methodology, data analysis, and conclusion.

The first chapter of this research document is an introduction which focuses on explaining the background of the research area, rationalize to select the particular area and state the problem identified in that area. Moreover, the researcher provides the aims and objectives as it helps to find the right direction to complete the study. In addition, the researcher explains the significance of the study to describe the importance of the study.

The second chapter of this document is a literature review to find a different framework to solve the research problem of this study. The researcher describes the foreign and local literature to analyze this chapter as it helps to find out the different scenarios which might help to solve this research problem. The researcher discusses empirical findings, different models and theories related to the BIM.

The third chapter explains the research methodology of this study as a researcher needs to follow a formal process to complete a research successfully. This chapter explains the research design, research methods, approach and strategies that the researcher uses to complete the study. Further, the researcher explains data collection methods and data analysis which helps to prepare for data interpretation.

The fourth chapter of this research document is data analysis which aims to analyze the collected data by using suitable data analysis methods. The researcher explains the participants' details as it helps to emphasize the accuracy of the final result. The reliability and validity is another aspect which focuses in this section as it helps to prove the accuracy of the final result.

The fifth chapter is the conclusion and recommendation which is the last chapter of this document. This chapter is used to summarize the overall research and provide limitations of the study and further research areas to a future researcher. Further, this chapter summarizes the overall study and provides the recommendation based on the result obtained in chapter four.

2. LITERATURE REVIEW

2.1. Introduction

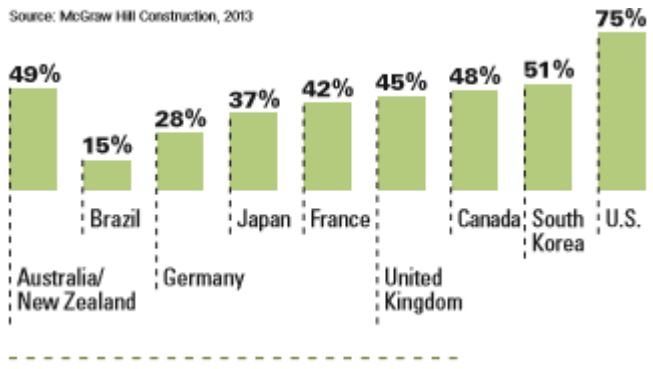
The second chapter named literature review highly influences on developing the suitable framework for the study. A rich literature review must refer to local literature and international literature as those literatures addresses the particular research areas in different manners and different contexts. The researcher mainly focuses on addressing the suitable variables and keywords in this chapter in order to find a suitable framework for this study. In addition, the words BIM readiness and realization are focused more on this chapter as those two are the keywords of the study.

2.2. Building Information Modeling (BIM)

BIM can be explained as a new paradigm with different changes to professionals who work in the construction industry. As explained by the Alabdulqader, Panuwatwanich, & Doh (2013) BIM is considered as a method to manage the building design and project data by using modern technology and digital format. The BIM cannot be introduced as software as it consists of processes and technology but there are several software for most of the engineering disciplinaries. The technological aspect of the BIM helps stakeholders of the project to identify the suitable design for the selected area, and identify the operational issues as explained in Nagalingam, Jayasen, & Ranadewa (2013). The process aspect of the BIM related software helps to collaborate all the stakeholders associated with it and to encourage all the stakeholders to commit to the project based on their expertise level and experience throughout the project life cycle. Nagalingam, Jayasen, & Ranadewa (2013) stated that BIM plays a very important role in the construction industry as it supports to make more reliable design in the design phase, and throughout the construction lifecycle. Parametric object modeling (creation of a digital model based on a series of pre-programmed rules or algorithms known as 'parameters') technology facilitates to create relationships such as physical characteristics and functional characteristics between objects within a virtual building model (Nagalingam,

Jayasen, & Ranadewa, 2013). Most of the research studies stated that BIM is not a software application but it is an IT solution which links with the software applications and IT tools to design a building by using a common platform. This is different from traditional Computer Aided Design (CAD) system. Mandhar & Mandhar (2013) stated that the BIM system helps to increase the efficiency, accuracy, speed, consistency, decrease the cost of project, decrease the environmental effects and etc. As explained in this study, the UK government takes a cabinet decision to mandate the 3D BIM system in all public sector organizations where public money is funded. This system transforms the way that engineers, contractors, architects and other professionals work in the construction industry and this software comes in 3D format, the stakeholders of the project can visualize and analyze the structure, services and facility management of the building easily.

Figure 2-1: Percentage of BIM users



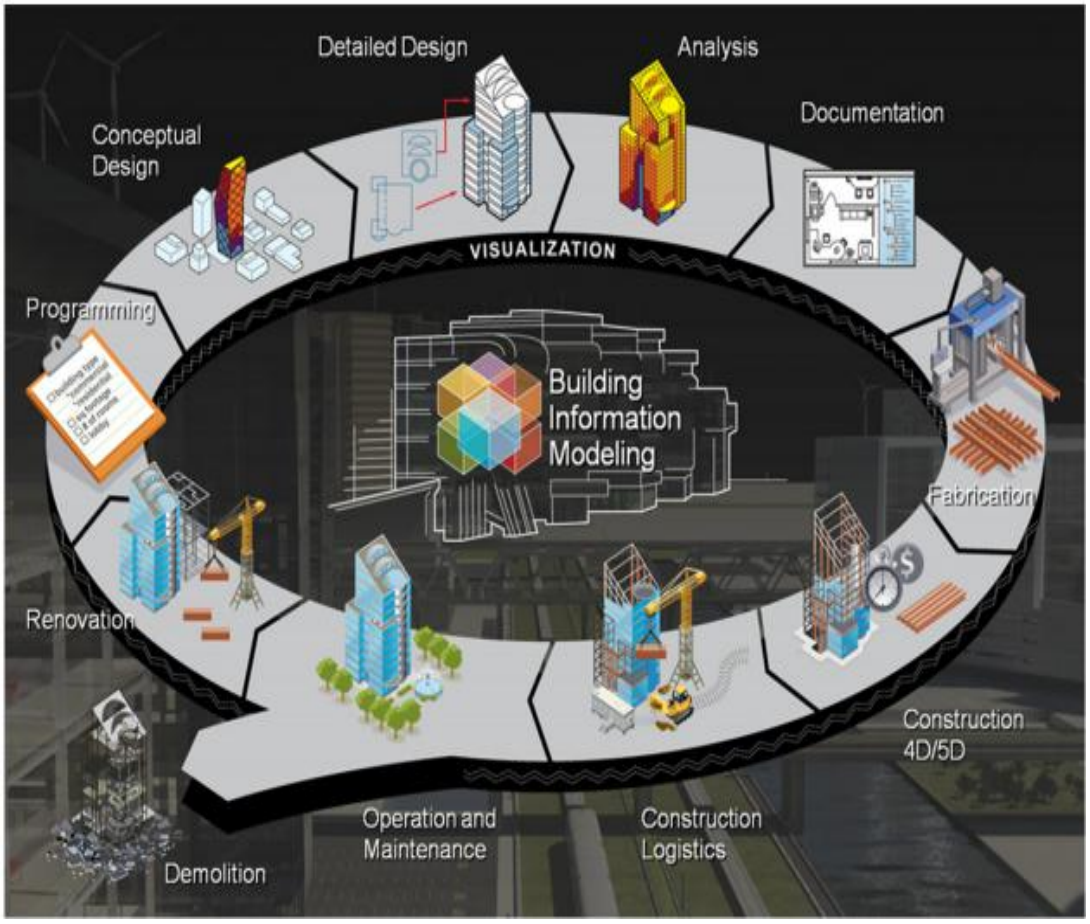
Source: (Fox , 2014)

Figure 2-1 shows the percentages of BIM users in Australia/New Zealand, Brazil, Germany, Japan, France, United Kingdom, Canada, South Korea & United States of America (USA). According to figure 2-1 in the USA from North American continent shows the highest percentage of BIM users and South Korea shows the second highest percentage of BIM users in the world where South Korea stands as the highest percentage of BIM users in Asia. (Mohd-Nor & Grant, 2014) described as per the 2012 Smart Market Report by McGraw Hill the rate of adoption of BIM in the United States has reached 72% and South Korea has reached to 58% making the second highest rate of BIM adoption.

Haron A. (2013) stated that BIM is a good solution for the construction industry due to the law reliable rate of profitability, less investment on R & D and attempt to select the lowest price for construction task. Most of the individuals, businesses, and government agencies of many countries use this system to plan, design, construct and maintain physical infrastructure namely water, wastewater, gas, electricity, roads, bridges and various buildings in town. This BIM system can be used for calculation and analysis, to update design necessarily when required, bind geometrically and fit into the coordinates. In another ways, BIM is a database of buildings that manage the digital system and enhances the accuracy and efficiency of the design and project.

Figure 2-2 shows the building lifecycle according to the BIM. Most of the areas in building lifecycle can be addressed through the BIM system as it maintains numerical values and organizational information to design the project efficiently maintain the building operation and maintain the building throughout the warranty period. The organizations concern more on the trade-off between the projects as the main objective of the organization is to earn more profit than competitors. BIM helps to compare the projects based on the functions, scope, and costs to take best investment decisions (Koppel , 2015). Further, it supports to analyze energy, environment, and visualize and analyze the feasibility, and enhance the quality of the project.

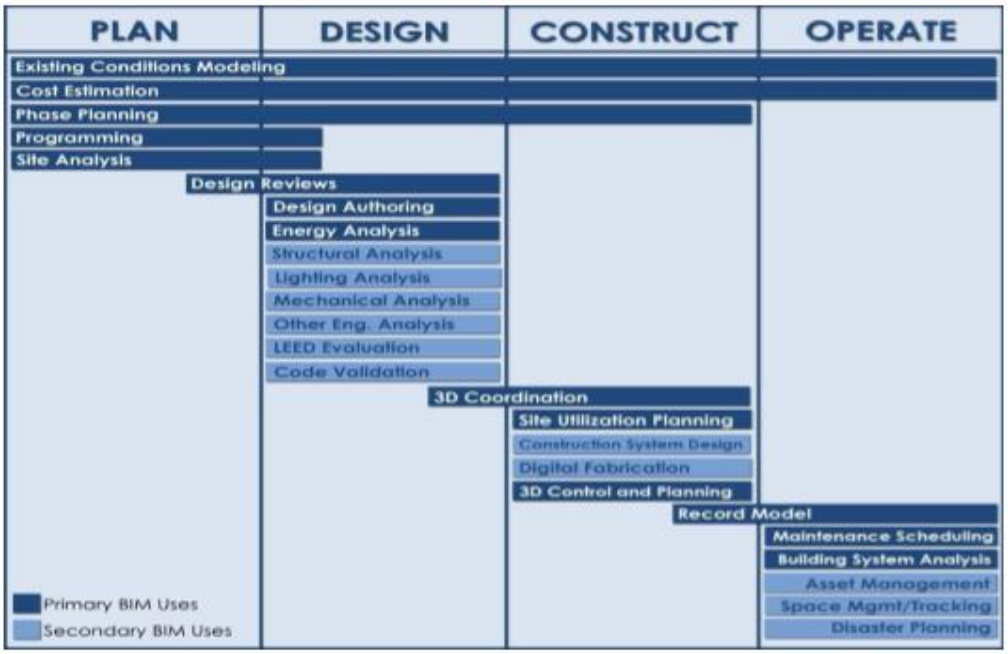
Figure 2-2: Building lifecycle according to the Building Information Modeling



Source: (Koppel , 2015)

Haron, MarshallPonting, & Aouad (2010) explained that the BIM system can be used in every phase of the construction project lifecycle.

Figure 2-3: BIM Application in Project



Source: (Haron, MarshallPonting, & Aouad, 2010)

2.3. Technological Aspects and BIM in Sri Lanka

Most of the western countries now adapt to the BIM system when compared with the Asian context (Gunasekara & Jayasena , 2013). Singapore initiated the BIM in their country due to the government intervention to implement the system in the construction industry of their country. Reginold, (2009 cited in Jayasena & Weddikkara, 2012) stated that low level of Information Technology in Sri Lankan construction industry highly influences on introducing and implementing BIM system as it can impact on the productivity of the industry. Further, Navaratna, 2006 cited in De Silva, Rajakaruna, & Bandara (2010) explained that Sri Lankan authorities and particular institutes do not provide sufficient attention to improve the productivity of construction industry by using ICT. This highly influences the implementation and adaption to BIM in the country. Moreover, Gunasekara & Jayasena (2013) stated that 74 % of the construction value holds the public sector of the construction segment. This averse to spend the money on AEC related software. This highly influences shifting to BIM system as companies need to invest in hardware and software. Further, Sri Lanka spent 0.11 % on research and

development (R & D) from GDP in 2008 which is significantly less than the countries who implemented the BIM software.The BIM system implementation and adaptation can be accessed if the country has a necessary workforce (professionals) with high computer knowledge and high ICT literacy rate.

2.4. Dimensions of Building Information Modeling (BIM)

For deeper undestanding of BIM realization or the BIM readiness , it is important to know about different dimentions of BIM. BIM system has increased the business opportunities and helps to explore new business directions. Chen (2015) explained that BIM helps to transfer some technology which has been used in the construction industry such as work with multi-dimensional aspects. The several dimensions of the BIM implementation process are technology, management, process, people, and policy.

Technology dimension can be explained as an application of scientific theories in the practical stage. Gray, Gray, Teo, Chi, & Cheung (2015) explained the BIM as amplification of the CAD operations in the construction industry. The major purpose of introducing the BIM is achieving the speed in building lifecycle by improving the relevant technologies. The weaknesses of the BIM can be explained as ignorance of the non-technological people by implementing the system in an organization (Azhar, Khalfa, & Maqsood, 2012).

Management of an organization always focuses on enhancing the profit, productivity, efficiency, and accuracy of decision-making by aligning the project andtheir strategic planning with the business plan of the organization (Bryde, Broquetas, & Volm, 2013). The BIM helps to enhance the decision-making efficiency, accuracy and to maintain the building lifecycle effectively by providing necessary information at the necessary time period (Alaloul, Liew, & Zawawi, 2016).

The process can be explained as a set of construction activities executed in order to complete the project on time by explaining duration, place, inputs, outputs, and

structure of the actions. Activities, tasks, analysis and interoperable information can be used throughout the project by using the BIM system (Azhar, Khalfa, & Maqsood, 2012).

People is the primary medium of the revolution in an organization and the party who decides to implement and maintain new technology successfully (Alabdulqader, Panuwatwanich, & Doh, 2013). The new role of the individuals in the construction project and their responsibilities highly influences and is important in implementing the BIM system. The leadership style and vision highly influences on motivating and inspiring employees towards a new system to enhance the collaboration and solve the problem relating to the BIM system implementation.

A policy which can be used to guide the relevant parties in the organization is highly influenced by proper guidance in the decision-making process. This includes problem, research and findings, benefits, risks, stakeholder analysis ,etc. which can be used to develop a suitable legal framework, standards, and regulations in the study (Azhar, Khalfa, & Maqsood, 2012).

2.5. Building Information Modeling (BIM) Implementation Process

Lee, (2007 cited in Fadeyi, 2017) explained four stages of BIM implementation in an organization. The first step is personal adoption, the individuals who use the system can produce data for their own discipline. The second stage is the adoption of BIM in a single discipline within the organization. The third stage is the adoption of multi-discipline of BIM within the organization and the fourth is the adoption of BIM through the organization and different platforms. Ali Taha, Sirková, & Ferencová (2016) explained the organization as a system to coordinate the activities and resources effectively. An organization is a place where different level of skills, experience, and expertise gather and work to achieve a common goal. The main challenges of adapting to the BIM system can be explained as not ready to accept new technology and procedures, and negative attitudes of the employees towards it.

The willingness of the employees to change can be enhanced by providing awareness sessions and increasing confidence levels with regard to BIM operations. Another issue can be explained as the lack of a developed strategy to improve the link between disciplines and organizations on an industrial level.

BIM implementation is a challenging task (Gunasekara & Jayasena , 2013). Further, Bernstein and Pittman, (2004 cited in Gunasekara & Jayasena, 2013) stated that transition to the BIM-based paradigm is better than working with CAD because BIM helps to minimize the labor and cost. The company has to invest time in evaluating the BIM before implementing in their organization and software and hardware must be upgraded which is costly to the organization. The BIM depends on the technology, therefore, it is necessary to develop a suitable framework for their own requirement. Further, the organization needs to create a BIM execution plan ,and share information among all the necessary stakeholder to implement the BIM system successfully.

In the process of BIM implementation, it is necessary to consider hardware and networking aspects of the company as it is one of the major requirements of the system. Mainly, the company needs to be provided with a computer which is up to the requirements of the system with connectivity. Most of the time LAN (Local Area Network) is suitable as a data transfer mechanism to share the data between necessary parties. It is essential to use broadband or higher service to transfer the files in between different locations. Moreover, the central database, software for BIM, cloud computing can be used to enhance the hardware facilities for the BIM softwares (Nagalingam, Jayasen, & Ranadewa, 2013).

Figure 2-4: BIM with Cloud

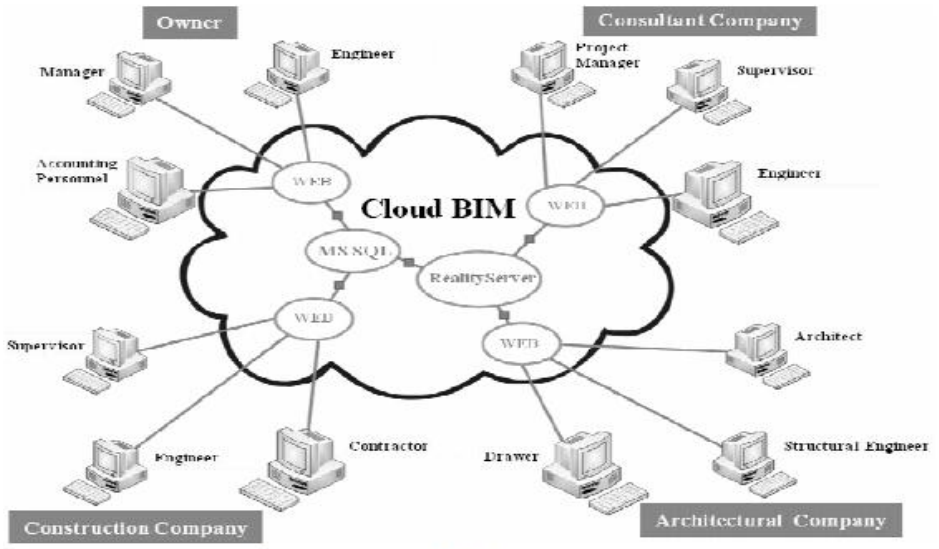


Figure 1: The Concept of Cloud-BIM (Chuang *et al.*, 2011)

Source: (Gunasekara & Jayasena, 2013)

2.6. BIM Readiness and BIM Realization.

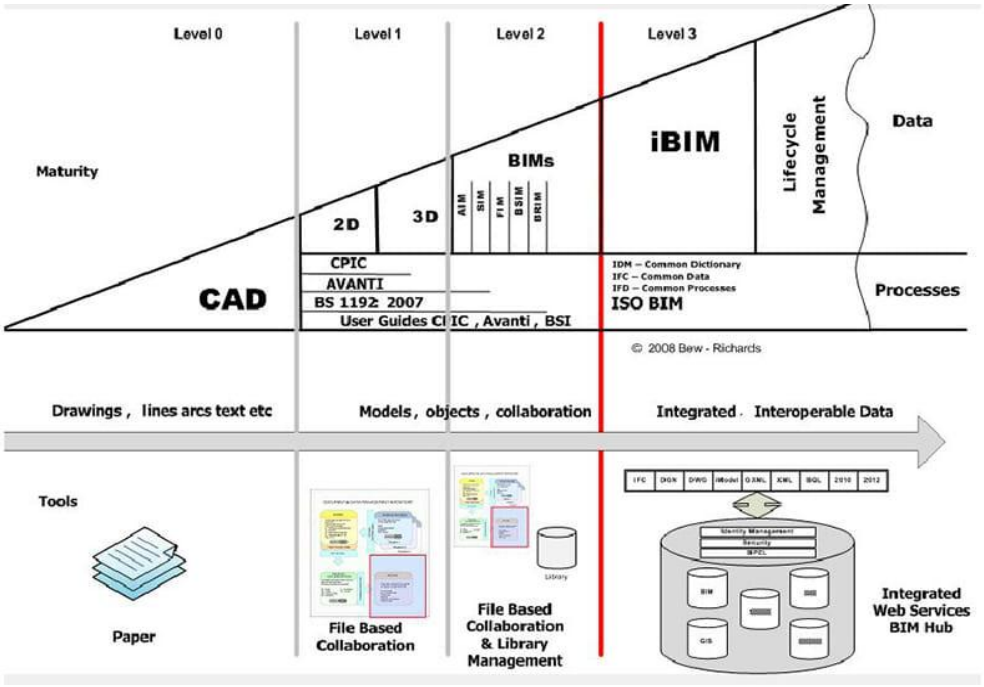
Readiness cannot be explained but it depends on the context, situation, and involvement of the particular group of people (Aziz and Salleh, (2011 cited in Kugbeadjor , Suresh , & Renukappa, 2016). Harvard University Centre for International Development, 2001 cited in Alabdulqader, Panuwatwanich, & Doh, 2013) explained readiness as the preparation of the community to participate and accept particular phenomenon in order to achieve the goals of the company or professional level more effectively. Othman et al., (2012 cited in Kugbeadjor , Suresh, & Renukappa, 2016) explained BIM readiness as the willingness of the particular group of people to do something. The organizational culture, attitudes of the people and management motivation highly influences on changing the readiness (Haron A. , 2013). Most of the system implementations fail, as most of the employees and organizational cultures do not adopt to the changes as they do not like to take the risk. Lindblad & Vass (2015) explained that organizational change can adapt to the more innovative channels to share information, decentralize the decision-making process and invest in IT training and development.

Succar, (2010 cited in Lindblad & Vass, 2015) discusses the BIM and organizational change as it highly influences on understanding the BIM readiness. It is essential to understand the organizational changes when implementing BIM to fully utilize the potential benefits and successfully implement BIM in the organization. The organization can achieve the maximum benefits from BIM by changing workplace culture, attitudes of the employees, work practices and skills of the employees who participate in the project.

The policies of the organization, process, technologies, actors, and organizations need to change and improve with the BIM as expanded by Lindblad & Vass (2015). BIM implementation gradually changes the organizations' business processes and work practices. The main goal of the BIM implementation is to increase the productivity of the organization internally as it makes easy to capture and monitor the project at each stage. The BIM can be categorized into three stages named product, organization and process Lindblad & Vass (2015) in the initial implementation stage. The BIM initiation project focuses on developing the right condition to implement BIM by using various activities.

It is essential to understand the evolution of BIM and Figure 2-5 explains it. BIM evoluton consists of four stages named Level 0, Level 1, Level 2, Level 3.

Figure 2-5: BIM Evolution



Source: (Haron, 2013)

As per Figure 2-5 Bew Richards wedge ,one of the widley used and also common reference in industry can be used systematric method to asses BIM realization. According to Figure 2-5 Level 0 reffered to unmanaged CAD in 2D. In level 0 data or information is sharing by paper base drawings or digital files like PDF type. Level 1, CAD is managed in 2D or 3D format or mix of 2D and 3D formats. In Level 1 it is providing a Common Data Environment with British Standars 1192. In Level 2 , it is describing by developing BIM in a collaborative 3D environment with data attached, but created in separate discipline models and Level 3 BIM is consist with interoperatble data and it is integrated BIM.

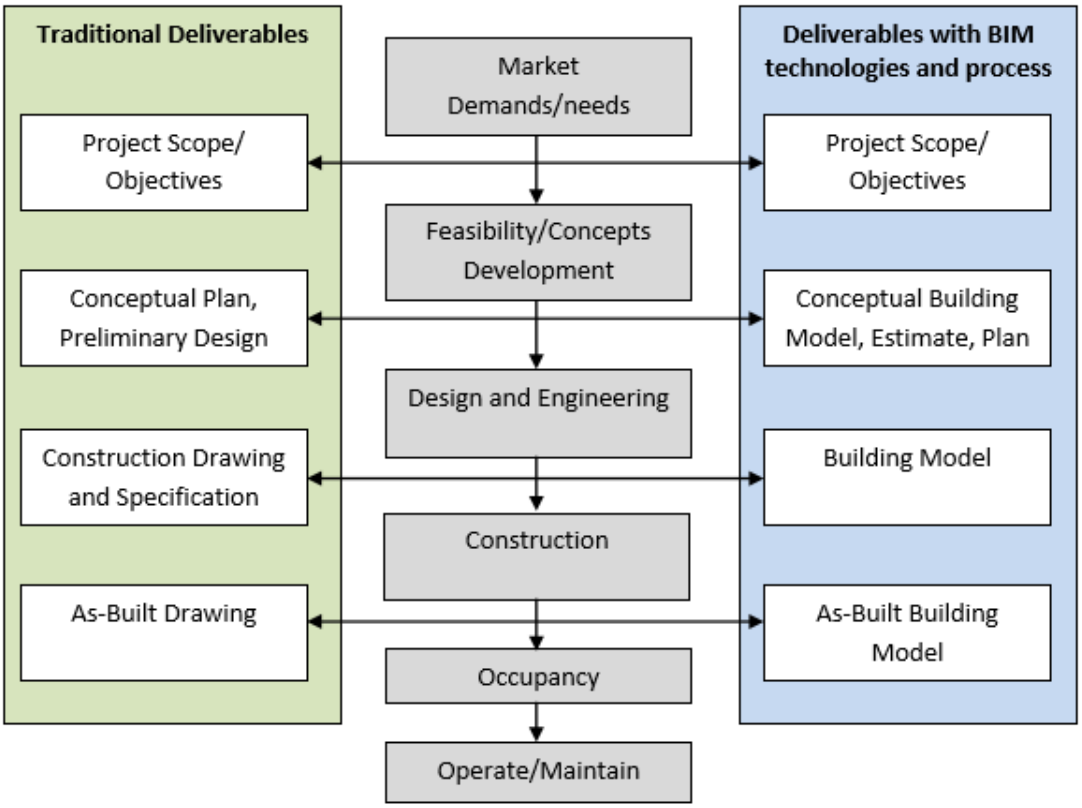
2.7. Technological Aspects and BIM in Sri Lanka

Most of the western countries now adapt to the BIM system when compared with the Asian context (Gunasekara & Jayasena , 2013). Singapore initiated the BIM in their country due to the government intervention to implement the system in the construction industry of their country. Reginold, (2009 cited in Jayasena & Weddikkara, 2012) stated that low level of Information Technology in Sri Lankan construction industry highly influences on introducing and implementing BIM system as it can impact on the productivity of the industry. Further, Navaratna, 2006 cited in De Silva, Rajakaruna, & Bandara (2010) explained that Sri Lankan authorities and particular institutes do not provide sufficient attention to improve the productivity of construction industry by using ICT. This highly influences the implementation and adaption to BIM in the country. Moreover, Gunasekara & Jayasena (2013) stated that 74 % of the construction value holds the public sector of the construction segment. This averse to spend the money on AEC related software. This highly influences shifting to BIM system as companies need to invest in hardware and software. Further, Sri Lanka spent 0.11 % on research and development (R & D) from GDP in 2008 which is significantly less than the countries who implemented the BIM software. The BIM system implementation and adaptation can be accessed if the country has a necessary workforce (professionals) with high computer knowledge and high ICT literacy rate.

2.8. Construction Lifecycle with BIM

It is essential to understand the behavior of BIM in construction lifecycle in developing the readiness framework. As explained in the literature, BIM can be used in every stage of the construction project. The advantage of the BIM is enhancing the efficiency of the construction projects. Figure 2-6 explains the comparison between the traditional construction lifecycle and BIM related construction lifecycle.

Figure 2-6: Comparison between the traditional construction lifecycle and BIM related construction lifecycle



Source: (Nagalingam, Jayasen, & Ranadewa, 2013)

The design stage of a project is very important as it involves many information and details related to the project. Elvin, (2007 cited in Lindblad & Vass, 2015) explained that with the BIM, the project team has the ability to control the cost and design. The organizations need to invest in long-term training and education, software and cover the necessary hardware cost.

Nagalingam, Jayasen, & Ranadewa (2013) explained the BIM application covers the entire building lifecycle such as project programming, design, preconstruction and post construction of the project. Further, Autodesk, (2013 cited in Nagalingam, Jayasen, & Ranadewa, 2013) explained how traditional 2D CAD systems focus on increasing the productivity of the construction document while BIM application

focuses on changing the workflow of the project by enhancing design information through all the project phases.

Figure 2-7: Comparison between the bid-build system and BIM system

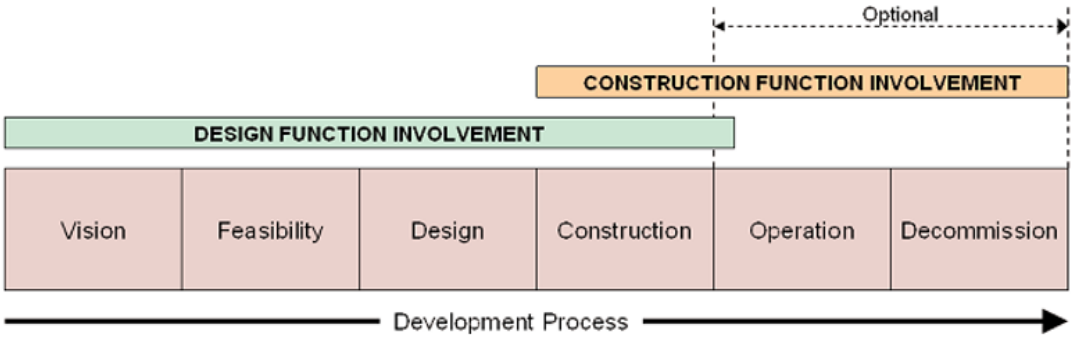


Figure 1: Design-Bid-Build Delivery System

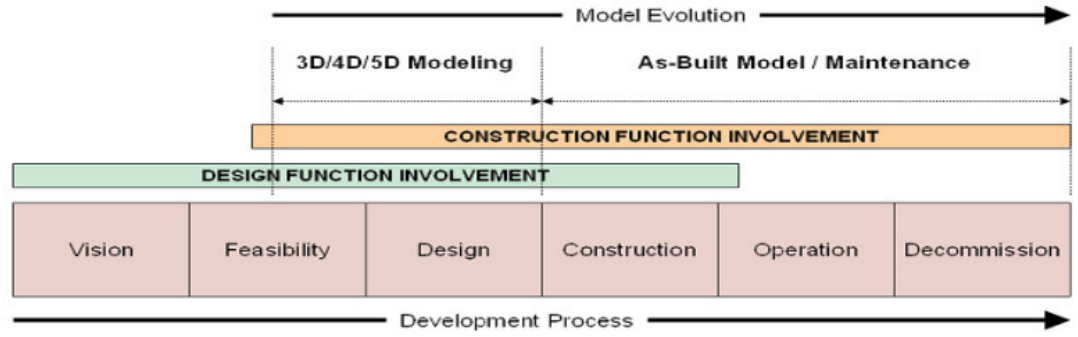


Figure 2: BIM Based Delivery System

Source: (Nagalingam, Jayasen, & Ranadewa, 2013)

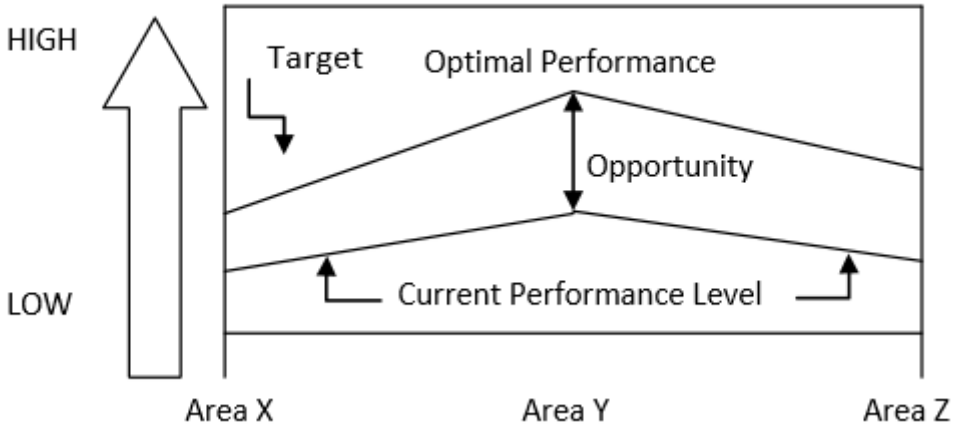
According to Figure 2-7, BIM is the fastest and most efficient method when compared with other methods and has the ability to propose a better design. The BIM has the ability to accurately predict the environment and provides better production quality.

2.9. Readiness Concept

Alshawi, (2007 cited in Haron A., 2013) explained the readiness assessment as a managerial evaluation tool to measure the gap between the current organizational

capability related to the Information system and Information Technology investment and target level that company would achieve to invest on achieving the goals. Mahamadu, Mahdjoubi , & Booth (2015) explained e-readiness as evaluating the company capabilities to adapt and use the Information Technology in an organization. The literature explained that the organizations need to investigate on capabilities of the organizations such as processes, structure and work environment to implement the IT system effectively. All the relevant areas should be covered in the assessment to develop a required IT or IS system in an organization.

Figure 2-8: Performance analysis chart

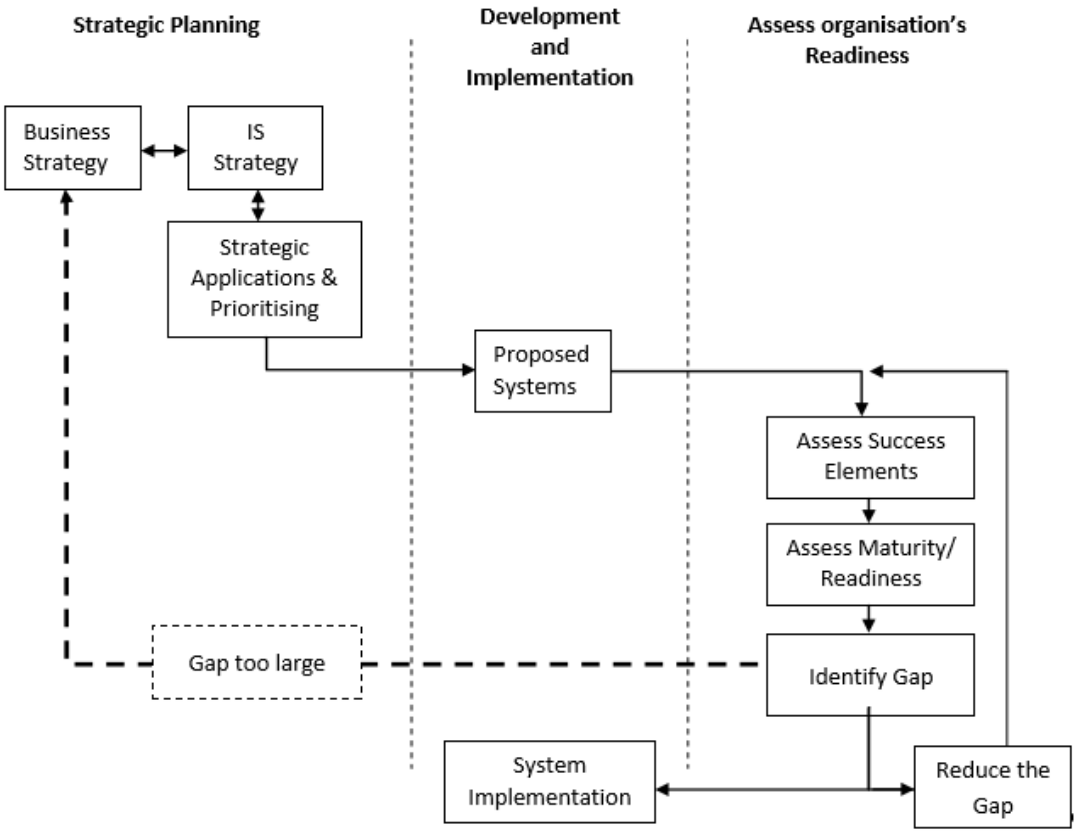


Source: Alshawi, (2007 cited in Haron A., 2013)

As shown in Figure 2-8, current performance level helps to identify the current status of a business and target performance level helps to identify the desirable status of the performances. The gap between current performance level and target performance level is named as the opportunity gap. The opportunity gap can provide the information to prioritize the resources by identifying the critical areas and noncritical areas. This also helps to improve each area. The opportunity gap also helps to implement the IT or IS system in the organization successfully. Also, the opportunity gap can work as an indicator to identify the risk in the system implementation period.

The accuracy of gap analysis depends on the business functions of the organization and measures the functions accurately. Further, criteria that is used to measure the current performance and progress of the performance also influences on analyzing the gap accurately.

Figure 2-9: Readiness assessment process



Source: Alshawi, (2007 cited in Haron A., 2013)

The readiness assessment takes place when the organization gives the permission for the proposed system to be implemented and before the system is implemented in the organization. As shown in Figure 2-9 ,the assessment needs to be focused on identifying the level of requirement that changes the current organization. After identifying the readiness gap, the organization needs to process the implementation in the organization or create the plan to reduce the readiness gap of the organization. In the evaluation criteria, the project team needs to focus on two elements named

evaluation criteria and target of the system implementation as explained in the Haron A. (2013) study. The BIM implementation is wide and different from one organization to another. Therefore, it is essential to understand the BIM implementation by the organization. After the assessment, the organization should develop the target performance level. This process helps to identify the readiness gap which leads to take key decisions to minimize the readiness gap.

2.10. Relevant Theories and Models of BIM Readiness

It is essential to understand and identify the suitable theoretical framework that aligns with the organizational readiness.

2.10.1. Capability Maturity Model Integrated (CMMI)

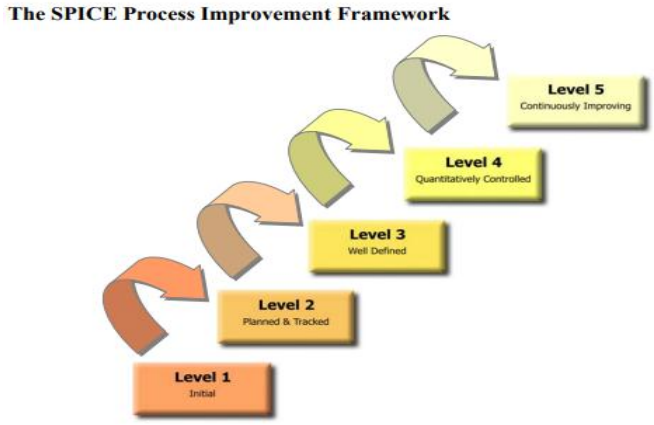
This discusses the process improvement maturity model as explained in the Majumdar, Ashiqe-Ur-Rouf, Islam , & Arefeen (2011). This can be used to analyze the development of service or product. This model plays an important role in the software development industry as it helps to improve the maintenance and development processes for both products and services. The aim of developing a software for an organization is to develop the organizational performance. Mainly, the organization needs to focus on characteristics of the software process. This model which is explained by using five levels named initial, managed, defined, quality managed and optimizing, prioritizes to improve the software. The CMMI focuses on improving the performances of the organization by improving the operational process. The CMMI has provided significant value for many organizations in the engineering field to improve their engineering work. This helps to control the process such as management, engineering and supporting processes to serve the organizational requirement.

2.10.2. Structured Process Improvement for Construction Enterprises (SPICE)

Structured Process Improvement for Construction Enterprises (SPICE) is another model that can be used to discuss BIM readiness of an organization. This model helps to explain the continuous process improvement specifically for construction industry. The scope of the model is to incorporate the process that directly related to the design, construction and maintenance procedures of a construction organization that can use to explain the support of the community (Azhar, Khalfa, & Maqsood, 2012). Tarmizi Haron (2013) explained this model as a systematic framework to improve the process of the construction industry. Finnemore, Sarshar, & Haigh (2016) showed the importance of enhancing the productivity and improving the quality by minimizing the defect in the final product. This model discusses the process of improvement in the construction industry.

Initial is the first level of the SPICE models. The success depends on the effort that the organization puts into it. Repeatable is the second level of this study. In this stage, the organization establishes basic project management processes and repeat it. The basics and success of the project depend on previous projects. Defined , the third level of the SPICE process is the process where all the activities are being documented and integrated into the organization by developing all the necessary standards. Level four of the SPICE model is managed and product quality and the measurement of each process is collected to control the necessary activities. Level five is optimizing and it enables continuous process improvement by providing feedback from the earlier processes.

Figure 2-10: SICE process improvement framework.



Source: (Finnemore, Sarshar, & Haigh, 2016)

2.10.3. General Practitioner Information System (GPIS)

General Practitioner Information System (GPIS) is another model that is used in the research to explain the readiness for IT or IS systems. This consists of six levels and can be used to assess the readiness of an organization to uptake IT and IS. GPIS embraces much of the IT tasks that need to be performed by a general practice wch helps to understand the requirement of the industry and the perception of the users (Bryde, Broquetas, & Volm, 2013).

The primary key element and categories of the model are people such as Head of IT, staff, and skills of the employees. The secondary key element of this model process can be named as generic practice, IT infrastructure such as system and environment such as culture, leadership, and structure.

2.10.4. IS Competency Framework

Haron A. (2013) explained IS competency framework as a framework that uses six elements of IS competencies. This framework links with both IS and business aspects. The key elements can be named as strategy, defining the IS contribution, defining the IT capabilities, exploitation, delivery solution and supply. The strategy needs to address business strategy, technology innovation, information governance and investment criteria. IS contribution can be defined prioritization, IS strategy and

aligning, business process, business process improvement, and system and process innovation. IT capability elements include infrastructure development, technical analysis and sourcing strategies. Exploitation means benefitial planning and delivery and managing changes. Delivery solutions means application development, service management, information asset management, implementation management, application technology and business continuity and security. Supply elements include supplier relationships, technology standards and cost and asset management. This model helps to understand the stakeholders view about new system and ho it can align with the current business model (Chen , 2015).

2.10.5. Building Information Maturity Index (BIMMi)

Building Information Maturity Index (BIMMi) is designed to asess the maturity, capability and organizational scale of BIM. This model consists of five levels of maturity namely initial, defined, managed, integrated and optimized. The key elements are maturity, capacity and organizational scale. The maturity consists of technology, process and policy as those three do major roles in readiness. The organizational scale needs to measure the macro concept and micro concept as explained by Haron A. (2013).

2.11. Empirical Findings

Ryal-Net & Kaduma (2015) study focused on assessing the BIM knowledge in the Nigerian construction industry. As explained by the researcher, the Nigerian construction industry is very slow to complete the particular construction project. This study was conducted using 90 structured questionnaires. The sample individuals of the study were selected by using a stratified random sampling method. The researcher collected valid 43 responses as some of the data was missing in some of the questionnaires. The research revealed that the level of knowledge was low regarding the BIM in the Nigerian construction industry. The researcher suggested that BIM needs to be included in professional and university curriculum to provide necessary knowledge for the employees as BIM helps to enhance the productivity and efficiency of the construction industry.

Kim , Ma , Baryah, Zhang, & Hui (2016) focused their research on investigating the readiness for 4D and 5D BIM adaptation in the Australian construction industry. This study stated that BIM can help to enhance the productivity of construction projects by collaborating with the stakeholders. According to the study, lack of demand from clients and initial cost is a major barrier for most of the companies to implement the system.

Prušková & Nývlt (2017) focused their study to find the issues of BIM implementation in the Czech Republic. The research explained that BIM helps to enhance the quality of the project related documents.
Another study was done in Australia by Rodgers, Hosseini, Chileshe, & Rameezdeen (2015) focusing on finding BIM practices and drivers. The researcher selected questionnaire method to collect the primary data and 41 valid responses were used in this study. The study found that knowledge on BIM negatively impacts on the low usage of BIM in the companies.

Gunasekara & Jayasena (2013) focused their study on identifying a technological framework to implement BIM in Sri Lanka. The study stated that BIM provides better integration and optimum resource usage in the construction industry which drives towards the sustainability of the construction industry in every aspect. The current issues with BIM implementation is the minimal technological framework and low ability to invest in projects. The study stated that the construction industry of Sri Lanka needs to select the right technology to implement BIM project in their organizations.

Nagalingam, Jayasen, & Ranadewa (2013) conducted their research on BIM and future surveyor's practice in Sri Lankan construction industry. BIM software is a method to achieve sustainability in the construction industry. This study revealed that quantity surveys depend on bills of quantites which is a major barrier to automate the process.

2.12. Factors Impact on BIM Readiness

Alabdulqader, Panuwatwanich, & Doh (2013) explained that when an organization needs to implement a new system related to Information Technology, it needs to analyze the capability of the organization, culture of current working environment and the capability of the employees. The organization needs to check the IT literacy, an investment that should be done to implement a particular system.

Ali Taha, Sirková, & Ferencová (2016) explained that most of the time organizational policies and procedures need to be changed according to new business structure. Moreover, the researcher highlighted the importance of employees and the organizational culture. The organization needs to change traditional organization culture to knowledge sharing and learning culture as it helps to adapt to the new methods quickly. Kugbeadjor , Suresh , & Renukappa (2016) explained that technology and the investment for the technology is the most important part in BIM implementation as the organization has to invest a huge cost on that.

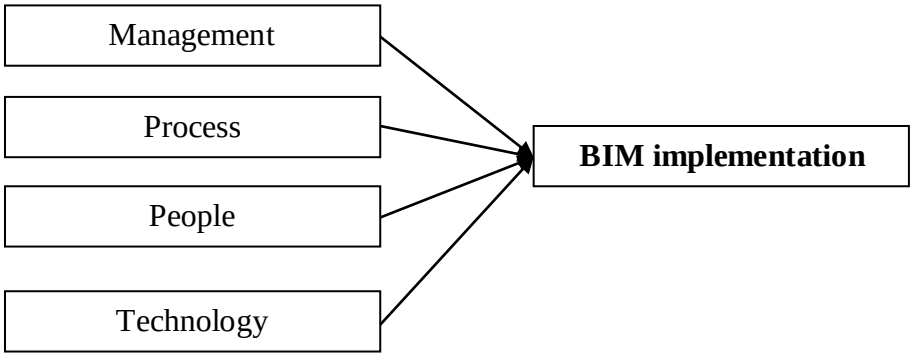
2.13. Conceptual Framework

BIM readiness is willingness of the particular people to do something (Kugbeadjor , Suresh , & Renukappa, 2016). BIM readiness explained by (Alabdulqader, Panuwatwanich, & Doh, 2013) as the preparation of the community to participate and accept particular phenomenon in order to achieve the goals of the company or professional level more effectively. BIM realization is becoming fully aware about the BIM and related factors (Fox , 2014).

The researcher could not find the literature related to real BIM realization in Sri Lanka. Therefore, the researcher could not find the evidence to show sucessful implementation of BIM in Sri Lanka.Existing maturity models are unlikely to offer deeper understanding due to perceived poor status of BIM implementation in Sri Lanka.They would show that BIM readiness is low, but would not offer critical qualitative knoweldge. Therefore , a frame work that covers all dimensions of BIM was conceptualized.Conceptual framework plays an important role in quantitative research studies as it explains the necessary theories and variables uses in the

research. The researcher tries to understand the level of readiness of the architectural, engineering and construction industry of Sri Lanka to implement the BIM in the construction industry. The researcher identified that importance given by management, people for process and technology highly influences on BIM readiness. Therefore, the conceptual framework can be explained in Figure 2-11.

Figure 2-11: Conceptual Framework



2.14. Chapter Summary

The researcher explained the Building Information Modelling (BIM) comprehensively as it is the based on the study. In addition, the background of the Sri Lankan construction industry, challenges of the Sri Lankan construction industry, dimensions of the BIM, BIM implementation process, BIM readiness, BIM implementation in Sri Lanka and relevant concepts are discussed in this chapter as it helps to develop the suitable framework. The researcher needs to find a systematical approach to identify the key component which has an impact on implementing BIM system in Sri Lanka as construction industry of Sri Lanka has not adapted with the modern technology at a considerable rate. Therefore, the proper framework can be used with the concept discussed under the BIM readiness in this chapter.

3. RESEARCH METHODOLOGY

3.1. Introduction

Research can be explained as addressing issues and solving the research problem. Bhattacherjee (2012) explained research as solving a problem by using scientific methods. Most of the researches associated with human behavior, attitudes, opinion, trends and different patterns are associated with that. This study is a formal research which has a defined process and procedure to conduct the study. In addition, the researcher contacted different levels of employees to collect the information for the study. This chapter explains the different strategies and methods that the researcher used for solving the specified research problem in chapter one. The researcher used both qualitative and quantitative research methods in this study. The questionnaire method was used in this study to collect the data and content analysis and statistic analysis were used to analyze data.

3.2. Research Philosophy

Research philosophy explains different information and beliefs that needs to be collected and analyzed through the study. Scotland (2012) explained realism philosophy and interpretivism under the ontology which motivates to discover the reality link with a particular research area. Positivism is mainly discussed under the epistemology . This helps to understand the existing knowledge related to the particular subject area. Positivist or positivism can be used to explain the direct relationship between the variables. Moreover, positivism can be used with a larger sample size and a highly structured study. Saunders, Lewis, & Thornhill (2007) explained interpretivism as most suitable to use when researcher considers smaller sample sizes and when it is necessary to analyze in-depth of the subject area.

Kuhn,(1962 cited in Kivunja & Kuyini, 2017) used paradigm to explain the philosophical thinking of humans beings. Mackenzie & Knipe, (2006 cited in Kivunja & Kuyini, 2017) used research paradigm to explain the view of the researcher regarding the particular phenomenon and the link between particular

research area and the world. The literature explained the research paradigm as a worldview and as a set of beliefs of research. Kivunja & Kuyini (2017) explained research paradigm as an important part of the research study as it provides the benefits for conducting a research, different factors having an influence on the study, different methods to study a particular research area and different methods to interpret the obtained result through data analysis. Scotland (2012) explained that epistemology, ontology and methodology are three different components of the research paradigm. In ontology research paradigm, the researcher needs to explain the perception of each phenomenon and how things work or practice in the real world Crotty, (1998 cited in Scotland, 2012). Epistemology focuses on the nature of the knowledge related to the particular phenomenon and the nature of the related information. This mainly focuses on creating knowledge, acquiring knowledge and communicating knowledge with relevant parties. Methodology paradigm discusses the strategy or action plan related to selecting each method of the study. In this study, the researcher used both epistemology and ontology as a research paradigm.

The researcher followed positivism to conduct this research study. Because BIM is currently on a radical development around the world and also is a novel idea to Sri Lankan industry. It was necessary to aquire both generic and deep knowledge in order to come to conclusions of this study. Therefore, it can be stated that the research took a pragmatists paradigm.

3.3. Research Method

Saunders, Lewis, & Thornhill (2007) explained that the research method focuses on explaining data collection for a particular study as it is the major part which impacts on the conclusion. According to the literature, there are two different research methodology named qualitative and quantitative. In addition, some literature explained a research method named mixed method. Qualitative research method focuses on collecting information type data according to the participants' view. This helps to understand the different perception and in-depth analysis. The quantitative research method focuses on collecting data in numeric type and helps to identify the basic relationships between associated variables. In a mixed research method, the

researcher can use qualitative research method as well as quantitative research method according to the objectives, aims and goals. The researcher selected a mixed method which uses both qualitative and quantitative research method for data collection.

3.4. Research Approach

Bhattacherjee (2012) explained that mainly there are two different research approaches named deductive research approach and inductive research approach. Deductive research approach first identifies the suitable variables and theories. Then, those theories and variables are applied to the specific research study and data is observed to satisfy those condition. Based on the data, the researcher can conclude the session and understand the current research area. Inductive research approach can be used to understand the particular research area in-depth. This type of research approach helps to understand the particular research area by using participants ideas and perception and generate specific theories based on that information. Mixed research approach helps to use both types of research approaches in a study. The researcher used both inductive research approach and deductive research approach to study about implementing BIM in Sri Lankan AEC industry.

3.5. Data Sources used in this Study

Pandey & Pandey (2015) explained that the researcher can use two different data sources in their studies to develop the theoretical and conceptual framework. These data sources help in different way to conduct the research study. The two different data sources are the primary data source and secondary data source. Primary data source helps to collect unique data to satisfy a specific research study. The researcher used the primary data source to contact suitable people to collect the information for this study.

Moreover, the secondary data source also helped to collect the suitable information to conduct the study. Secondary data source means the information that reveals about previous research work in regard with the particular research area. The researcher uses websites, journals, books etc. to collect the suitable data for the particular study.

The secondary data sources can be used to identify suitable theories and concepts related to the study.

The researcher use use interview method and survey questionnaire as primary data source and journals, books, websites etc. as secondary data source to collect the information.

3.6. Data Collection Method

As explained in section 3.5, the researcher used both primary data sources and secondary data sources for collecting relevant information to develop a suitable framework for this study. The researcher used a questionnaire method to collect the primary data. As explained under the research method, the researcher used both quantitative and qualitative data to conduct this study. Therefore, the quantitative type data was collected using five-point Likert scale type questions and qualitative data was collected with open-ended questions.

The quantitative type research questions help to understand the current situation and different factors which impact on the problem. Open-ended qualitative type questions are used to understand the in-depth information related to the research area. The questionnaire consisted two section to gather demographic factors and perception of them regarding the factors impact on BIM implementation in Sri Lankan construction industry using Likert scale questions. In addition, the researcher tried to gather direct views of construction employees related to BIM using open ended questions. The questionnaire consist of 27 Likert scale type questions and 30 open ended questions. All these questions covered the factors showed in the conceptual framework.

3.7. Population and Sample

Creswell (2009) explained that a researcher needs to be more concerned about the population of the study and the sample of the researcher. Population is the entire group that is suitable to collect the information for the study (Banerjee & Chaudhury, 2010). The target population of this study is all the employees in construction

industry who have BIM related knowledge in Sri Lanka. It is difficult to contact each and every head in a population due to the time constraint and cost constraints of the study. Therefore, the researcher needs to select a suitable sample logically to conduct the study. The sample can be defined as a portion of the population which needs to have the same qualities as the population and who can represent the population of the study (Banerjee & Chaudhury, 2010). Sample size of this study is fifty five for quantitative data collection and 11 participants for qualitative data collection.

3.8. Sampling Techniques

Molenberghs (2010) explained the sampling technique helps to select a suitable sample for a particular study as it highly influences on the accuracy of the findings and the conclusion of the study. There are two different sampling techniques mainly named probability sampling and non-probability sampling technique. Each member of the population has an equal opportunity to be selected for the sample in probability sampling technique and non-probability sampling selects the individuals based on the objectives and aims of the study. The researcher selected a purposive sampling technique which is discussed under the non-probability sampling. The researcher selected the employees who have BIM related knowledge as this study needs to collect data from people who have relevant knolwedge about that.

3.9. Data Analysis Methods of the Study

Data analysis is an important part of the studies which focuses on collecting primary data. The researcher used both qualitative and quantitative research methods for data collection. Therefore, the research analysis methods were deductive and inductive research approaches. This emphasized the importance of content analysis and statistic analysis in this study (Bhattacherjee, 2012). The content analysis can be used to analyze the qualitative data and statistic analysis can be used for quantitative analysis method. The researcher identified the code analysis to identify and categorize the different answers provided by participants. The researcher used Microsoft excel for code analysis and SPSS software for statistic analysis of this study.

3.10. Ethical Consideration

Akaranga & Makau (2016) explained that a researcher needs to meet the ethical obligation once they conduct the survey, once they work on making a report and publishing research. The researcher needs to provide all the right to the authors of previous research studies when researcher is using their work. In conducting the survey, the researcher needs to explain all the aims and objectives of the study to provide an idea for the participants. Moreover, the researcher asks them to participate in the survey voluntarily. Moreover, participants could leave the survey at any point. This action was taken to enhance the ethical factors which link with the study. The researcher needs to correct if he found an error in the findings of the study properly to enhance the ethical aspects related to the study.

3.11. Summary

This chapter totally focuses on studying and finding the suitable direction for the study. Research methodology works as a map in a research study. The researcher selected qualitative and quantitative analysis methods as it helps to enhance the accuracy of the study. The quantitative data were used to identify the factors impact on BIM readiness and qualitative research method was selected to collect the practitioner's direct perceptions and view related to the BIM implementation readiness. The researcher selected both deductive and inductive research approaches to analysis data. The researcher uses both statistical analysis methods and content analysis methods for data analyzing as both qualitative data and quantitative data were used in this study.

4. DATA PRESENTATION AND ANALYSIS

4.1. Introduction

Data presentation and analysis is the most important part of the research as it helps to analyze the primary data. The researcher distributed a questionnaire among the selected sample to collect primary data. As explained in research methodology, the researcher used the mixed method to conduct this study. Therefore, both qualitative and quantitative type data were collected using a questionnaire. Five point Likert scale type questions were used to measure the quantitative type data and open-end questions were used to collect the qualitative type data. Quantitative type data was analyzed using statistic methods such as frequency analysis, correlations analysis etc. Qualitative type data was analyzed using content analysis methods such as coded information. Fifty-five people who work in architectural engineering and construction industry participated to this survey. The questionnaire was distributed among 90 individuals .Total of 55 returned with first part-likert scale question fully completed .However among them , only 11 had completed econd part of the questionnaire probably due to relatively higher knowledge of BIM required to anwer that part.

4.2. Reliability and Validity of Quantitative data

Reliability and validity are two key elements which the researcher needs to focus on quantitative research studies. Reliability discusses the consistency of collected data. This helps to understand the quality of the questionnaire. These two measurements help to collect accurate data which reflect the current industry practices and the behavior of the participants. Heale & Twycross (2015) explained three attributes that can be used to measure the reliability of the study named homogeneity or internal consistency, test-retest for stability and inter-rater reliability to measure equivalence. Homogeneity or internal consistency is most common and most famous measurement that is used with in a research study. Split-half reliability, Kuder-Richardson coefficient, and Cronbach's α can be used to measure the internal consistency of the variables. The most famous method is Cronbach's α which is also

used in this study. The strong correlation between the questions that are used to measure each variable explains the high reliability. The Cronbach's alpha value spreads between 0 to 1. The highest value explains the high reliability that can generate through the questionnaire. Zohrabi (2013) explained that an acceptable level of internal consistency score is 0.7 or higher value. The stability is another important measurement associated with the reliability. This can be measured using test-retest, parallel form reliability test or alternate-form reliability testing. Stability can be measured by distributing the same questionnaire several times under the same condition. A statistical comparison will be used to measure the test score and stability of the answers. Equivalence is another measurement that can be used to measure the reliability of quantitative studies. This is measured using inter-rater reliability test. This can be used to explain the agreement between two or more observations.

Validity use to measure the level of the extent that a concept can be measured accurately in the quantitative study. The questionnaire is required to measure the desired things which focus on the study. Heale & Twycross (2015) explained that there are three major types of validity named content validity, construct validity and criterion validity. Content validity focuses on measuring whether the researcher covers all the theories and concepts in the questionnaire. Construct validity check whether the researcher can collect enough data through the study. Criterion validity examines whether any other instrument measures the same variable or not. The researcher uses the previous questionnaire, and experts support to create the quantitative questionnaire and enhance the validity of the study.

Table 4-1 explains the Cronbach's alpha value for each variable of this study. The literature review revealed that management, technology, people and process highly influences on BIM readiness of the construction industry in Sri Lanka. Therefore, the researcher considered all those variables when creating a quantitative survey questionnaire.

Table 4-1: Reliability test result of the study

Variable	**Cronbach's alpha value**
Independent Variable	
Management	0.702
Process	0.778
People	0.811
Technology	0.745
Dependent Variable	
BIM readiness	0.785

The researcher considered internal consistency when measuring the reliability of the variables as the researcher uses a number of questions to measure each variable.

The researcher used six questions to measure the management variable which is used as an independent variable of this study. The Cronbach's alpha value of this study was 0.702 which was greater than 0.7. Zohrabi (2013) explained an acceptable level of Cronbach's alpha value for internal consistency is 0.7 or higher. Therefore, the researcher can state that all the six instruments can be used with this study.

The researcher used nine questions to measure the process variable which is an independent variable of this study. The Cronbach's alpha value of the process variable was 0.778 which was greater than 0.7 and as explained by Zohrabi (2013) acceptable level of Cronbach's alpha value for internal consistency is 0.7 or higher. Therefore, the researcher can state that all the nine instruments can be used with this study.

The researcher used six questions to measure the people variable which uses as an independent variable of this study. The Cronbach's alpha value of the people variable was 0.811 which was greater than 0.7. Zohrabi (2013) explained an acceptable level of Cronbach's alpha value for internal consistency is 0.7 or higher. Therefore, the researcher can state that all the six instruments can be used with this study.

The researcher used six questions to measure the technology variable which is used as an independent variable of this study. The Cronbach's alpha value of the technology variable was 0.745 which was greater than 0.7. Zohrabi (2013) explained an acceptable level of Cronbach's alpha value for internal consistency is 0.7 or higher. Therefore, the researcher can state that all the six instruments can be used in this study.

The researcher used twenty-seven questions to measure the level of readiness to implement the BIM in construction industry variable which is as the dependent variable of this study. The Cronbach's alpha value of the readiness to implement the BIM in construction industry variable was 0.785 which is greater than 0.7. Zohrabi (2013) explained an acceptable level of Cronbach's alpha value for internal consistency is 0.7 or higher. Therefore, the researcher can state that all the twenty-seven instruments can be used with this study.

4.3. Reliability and Validity of Qualitative data

Leung (2015) explained qualitative research as a exploratory research. Qualitative type research can be used to analyze the problem in-depth using the participants' view. Qualitative research uses credibility, transferability, dependability and conformability as using reliability and validity in q ualitative studies. All the measurements mentioned above namely credibility, transferability, dependability and conformability can be used to measure the accuracy of the collected data.

Cypress (2017) explained credibility as accurate and truthful data according to the participant's experience. The researcher used several questions to measure one variable as it helps to collect views of participants in different angles. After checking the qualitative data, the researcher understood that all the data can be used with this study as those data explain the current nature of construction industry related to BIM.

Transferability means the ability to use the information that was provided by the sample and explain the past of a particular industry or the ability to use the collected data in a different matter. The researcher checked about the readiness of Sri Lankan

construction industry to implement BIM. The researcher identified that the findings can be applied to the overall construction industry of Sri Lanka.

Dependability of the qualitative study works as reliability in the quantitative studies (Golafshani, 2003). Dependability evaluates the quality of data collection, data analysis and generates the theory at the end. The researcher identified that dependability is high as most of the participants provide similar answers to specific questions.

Conformability in qualitative research means to validate the result by others. In this research, the researcher collected qualitative data by using questionnaire and it helped to compare the result and improve the confirmability.

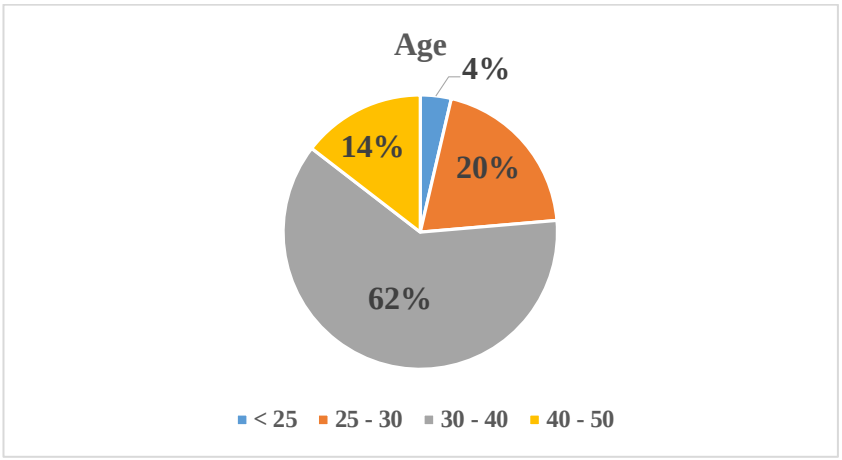
According to the analysis of 11 data sheets, the researcher identified that conformability, credibility and dependability are high and only transferability is limited in Sri Lankan construction industry.

4.4. Sample Profile

4.4.1. Age

Age plays an important role in this study as it can used to for explain the maturity of the participants. Maturity always represents the knowledge, skills and current industry updates. BIMis one of the new trends that focuses on the construction industry now. Therefore, all the employees who work in the construction industry are not updated with this system. This helps to get an idea about BIM related knowledge of employee's who work in the construction industry.

Figure 4-1: Age of the participants



As explained in Figure 4-1, most of the participants (62 %) belongs to the 30 to 40 age group. 4% of the participants represented the age group less than 25 and 14 % of the participants belonged in the agegroup 40 to 50. Moreover, 20 % of the participants who represented the 25 to 30 age group. There was a larger number of participants who represent the 30 to 40 age group which emphasized that most of them are updted aboutcurrent industry as people of this age are more interested in finding new things.

4.4.2. Job Category

Job category is another most important measurement which can explain the knowledge, skills, and experience of a person.

Figure 4-2: Job Category

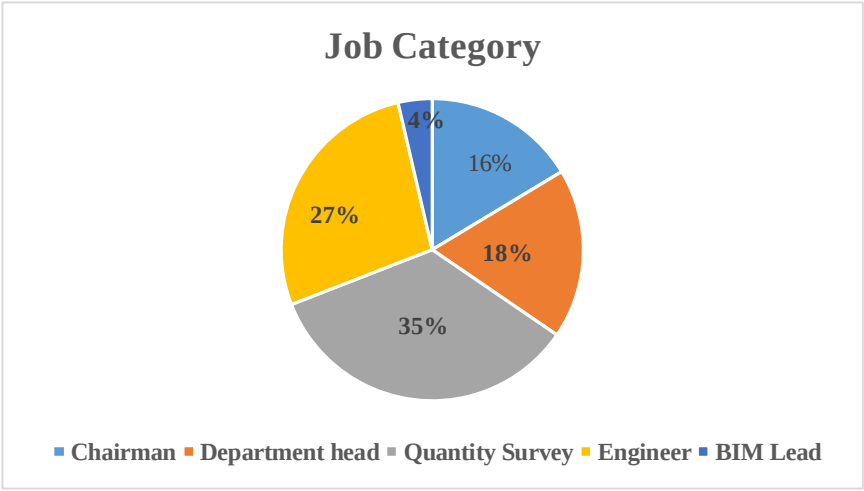
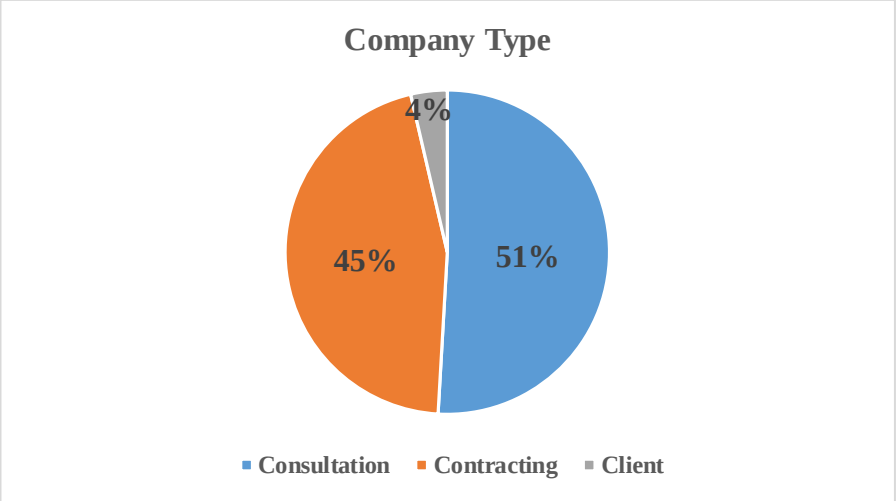


Figure 4-2 explains the participant's job category. According to the pie chart, the majority, which is 35% of the participants in this survey were quantitative surveyors. Department heads(most of them from architect profession) of the organizations also participated representing 18 % of the participants and 27 % of the participants in this study were engineers.. Moreover, 16 % of the participants were chairmen (most of them from architect profession) and 4 % were BIM leads.

4.4.3. Company Type

A number of employees in an organization help to understand the company's type. BIM implementation is a new trend to Sri Lankan construction industry. Moreover, the company needs to invest basic capital to implement the BIM system in an organization. Organization type explains the ability of different organizations to go for a new system named BIM and the demand for a particular system.

Figure 4-3: Company type



Most of the survey participants work in a consulting firm representing 51 % of the study and 45 % work for contracting companies. Moreover, 4 % of employees work for client companies. As most of the participants work for consultation and contracting companies, the researcher can assume that a fair sample is collected and can generate a fair result through this study.

4.4.4. Number of Employees in the Company

BIM implementation is a new trend to Sri Lankan construction industry. Therefore, it needs to have knowledgeable, skillful and experienced employees. Also, a number of employees explain the ability and capacity of the company to adapt to a new system.

Figure 4-4: Number of Employees

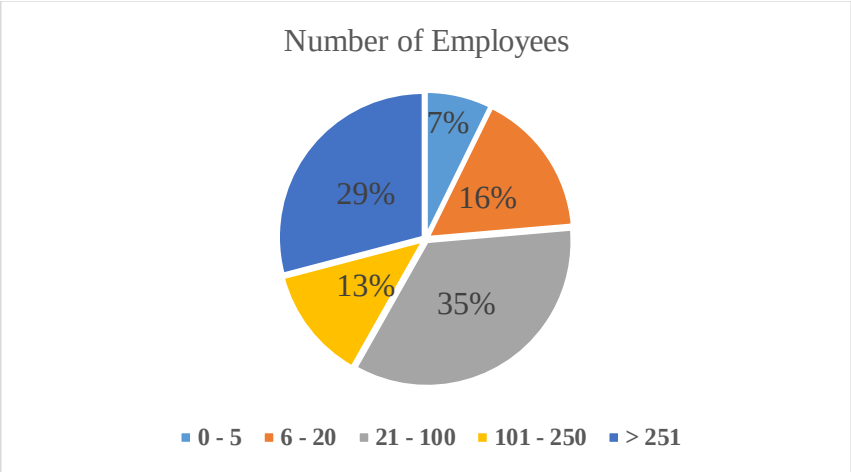
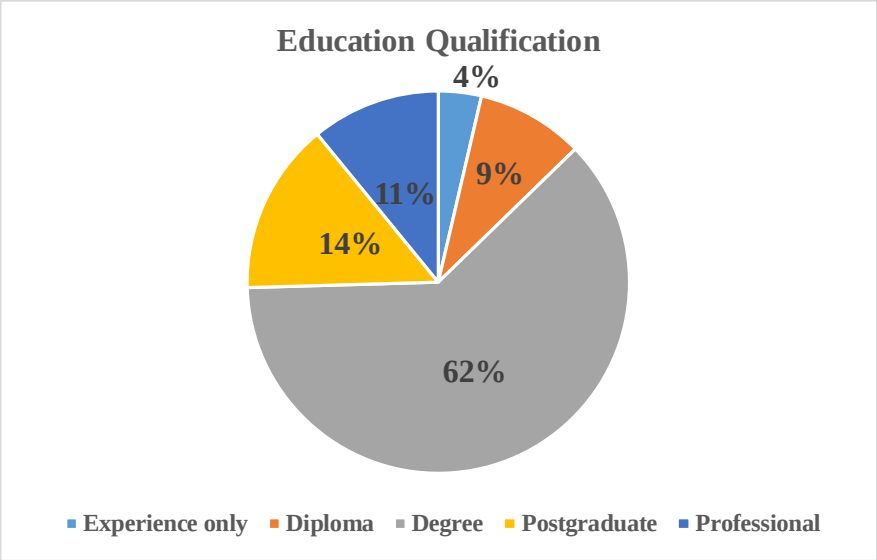


Figure 4-4, explains the number of employees working in the participant's companies. Most of the representatives in the survey come from companies with their employee count in the ranges of 21- 100(35%) and 101-250 (13%) and therefore, it can be declared that modt of the local companies are medium sized]. . In addition, participants from larger companies represented 29 % of the study. 7 % of companies can be categorized as micro enterprises as 5 or less than 5 employees work in their companies. Small companies with 6 to 20 employees Represented 16% of the survey.

4.4.5. Highest Education Level of the Employees

High educational levels increase the ability of participants to adapt to new technologies, new systems and new working methods. In addition, it helps to have a very good understanding about BIM system and BIM system implementation.

Figure 4-5: Educational qualification



As explained in Figure 4-5, most of the participants had a degree and represented 62 % of the participants. This is a good trend as most of them are educated and it is easy to adapt to new systems and new methods. Moreover, 14 % of the participants were qualified with postgraduate degrees which emphasized that most of the construction companies have enough capability and skillful employees. In addition, 11 % of participants fulfilled job required qualification by engaging with professional courses. 4 % of employees have experience only and 9 % of employees have a diploma level qualification. Therefore, the researcher can assume that the sample is well represented in each category which helps to enhance the accuracy of the study.

4.4.6. Working Experience

Working experience is another important measurement in this research study. This helps to understand the participant's skills and knowledge related to the construction industry. Experience helps to enhance the practices of the construction industry and compare the different methods used and the industry.

Figure 4-6: Working experience

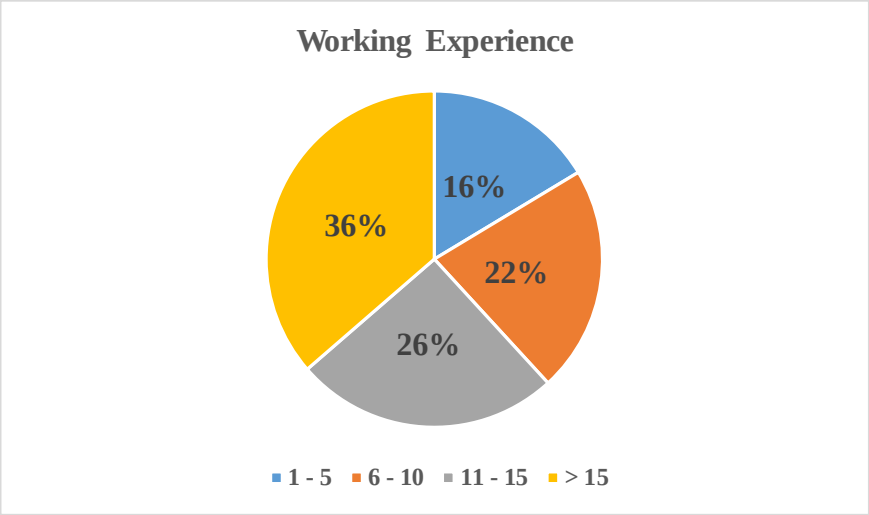
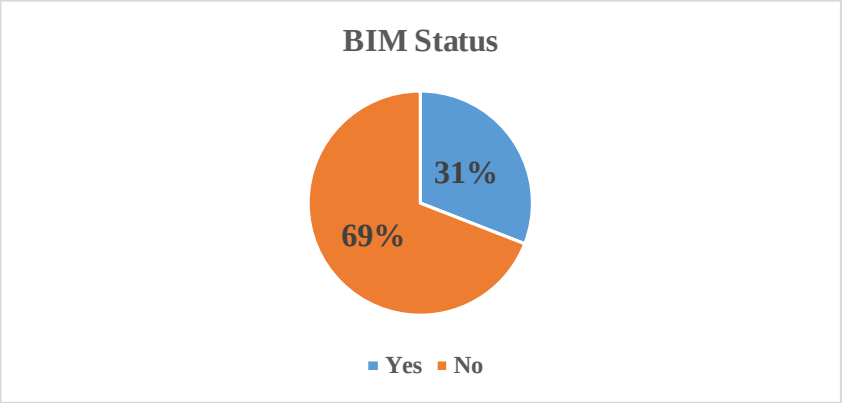


Figure 4-6 clearly explains the working experience of the participants in the construction industry. Majority of the participants has more than 15 years experience and denotes 36 % of the study. 26 % of the participants has 11 to 15 years of work experience. In addition, 22 % has 6 to 10-year work experience and 16 % had 1 to 5-year work experience. According to the statistics, participants have different levels of work experience which can use to generate an accurate result at the end of the study.

4.4.7. BIM Status

As explained throughout this study, BIM system is a new system for the company and is still new to the Sri Lankan construction industry. Therefore, it is essential to understand the current practices related to the BIM and the number of companies who are adopted to the new system currently.

Figure 4-7: BIM Status



According to Figure 4-7, participants stated that most of the companies do not practice BIM status at 69 %. 31 % stated that their companies practice the BIM system for construction-related work. According to the result, the researcher can assume that this study can generate the fair result as some companies not practice the BIM system and some other companies practice the BIM system.

4.5. Answers of the Participants

This section can be used to analyze the answers of the participants who participated in the survey. This section can be divided into two section such as answers of participants for qualitative questions and answers to quantitative questions. The researcher explains 55 data gathered for quantitative survey questionnaire and 11 data gathered for a qualitative survey questionnaire.

4.5.1. Answers of the participants for quantitative survey questionnaire

The independent variable of this study was the level of importance of management, people, process, and technology. The researcher comprehensively explains to the participants as it helps to understand their viewpoint.

Level of Importance of Management

According to the literature, management support is a very important factor in the readiness of BIM implementation in the construction industry. The literature explained management as a critical factor which leads an organization towards success. The researcher asked six questions to understand the participants's view

with regard to the management support to implement BIM system in an organization. Those six questions were goals of implementing BIM needs to align with the goals of the organization.It is essential to deal with all the business partners to get the ideas about BIM implementation before implementing it, risk management skills of the management is essential to work with BIM implementation, management knowledge related to BIM is essential to implement BIM, it is essential to have clear vision to management for implementing BIM in an organization and top-down approach is most suitable to implement BIM in an organization. Table 4-2 explains the participants's view related to management support towards the BIM implementation in an organization.

Table 4-2: Answers to the importance of management variable

Question	**Unimportant**	**Not Important**	**Netural**	**Important**	**Highly Important**
BIM objectives need to align with business goals	0	4	4	17	30
Negotiation with business partners essential	9	3	5	18	20
Risk management skill need to deal with risks associated with BIM implementation	3	2	13	6	31
Management needs to have an appropriate level of BIM awareness and knowledge	3	0	4	20	28
Management needs to have a clear vision and missions for BIM implementation	3	0	0	17	35
Top-down approach suitable to implement BIM	0	3	6	29	17

Table 4-2 explains the answers of participants for six questions used for measuring the importance of management. According to frequencies, most of the participants disagree with the statements which emphasized their agreement for each statement. The result stated that management support, vision, the agreement between business

partners, management's risk management skills, and management knowledge related to BIM implementation are most important to enhance the readiness of BIM implementation.

These six questions were used to explain the importance of management to implement the BIM system in different organizational context in the construction industry. Therefore, the researcher measured factors related to the importance of management variable.

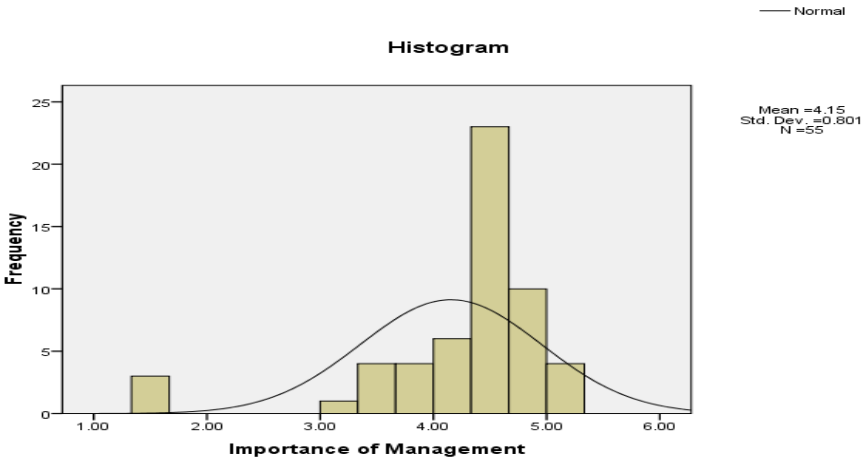
Table 4-3: Statistic - Importance of Management

Statistics

MF

N	Valid	55
	Missing	0
Mean		4.1545
Median		4.3333
Mode		4.33
Std. Deviation		.80114
Variance		.642
Skewness		-2.455
Std. Error of Skewness		.322
Kurtosis		6.645
Std. Error of Kurtosis		.634
Range		3.67
Minimum		1.33
Maximum		5.00
Sum		228.50

Figure 4-8: Histogram of Importance of Management



The researcher used five-point Likert scale questions to measure each variable. Therefore, the average value that a question can score is 3. The mean value being greater than 3 shows the agreement of the participants for the statement and that being less than 3 shows the disagreement for the statement. As shown in Table 4-3, the mean value of the importance of management was 4.15 which was greater than 3. This explains most of the participant's agreed with the given statements in the questionnaire. Median and mode of the variable were 4.33 which mean most of the participants scored as 4 or 5 out of 6 questions. The standard deviation was 0.80114 which was a relatively high value. The standard deviation can be used for explaining the spread of answers in a data set. According to the obtained value for standard deviation, the researcher can assume that most of the data spread in a larger area. Variance explains the spread between numbers in a dataset. The variance was 0.642 which was higher value. This emphasizes that the number of answers which deviate from one another in considerably high. Skewness was -2.455 which explain a long left tail for the data set. Kurtosis is used for explaining the sharpness of the peak of a data distribution. Kurtosis value being equal to 3 means normal distribution and less than 3 means platykurtic. The kurtosis value greater than 3 means leptokurtic. Kurtosis value was 6.645 which was greater than 3 which means this data set is a normal distribution and shows leptokurtic. Answers of dataset spread between 1.33 and 5 and the range were larger as 3.67. Figure 4-8 explains the data distribution in graphical formation.

Level of Importance of Process

According to the literature, implementing the new system in an organization means the organization has to change their process and need to analyze the new process to achieve the high rate of success. The literature explained the process as an important factor which leads an organization towards success. The researcher asked nine questions to understand the participants' view regarding the process related to implementing BIM system in an organization. Those nine questions were business redesign is an essential part in BIM implementation, small and incremental approach is most suitable, implement incentives and rewards help to motivate employees, essential to communicate among all the employees in all the levels to implement BIM successfully, essential to use design and build type of project delivery, BIM model helps to enhance the accuracy of the model, BIM system helps to find the collision, BIM system helps to design the building accurately, and the project team can do calculations very efficiently and accurately. Table 4-4 explains the participants view related to the importance of analyzing related to BIM implementation in an organization.

Table 4-4: Answers to the importance of process variable.

Question	**Unimportant**	**Not Important**	**Netural**	**Important**	**Highly Important**
Business redesign is an essential part	0	3	9	16	27
The small and incremental approach most suitable implementation to in BIM	0	4	2	24	25
Implement incentives and rewards helps to motivate employees	0	3	13	9	30
Essential to communicate among all the employees in all the levels to implement BIM successfully	0	3	11	3	38
Essential to use design and build type of project delivery to implement BIM	0	5	3	20	27

Question	Unimportant	Not Important	Netural	Important	Highly Important
The BIM model helps to enhance the accuracy	0	3	0	7	45
BIM system helps to find the collision in a design stage	0	3	1	10	41
BIM system is an innovative system for design building accurately	0	3	0	11	41
The project team can do calculation very efficiently and accurately	0	2	1	9	43

Table 4-4 explains the answers of participants for nine questions which were used for measuring the importance of process. According to frequencies, most of the participants disagree with the statements which emphasized their agreement for each statement. The result stated that business redesign, small and incremental approach for implement BIM system, providing incentives, communicattion about the new system among all the employees, and etc. is essential when implementing BIM system in an organization.

These nine questions were used to explain the importance of the process to implement the BIM system in the different organizational context in the construction industry. Therefore, the researcher measured factors related to the importance of the process variable.

Table 4-5: Statistic - Importance of Process

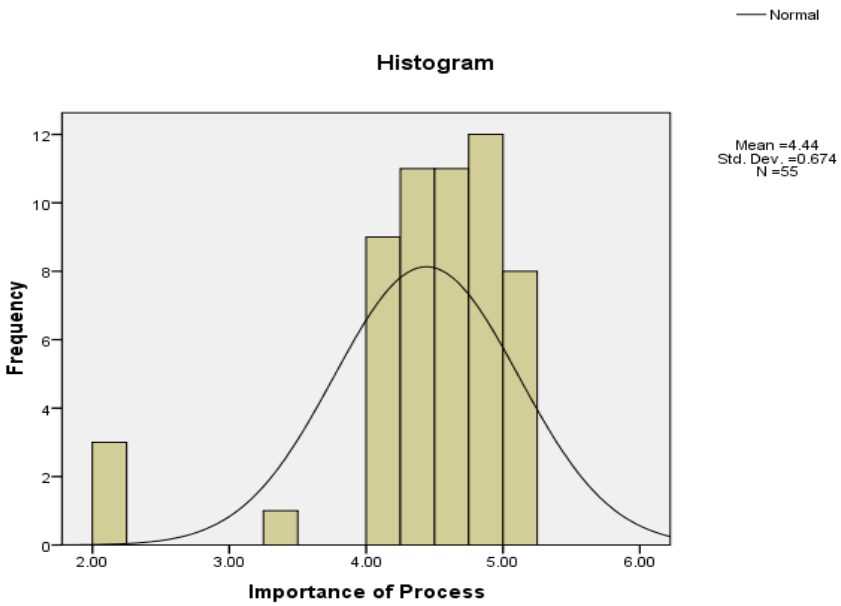
Statistics

PIF

N	Valid	55
	Missing	0
Mean		4.4404
Median		4.5556
Mode		4.89[a]
Std. Deviation		.67450
Variance		.455
Skewness		-2.659
Std. Error of Skewness		.322
Kurtosis		7.689
Std. Error of Kurtosis		.634
Range		3.00
Minimum		2.00
Maximum		5.00
Sum		244.22

a. Multiple modes exist. The smallest value is shown

Figure 4-9: Histogram of the importance of process



The researcher used five-point Likert scale questions to measure each variable. Therefore, the average value that a question can score is 3. The mean value being greater than 3 shows the agreement of the participants for the statement and that being less than 3 shows the explain disagreement for the statement. As shown in Table 4-5, the mean value of the importance of process was 4.44 which was greater than 3. This denotes that most of the participants agreed with the given statements in the questionnaire. Median and mode of the variable were 4.55 and 4.89 respectively which means most of the participants scored 4 or 5 out of 9 questions. The standard deviation was 0.67450 which was a higher value. The standard deviation can be used to explain the spread of answers in a data set. According to the obtained value for standard deviation, the researcher can assume that most of the data is spread in a larger area. Variance explains the spread between numbers in a dataset. The variance was 0.455 which was a lower value. This means that there are different answers which deviate from one another on a larger scale. Skewness was -2.659 which explains a long left tail for the data set. Kurtosis is used to explain the sharpness of the peak of a data distribution. Kurtosis value being equal 3 means normal distribution and less than 3 means platykurtic. The kurtosis value greater than 3 means leptokurtic. Kurtosis value is 7.689 which is greater than 3 means this data set is a normal distribution and shows leptokurtic. Answers of dataset spread between 2 to 5 and the range were larger as 3.00. Figure 4-9 explains the data distribution in graphical formation.

Level of Importance of People

According to the literature, implementing the new system in an organization means most of the time people show a resistance to change with new methods. Therefore, people readiness highly influences on implementing BIM system in an organization. The researcher asked six questions to understand the participants view regarding the people related matters to implement BIM system in an organization. Those six questions were, it is essential to clearly defined roles and responsibilities, all the employees need to have required a set of skills and attitude necessary to carry the roles and responsibilities, A continuous on-job training essential to improve the skills

of employees, organizational culture should respect knowledge sharing, and BIM helps to balance workload in a construction site.

Table 4-6: Answers to people variables

Question	**Unimportant**	**Not Important**	**Netural**	**Important**	**Highly Important**
It is essential to clearly defined roles and responsibilities	3	0	1	6	45
Empowerment for all new roles	3	0	1	19	32
All the employees need to have required a set of skills and attitude necessary to carry the roles and responsibilities	3	0	1	31	20
A continuous on-job training essential to improve the skills of employees and confidence level	3	0	1	23	28
Work environment and organizational culture should respect knowledge sharing and support to each other	3	1	0	7	44
BIM helps to balance workload in a construction site	3	0	1	12	39

Table 4-6 explains the answers of participants for six questions which were used to measure the importance of people in BIM implementation. According to frequencies, most of the participants disagree with the statements which emphasized their agreement for each statement. The result stated that it is essential to clearly define roles and responsibilities, all the employees need to have a required set of skills and attitude necessary to carry the roles and responsibilities, a continuous on-job training essential to improve the skills of employees, organizational culture should respect knowledge sharing, and BIM helps to balance workload in a construction site. These six questions were used to explain the importance of the process to implement the

BIM system in the different organizational context in the construction industry. Therefore, the researcher measured factors related to the importance of people variable.

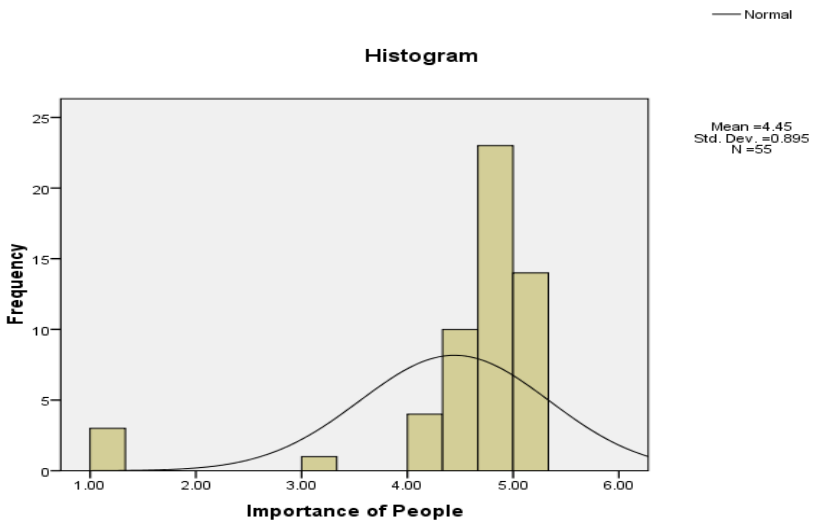
Table 4-7: Statistics - The importance of people

Statistics

PEF

N	Valid	55
	Missing	0
Mean		4.4455
Median		4.6667
Mode		4.67
Std. Deviation		.89526
Variance		.801
Skewness		-3.275
Std. Error of Skewness		.322
Kurtosis		10.579
Std. Error of Kurtosis		.634
Range		4.00
Minimum		1.00
Maximum		5.00
Sum		244.50

Figure 4-10: Histogram of the importance of people



The researcher used five-point Likert scale questions to measure each variable. Therefore, the average value that a question can score is 3. The mean value greater than 3 explains the agreement of the participants for the statement and less than 3 explains disagreement for the statement. As shown in Table 4-7, the mean value of the importance of people was 4.44 which was greater than 3. This explains most of the participants' agreement with the given statements in the questionnaire. Median and mode of the variable were 4.66 which means most of the participants scored as 4 or 5 among 6 questions. The standard deviation was 0.89526 which is a higher value. The standard deviation can be used for explaining the spread of answers in a data set. According to the obtained value for standard deviation, the researcher can assume that most of the data is spread in a larger area. Variance explains the spread between numbers in a dataset. The variance was 0.801 which was a lower value. This depicts that there are different answers which deviate from one another on a larger scale. Skewness is-3.275 which means a long left tail for the data set. Kurtosis is used for explaining the sharpness of the peak of a data distribution. Kurtosis value equal 3 means normal distribution and less than 3 means platykurtic. The kurtosis value greater than 3 which means leptokurtic. Kurtosis value was 10.579 which was greater than 3 means this data set is a normal distribution and shows leptokurtic. Answers of dataset spread between 1 and 5 and have a large range of 4.00. Figure 4-10 explains the data distribution in graphical formation.

Level of Importance of Technology

According to the literature, implementing the new system in an organization means the organization and the management need to have good understanding regarding the modern technology to get the maximum benefits out of that. Therefore, technology highly influences on implementing BIM system in an organization. The researcher asked six questions to understand the participants's view regarding with the technology related matters to implement BIM system in an organization. Those six questions were, company should develop well-defined ICT policy for BIM, ICT infrastructure should be implemented to support BIM, it is necessary to provide appropriate technical support to implement BIM, compatibility, and interoperability

of BIM software is essential, essential to have regular review and upgrade of ICT systems to meet changing, and company should develop effective coordination.

Table 4-8: Answers to the importance of technology

Question	**Unimportant**	**Not Important**	**Netural**	**Important**	**Highly Important**
The company should develop well-defined ICT policy for BIM	0	3	3	6	43
Considerable ICT infrastructure should implement to support for BIM	0	3	1	4	47
The provider needs to provide appropriate technical support to implement BIM	0	3	3	12	37
Compatibility and Interoperability of BIM software with legacy and business partners‟ ICT system is essential	0	3	1	14	37
Regular review and upgrade is essential	0	3	1	8	43
The company should develop effective coordination	0	2	0	5	47

Table 4-8 explains the answers of participants for six questions which were used for measuring the importance of technology in BIM implementation. According to frequencies, most of the participants disagree with the statements which emphasized their agreement for each statement. The result stated that company should develop well-defined ICT policy for BIM, ICT infrastructure should implement to support for BIM, needs to provide appropriate technical support to implement BIM, compatibility and interoperability of BIM software is essential, essential to have regular review and upgrade of ICT systems to meet changing, and company should develop effective coordination.

These six questions were used to explain the importance of technology to implement the BIM system in different organizational contexts in the construction industry. Therefore, the researcher measured factors related to the importance of the technology variable.

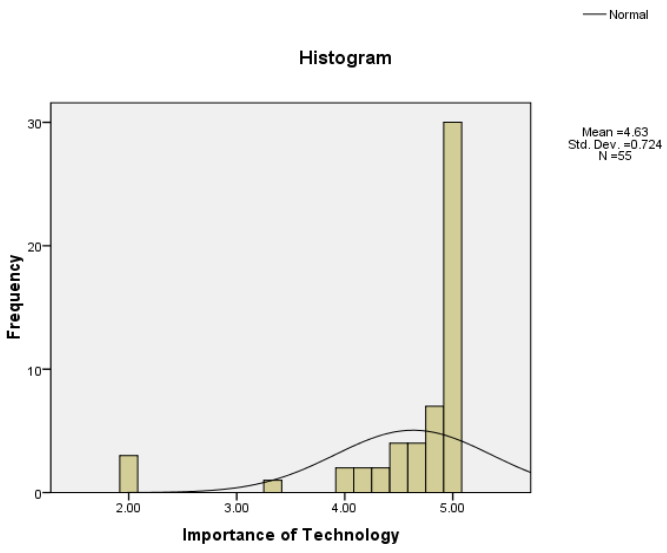
Table 4-9: Statistics - Importance of Technology

Statistics

TIF

N	Valid	55
	Missing	0
Mean		4.6333
Median		5.0000
Mode		5.00
Std. Deviation		.72393
Variance		.524
Skewness		-2.848
Std. Error of Skewness		.322
Kurtosis		7.986
Std. Error of Kurtosis		.634
Range		3.00
Minimum		2.00
Maximum		5.00
Sum		254.83

Figure 4-11: Histogram – Importance of technology



The researcher used five-point Likert scale questions to measure each variable. Therefore, the average value that a question can score is 3. The mean value greater than 3 shows the agreement of the participants for the statement and less than 3 shows disagreement for the statement. As shown in Table 4-9, the mean value of the importance of technology was 4.63 which is greater than 3. This explains most of the participants' agreement with the given statements in the questionnaire. Median and mode of the variable were 5 which means most of the participants scored 5 out of 6 questions. The standard deviation was 0.72393 which is high value. The standard deviation can be used for explaining the spread of answers in a data set. According to the obtained value for standard deviation, the researcher can assume that most of the data is spread in a larger area. Variance explains the spread between numbers in a dataset. The variance was 0.524 which was a lower value. This emphasized that there are different answers which deviate from one another on a larger scale. Skewness was -32.848 which explains the long left tail for the data set. Kurtosis is used for explaining the sharpness of the peak of a data distribution. Kurtosis value being equal 3 means normal distribution and that being less than 3 means platykurtic. The kurtosis value greater than 3 means leptokurtic. Kurtosis value was 7.986 which is greater than 3 meaning this data set is a normal distribution and shows leptokurtic. Answers of dataset spread between 2 to 5 and has a considerably large range of 3.00. Figure 4-11 explains the data distribution in graphical formation.

Dependent Variable - Level of readiness

The researcher used 27 questions to measure the level of readiness of the construction companies to implement BIM system. All the questions were categorized under technology, people, process, and management. The answers to the 27 questions shown in Table 4-9.

Table 4-10: answers for the level of readiness

Question	**Totally incapable**	**Not capable**	**Neutral**	**Capable**	**Highly capable**
BIM objectives need to align with business goals	0	3	3	6	43
Negotiation with business partners essential	0	3	3	6	43
Risk management skill need to deal with risks associated with BIM implementation	0	3	3	6	43
Management needs to have an appropriate level of BIM awareness and knowledge	0	3	3	6	43
Management needs to have a clear vision and missions for BIM implementation	2	0	30	13	10
Top-down approach suitable to implement BIM	2	2	13	28	10
Business redesign is an essential part	2	0	17	29	7
The small and incremental approach most suitable implementation to in BIM	2	10	10	29	4
Implement incentives and rewards helps to motivate employees	3	0	4	20	28
Essential to communicate among all the employees in all the levels to implement BIM successfully	2	0	5	28	20
Essential to use design and build type of project delivery to implement BIM	2	12	9	23	9
The BIM model helps to enhance the accuracy	0	3	0	9	43
BIM system helps to find the collision in a design stage	2	6	5	11	31
BIM system is an innovative system for design building accurately	5	6	6	11	27

Question	Totally incapable	Not capable	Neutral	Capable	Highly capable
The project team can do calculation very efficiently and accurately	3	0	4	20	28
It is essential to clearly defined roles and responsibilities	2	6	3	14	30
Empowerment for all new roles	2	2	4	20	27
All the employees need to have required a set of skills and attitude necessary to carry the roles and responsibilities	4	4	8	37	2
A continuous on-job training essential to improve the skills of employees and confidence level	5	5	7	34	4
Work environment and organizational culture should respect knowledge sharing and support to each other	2	0	12	32	9
BIM helps to balance workload in a construction site	3	0	4	20	28
The company should develop well-defined ICT policy for BIM	2	1	9	35	8
Considerable ICT infrastructure should implement to support for BIM	2	1	7	17	28
The provider needs to provide appropriate technical support to implement BIM	3	0	4	20	28
Compatibility and Interoperability of BIM software with legacy and business partners‟ ICT system is essential	2	2	5	29	17
Regular review and upgrade is essential	2	0	7	20	26
The company should develop effective coordinations	2	0	7	28	18

Table 4-10 explains the participants' view regard with the level of readiness to implement BIM system in construction companies. The participants' stated that management, process, people, and technology can represent the company and all the four sectors need to function very well to achieve the success in BIM system implementation. The researcher studies the behavior of readiness to implement BIM system variables.

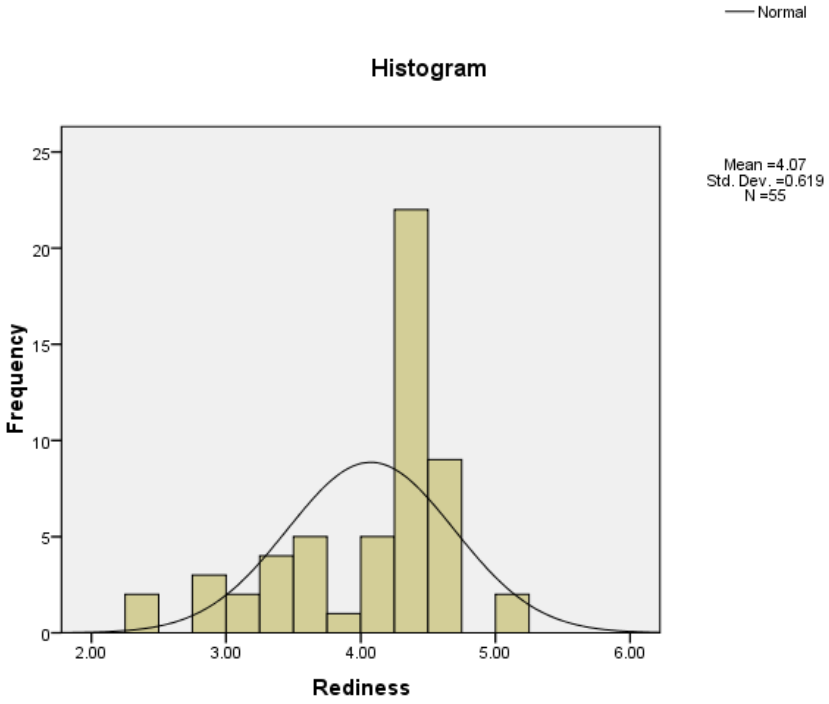
Table 4-11: Statistics - The level of Readiness

Statistics

DF

N	Valid	55
	Missing	0
Mean		4.0741
Median		4.3333
Mode		4.33
Std. Deviation		.61872
Variance		.383
Skewness		-1.157
Std. Error of Skewness		.322
Kurtosis		.779
Std. Error of Kurtosis		.634
Range		2.67
Minimum		2.33
Maximum		5.00
Sum		224.07

Figure 4-12: Histogram for the level of readiness



As shown in Table 4-11, the mean value of the level of readiness was 4.07 which is greater than 3. This explains most of the participants' agreement with the given statements in the questionnaire. Median and mode of the variable were 4.33 which means most of the participants scored 4 or 5 out of 27 questions. The standard deviation was 0.61872 which is a considerably high value. The standard deviation can be used for explaining the spread of answers in a data set. According to the obtained value for standard deviation, the researcher can assume that most of the data is spread in a larger area. Variance explains the spread between numbers in a dataset. The variance was 0.383 which was a lower value. This emphasized that there are different answers which deviate from one another on a larger scale. Skewness was -1.157 which was explaining long left tail for the data set. Kurtosis is used for explaining the sharpness of the peak of a data distribution. Kurtosis value equal 3 means normal distribution and less than 3 means platykurtic. The kurtosis value greater than 3 meaning leptokurtic. Kurtosis value was 7.779 which was greater than 3 means this data set is a normal distribution and shows leptokurtic. Answers of

dataset spread between 2 and 5 and the range is 3.00. Figure 4-12 explains the data distribution in graphical formation.

4.5.2. Answers of the participants for qualitative survey questionnaire

Table 4 12 shows the profile of participants in qualitative questionnaire survey.

Name of the participants	Job Title	Education Qualification	Experience
P1	Engineer	Diploma	>15 years
P2	Engineer	Degree	1 – 5 years
P3	Chairman	Degree	1 – 5 years
P4	Quantity Survey	Degree	11 – 15 years
P5	Quantity Survey	Degree	11 – 15 years
P6	Quantity Survey	Degree	1 – 5 years
P7	Quantity Survey	Degree	11 – 15 years
P8	Engineer	Experience only	6 – 10 years
P9	Engineer	Postgraduate	>20 years
P10	Engineer	Postgraduate	>20 years
P11	Architecture	Professional qualification	11 – 15 years

The researcher considered 11 views during the qualitative survey questionnaire analysis as many participants did not answer most of the questions. The researcher identified that most of the industry experts do not have in-depth understanding related to the BIM system. The researcher named participants as P1, P2, P3, P4, P5, P6, P7, P8, P9, P10, and P11.

P1 explained BIM as a process for creating and managing all of the information and data on a project – throughout the project lifecycle. P2 explained BIM as BIM is processed/ Methodology consists of several software for each professional in the AEC industry. And work in central model real-time changes can be performed by all stakeholders if we implemented the BIM. P3 explained BIM as BIM is future of the

construction industry. BIM (Building Information Modeling) is an intelligent 3D model-based process that AEC professionals the insight and tools to more efficient planning, designing, constructions, and manage buildings and infrastructure. P11 explained the BIM as a Platform to design and Build in a 3D Platform with parametric coordination.

According to the participants' view, advantages of the BIM system is to visualize 3D model, Easy to generate shop drawings for various building systems, cost estimating and easy for quantity take off, construction scheduling, detection and solving conflict, interference and collision detection, forensic analysis, cost-effective and facilities management. Moreover, the researcher also identified the following advantages through the questionnaire which can be named as reducing the cost of rework, reducing contractual dispute and reduce EOT claims and variation, extra work claims, real-time approval processes, accuracy take-off method, digital representation, applicable for total project life cycle. In addition, BIM reduces the complexity of the work, reduce the rework cost, helps to promote the business, helps increase the confidence of the staff, can enhance the efficiency of the work and productivity is another advantage of this system. P11 stated that inter-Disciplinary coordination and clash detection helps to resolve construction issues, can work with more accurate quantities, and more accurate project planning.

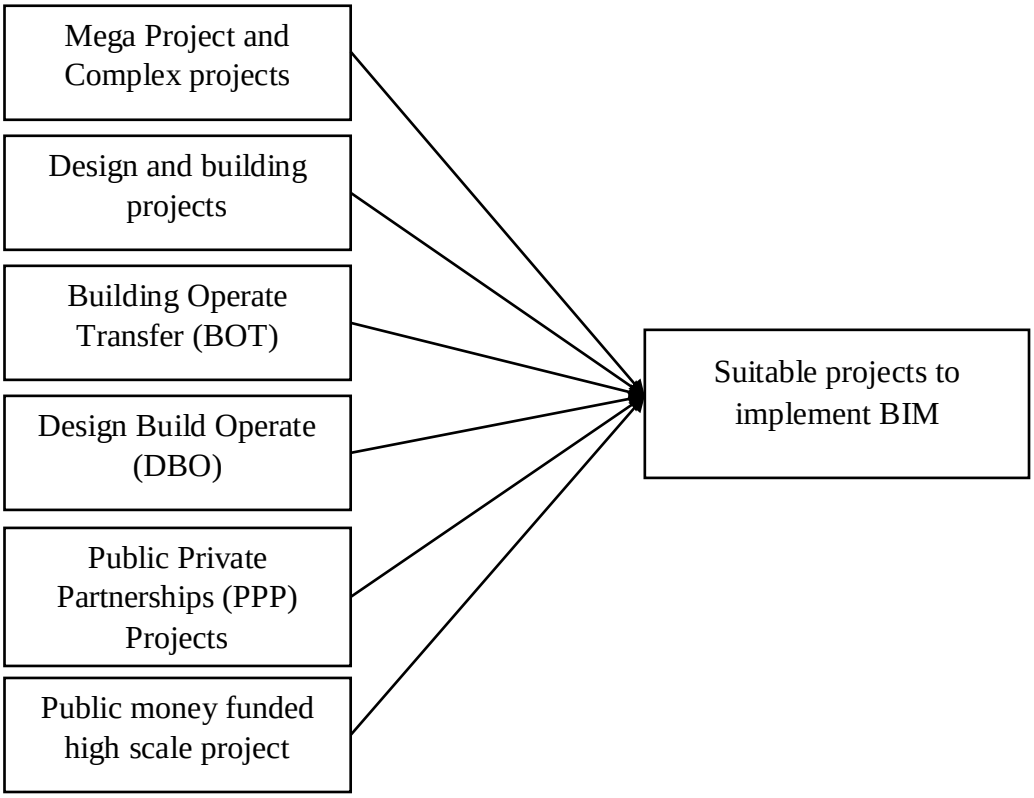
Most of the companies use AutoCAD, Revit Structure, Revit Architecture, Revit MEP, Naviswork, Cost X, Bluebeam, PlanSwift, PlanGrid, AconeX, Primavera, Autodesk Civil 3D, Tekla, Surfer, and SAP 2000.

Some companies do not use BIM for their business process currently and some companies use BIM for their business process. The participants who stated that their companies use BIM explained they work with Revit Structure, Revit Architecture, Revit MEP, Naviswork, Cost X. The companies use licensed software which highly influences on the cost of the organization. Most of the companies who implemented the BIM system in their company are still in trainee level as they are still in the

beginning. P11 stated that their company in BIM maturity level and indicate as level 2.

The company aligns with the BIM approach by introducing new roles, responsibilities, and procedures. The view of the P1 was current organizational flow had changed with the new BIM system implementation. P2 highlighted that it is essential to create new roles and responsibilities when implementing BIM for control and keep password as someone resigns from the company he or she will be able to use the same password and continue the work with AconeX. P6 stated that when implementing BIM it needs to create roles such as BIM coordinator, BIM trainer, BIM technicians, BIM project manager and BIM lead. The idea of P1, P3, P4, P5, P6, P7, P9 and P10 was that BIM system is more suitable to work with the complex projects. Further, P2 and P8 stated that BIM software is more suitable to work with mega projects. In addition, P3 stated that BIM software more suitable to manage Public Private Partnerships (PPP) , Design-Build-Own-Operate projects and Public money funded high scale project. According to the participants views, the researcher can create the following diagram for emphasizing the suitable job scope for BIM system implementation. P11 stated that any type of scope is suitable to work with BIM approach.

Figure 4-13: Suitable job scope for BIM system implementation



It is essential to identify the challenges that an organization has to face when implementing BIM system in their organizations. The challenges can be categorized as internally and externally. P1 explained time and budget, management commitment, and cost of the implement are internal challenges while competency of other firms, government support, and commitment of clients are external challenges which influence on BIM system in an organization. P3 explained that the organization has to invest huge cost for hardware and software associated with BIM system implementation. P5 highlighted that the organization needs to change policies, rules, business model, organizational structures, roles, decision making culture and practices to implement BIM system. This is a main challenge to the organization that can be categorized as an internal challenge. P11 stated that adopting to new technology, the cost associated with hardware update and purchasing license software is the most challenging part in BIM implementation.

The researcher needs to compare the building permit review process in two different scenarios namely traditional and BIM system implementation. Participants's view was that a traditional building permit review process is not as efficient as it is complex. The participants stated that with the BIM system they can avoid delays, helps to visualize the project in good view, and speed up real-time approval. P6 stated that BIM system helps to create paperless work which can be mentioned as an advantage. P5 explained that it is difficult to understand the drawing with the current system which influences on the quality.

The researcher tries to collect the BIM readiness criteria using four different aspects such as process, management, people, and technology. P1 explained that responsibilities and roles change with the BIM system implementation. P2 explained that process needs to change to enhance the accuracy and the efficiency. P3 stated that when implementing BIM system in the organization it needs to establish a dedicated process. P4 and P5 stated that when implementing BIM system it needs to create a separate risk management plan, software purchasing plan, staff training plan, and new business plan.

The participants' think when implementing BIM it is required needs to change the organizational process. Most of the time it takes more than 6 months to implement BIM system as it needs to train people and pass trial and error period. The company creates new job roles, redesign job description and salary level when implementing BIM system in an organization. Most of the participants' stated that it took so much time to implement BIM system due to lack of knowledge related to BIM system among Sri Lankans. In addition participants' stated that factors such as Organization's vision, clients requirement, rules and regulation of the local institution and government, competition from other similar firms, performance of the other sub-contractors, contractors, and relevant other stakeholders, performance of the staff, time period, cost, budget and profit and most importantly management commitment. P11 stated that it is essential to identify the gap first before changing the process. The company selects any suitable application of BIM system based on their requirement. It is essential to have a good plan to implement the BIM system

successfully in an organization according to the participants. BIM implementation plan needs to align with the vision, mission, policies, and business. The P1 explained his view as, "BIM will assist the company to be a pioneer consultancy firm with BIM in Sri Lanka. It will help to win more mega and complex nature projects, international awards, rankings and the best theme for the marketing". To successfully achieve all the objectives and goals the organization needs to monitor the BIM closely.

Management considers an important factor to implement the BIM system successfully. The participants highlighted that to implement BIM, it needs to invest huge costs. Therefore, the management needs to have a good idea about that. Participants stated that the client is not a very important aspect in BIM implementation as they do not have much knowledge about BIM yet. The management needs to have the capacity to manage the risk and challenges associated with the BIM. When implementing a new system to the company it can have mistakes, less productivity and low speed. Therefore, the management needs to plan for risks and other problems associated with that. The management has to face difficulties when changing the organizational process as most of the employees resist. Therefore, the management needs to have a good idea, good understanding, good decision-making ability and the ability to face uncertainty. Due to all these reasons management support and commitment is highly essential to implement the BIM system in an organization.

The participants's view is an employee is an essential factor in BIM system implementation in an organization. The employees should have the ability to work in a team, ability to communicate with all the stakeholders and technical skills. P5 stated that employees should have meeting handling and presentation skills, analytical skills, software and knowledge related to IT, leadership traits, and organizational skills. P6 stated that soft skills adaptability is essential to adapt to the new organizational culture.

It is essential to provide necessary training when introducing a new technology, working method or a system to an organization. The participants suggested internal training along with the software vendors. In addition, the participants stated that online document sharing can be covered in such training programs and video training system is the best method to train employees. Moreover, external training, and knowledge sharing was highlighted by many participants as it is easy to adapt to new methods and technologies.

Another factor that the researcher aimed throughout this study was the impact of technology on readiness to implement the BIM system. The participants who have BIM implementation in their organizations stated that the company needs to invest in hardware and software. Therefore, the organization has to change their current hardware infrastructure in the organization. The reasons as to why the organization needs to change the hardware infrastructure is BIM system needs high-performance resources. The participants highlighted that it is essential to have the spaces in the hard disk as it needs extra space to get backups. Most of the companies face difficulties such as budget, demand and available professional when try to implement BIM in their organization. The participants highlighted that, when selecting suitable applications it is needs necessary to consider about available budget, performances and job duties of each department, and training facilities for the employees. The companies can get the expertise ideas before selecting a suitable BIM application. The company needs to have good understanding about project scope when selecting a suitable application.

According to the qualitative data, the researcher can state that management involvement, business process, the ability of the people and technology can influence on the readiness of BIM system implementation.

4.5.3. Correlation analysis

Crossman (2018) explained correlation analysis as a method to measure the strength of the relationship between two variables. Gogtay & Thatte (2017) explained that correlation analysis can be used to find the association between two quantitative

variables. The fundamental of the correlation analysis is a linear relationship between two variables. The correlation analysis result spread between +1 to -1. +1 explains the perfect linear relationship between variables and it behaves in a positive manner. Correlation coefficient -1 means two variables are related negatively and the relationship is perfect. Correlation coefficient 0 means a negative relationship. There are different methods available to find the correlation analysis and the researcher used Pearson correlation analysis method to identify the association between two variables. The correlation analysis result comes up with sig value and correlation coefficient value. Correlation coefficient value can be used to express the strength of the relationship and sig value can be used to express the significance of the relationship. Table 4-13 explains correlation analysis result.

Table 4-12: Correlation analysis result

	The readiness of BIM implementation	
Importance of management	Value	0.561
	Sig.	0.000
Importance of process	Value	0.547
	Sig.	0.000
Importance of people	Value	0.498
	Sig.	0.000
Importance of technology	Value	0.507
	Sig.	0.000

According to the result, the importance of management and readiness of BIM implementation have a positive and strong relationship as Pearson correlation value was 0.561 which was greater than 0.5. The relationship between the importance of management and readiness of BIM implementation are significant as sig value or p-value was 0.000 which was less than 0.05.

According to the result, the importance of process and readiness of BIM implementation has a positive and strong relationship as Pearson correlation value is 0.547 which is greater than 0.5. The relationship between the importance of process and readiness of BIM implementation is significant as sig value or p-value was 0.000 which was less than 0.05.

According to the result, the importance of people and readiness of BIM implementation has a positive and weak relationship as Pearson correlation value was 0.498 which was less than 0.5. The relationship between the importance of people and readiness of BIM implementation is also significant as sig value or p-value was 0.000 which was less than 0.05.

According to the result, the importance of technology and readiness of BIM implementation has a positive and strong relationship as Pearson correlation value is 0.507 which was less than 0.5. The relationship between the importance of technology and readiness of BIM implementation is significant as sig value or p-value was 0.000 which was less than 0.05.

According to the correlation analysis test result, management, process, and technology highly influences on the readiness of BIM system implementation.

4.5.4. Regression analysis

Correlation analysis confirmed that there is a relationship between selected variables. Therefore, it is essential to identify the gravity of the relationship. This analysis can be used to identify the exact impact that independent variable can make on the dependent variable. B value is used to express the significance and the impact of the variable. The results are demonstrated in Table 4.13.

Table 4-13: Regression analysis result.

Variable	R square	B	B constant	Sig.
Importance of management	0.315	0.433	2.274	0.000
Importance of process	0.299	0.501	1.848	0.000
Importance of people	0.248	0.344	2.544	0.000
Importance of technology	0.257	0.433	2.066	0.000

As demonstrated in Table 4-14, the researcher can use the R square value to express the variance of readiness of BIM system implementation and can be explained using an independent variable. According to the values, 31.5 % variance of readiness of BIM system implementation can be explained using the importance of management. In addition, 29.9 % variance of readiness of BIM system implementation can be explained using importance of process. 24.8 % variance of readiness of BIM system implementation can be explained using importance of people and 25.7 % variance of readiness of BIM system implementation can be explained using the importance of technology. Moreover, regression analysis result can be used to develop suitable formulas to predict the dependent variable.

All the results obtained through analysis of qualitative data and quantitative data explained that management, process, people, and technology are essential factors that need to be considered before implementing BIM system.

4.6. Summary

Questionnaire method was used to collect the information related to this study and statistical and thematic analysis was used to analyze the quantitative data and qualitative data respectively. Fifty-five employees who work in the construction industry participated in the quantitative data collection and eleven participants

participated in qualitative data collection. The result explained that management, process and technology are highly important for the BIM system implementation in an organization. Therefore, organizations need to consider these factors more when implementing BIM system in their organization.

5. CONCLUSION AND RECOMMENDATION

5.1. Introduction

The last chapter of the research document is helpful to summarize the study and come up with the final conclusion. The researcher followed mixed method to understand the BIM in Sri Lankan construction industry. The researcher used quantitative and qualitative questions in the questionnaire to understand the BIM implementation in the construction industry, the readiness of the organization to implement the BIM system in the construction-related organization and current level of BIM system implementation. The researcher used both statistical analysis method and thematic analysis method to analyze the collected data. The researcher distributed 90 questionnaires among selected employees who work in the construction industry but received only 55 answered questionnaires for quantitative research questions and 11 questionnaires for the qualitative research questions. The researcher comprehensively explained the interpretation using collected data.

5.2. Achievement of the Objectives

The researcher derived four objectives to achieve through this study. Those objectives were to identify the framework for the assessment of the state of BIM realization, to find the state of BIM realization in Sri Lanka, to identify a suitable framework to assess BIM readiness of construction organizations, to find the BIM readiness of Sri Lankan construction organizations.

<u>To identify the framework for the assessment of the state of BIM realization</u>

Architectural Engineering and Construction (AEC) Industry needs to invest more time and energy to manage the business and lead to achieve the growth of the business. Therefore, it is essential to enhance the efficiency of the organization. According to the literature, it is difficult to measure the BIM realization at the beginning of the BIM implementation. The organizations have to invest huge costs on BIM at the beginning of BIM implementation and it takes sometime to measure the BIM realization. Most of the document argued that Return Of Investment(ROI) ,

cost-benefit analysis is most suitable to measure the BIM realization. The suitable framework for assessment of the state of BIM realization is understanding the benefits at the beginning of the implementation. Then, the organization can measure the intermediary benefits and end-benefit at the necessary level.

To Find the state of BIM realization in Sri Lanka

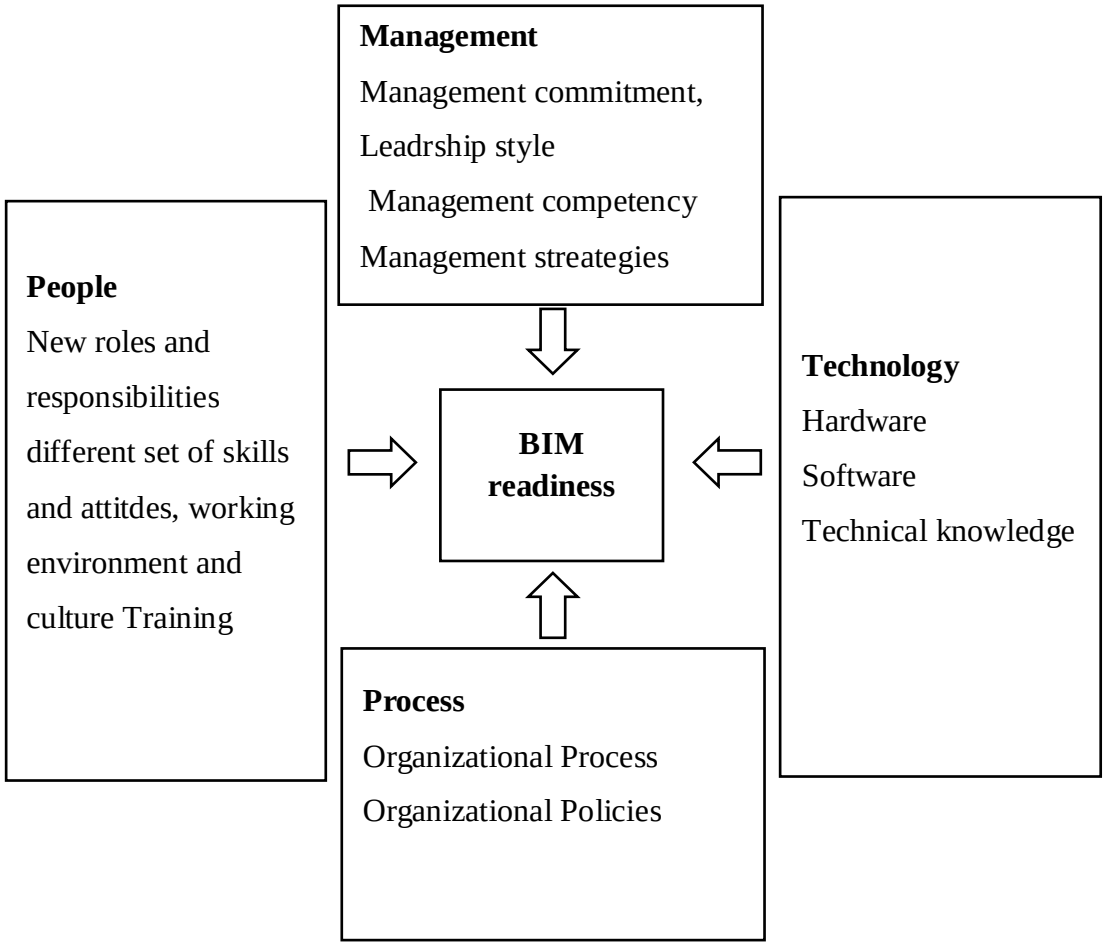
According to the qualitative data analysis, the researcher identified that some of the organizations are still at level 0 of BIM implementation and one company was in maturity level as level 2. Most of the companies have not yet implemented the BIM system and some companies still do not have a proper not much idea about BIM implementation and the benefits of the new method. Therefore, BIM realization in Sri Lanka can be explained as still being in the beginning level. According to the result of the quantitative study, the researchers found that most of the participants don't even have the slightest knowledge related to BIM implementation which highly influences on BIM implementation in Sri Lankan construction industry. Therefore, most of the companies need more expertise ideas and need to train their employees well to enhance the knowledge related to BIM to improve the knowledge related to BIM system before implementing in the companies.

To identify a suitable framework to assess BIM readiness of construction organizations

Harvard University Centre for International Development, (2001 cited in Alabdulqader, Panuwatwanich, & Doh, 2013) explained readiness as the preparation of the community to participate and accept particular phenomenon in order to achieve the goals of the company or professional level more effectively. According to the literature and the data analysis, the researcher found that management commitment and support, employees commitment, skills and support, technology and process of the organization which is necessary to work with BIM implementation highly influences on BIM implementation in the organization. Readiness helps to identify the gap between current organizational capabilities and requirement for implementing BIM system in the organization. The researcher identified that the organizational process, and policy of the company need to change.

The qualitative data revealed that management commitment, leadership style, management competency and their strategies highly influence on implementing BIM system in the organization. BIM implementation introduces new roles and responsibilities to the organization, requires a different set of skills and attitudes, changes the working environment and culture such as knowledge sharing and provide necessary training. Most of the companies think BIM is a huge cost to the organization as it needs to invest a huge amount on hardware, software, and technical knowledge. All the details can be shown using one image as shown in Figure 5-1.

Figure 5-1: BIM readiness Framework



To find the BIM readiness of Sri Lankan construction organizations

According to the quantitative analysis management, process and technology are highly important during BIM system implementation. According to the correlation analysis the people is showen as a less important factor than the other three factors that impact on the readiness of BIM system implementation. The qualitative data explained the direct viewpoint of participants. According to the result, process, management, employees, and technology are more important parts to BIM readiness of Sri Lanka. The organization needs to understand the current capabilities related to management, people and technology to align them with the BIM system implementation. In addition, the business process re-engineering is another most important factor that is necessary to identify the gap before planning for BIM implementation. According to the result, most of the people have less knowledge related to BIM and most of the organizations are in at level 0.

5.3. Limitation of the Study

The sample size of this research study was limited to 55 quantitative data and 11 for qualitative data. The researcher distributed 90 questionnaires among the employees who work in the construction industry. The researcher received only 70 quantitative data answer sheets and 10 ware incomplete and the rest of the respondents marked two answers for one question. Therefore, the researcher had to drop them due to the low quality of the data sheet.

Another limitation of this study is geographical boundaries as this research study covers only Sri Lankan context and the current status of the construction industry.

5.4. Future Research

Future researchers can identify the companies that implement the BIM system or the companies who currently practices the BIM in their organization. This will lead to collect data and identify more factors related to BIM readiness. In addition, future researchers can involve with knowledge and skill level of the employees which influences on implementing BIM system successfully in construction-related organizations.

5.5. Recommendation

The researcher developed a suitable BIM readiness framework for Sri Lankan context using the obtained result of this study. The researcher identified that factors such as management, process, people, and technology highly influences on BIM implementation readiness. Some people explained that top-down approach is most suitable to implement BIM system in construction organizations and some organization stated that some people suggest bottom-up approach is suitable to implement BIM system in the organization. Usually, employee resistance to change is a difficult problem that an organization has to face when introducing new methods. Therefore, the management of the organization needs to communicate all the updates related to BIM system implementation throughout the implementation process. Management commitment and the communication ability is highly important to introduce BIM system. In addition, it needs to have good leadership skills and knowledge when working with new technologies.

When an organization adapts to new technology, the organization needs to do necessary changes for the process. Therefore, all the responsible parties need to monitor the process from the beginning of the implementation and create a suitable plan.

The organization needs to upgrade the current hardware, software and technology related aspects. Therefore, the organization should create a budget first and need to find the funds for changing the organization according to new technology.

Knowledge sharing culture would help to adapt to the modern technology easily. In addition, the organization needs to provide enough training to develop the skills of the employees.

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APPENDIX 1 – QUESTIONNAIRE

SURVEY QUESTIONNAIRE-PART 1

BIM READINESS IN SRI LANKAN ARCHITECTURAL ENGINEERING AND CONSTRUCTION (AEC) INDUSTRY.

Part A - Personal Information

1. Age :

○ Less than 25 years ○ 25 – 30 years ○ 30 – 40 years

○ 40 – 50 years ○ 50 – 60 years ○ More than 60

2. Job Category

☐ Chairman ☐ Department head

☐ Quantity Surveyor ☐ Engineer

☐ Architect

Other (Please specify) _____

3. Which of Following discipline does your company belongs to (Please specify any other)

☐ Consultation ☐ Contracting

☐ Client

Other (Please specify) _____

4. How many employees does your company have?

- ○ 0 - 5
- ○ 6 - 20
- ○ 21 - 100
- ○ 101 - 250
- ○ More than 251

5. What is your highest education qualification related to the construction industry?

- ○ Industrial Experience only
- ○ Diploma
- ○ Degree
- ○ Postgraduate
- ○ PHD
- ○ Professional qualification(s)

6. How long have you been working in Architectural Engineering and Construction(AEC) industry?

- ○ Less than a year
- ○ 1 – 5 year
- ○ 6 – 10 years
- ○ 11 – 15 years
- ○ More than 15years

7. Is your Company currently using Building Information Modelling (BIM) tools as a part of the working process?

- ○ Yes
- ○ No

8. If the answer to above is YES select (tick) all BIM software used in your company.

☐ Revit Structures	☐ Touchplan	☐ BIM Track
☐ Revizto	☐ Assemble Insight	☐ Orion
☐ Revit Architecture	☐ Revit MEP	☐ VectorWorks
☐ Bently Structures	☐ BOCAD	☐ Autodesk Civil 3D
☐ Archicad	☐ Tekla Structures	☐ Naviswork
☐ PDMS	☐ Virtual Office	Others (Pls. specify)

9. Please state the application of BIM for following tasks in your company (Only answer, if the answer was YES for the question. No 7)

☐ Visualization	☐ Drawing Automation
☐ Scheduling (4D)	☐ Cost Analysis (5D)
☐ Automated Clash	☐ Material Taking Off
☐ Day Light /Lighting	☐ Energy Analysis
☐ Structural Analysis	

Others (Pls. specify)

10. Please mark the software file types used in your company to send and receive information

☐ DWG	☐ RVT	☐ DXF
☐ IFC	☐ NWD	☐ COBie
☐ XLS, XLSX	☐ MPP	☐ PDF
☐ DWF, DWFx	☐ PLN	

Others (please specify)

The following question is used to measure the level of importance and level of readiness. Therefore, please select a best appropriate answer for each statement under the level of importance and level of readiness of your company.

Level of Importance: 1- unimportant 2-Not Important 3-Neutral 4-Important 5-Highly Important

Level of readiness: A-Totally incapable B-Not capable C-Neutral D-Capable E-Highly Capable

Q. No	**Question**	**Level of Importance**					**Level of readiness**				
		1	**2**	**3**	**4**	**5**	**A**	**B**	**C**	**D**	**E**
	Management										
01	BIM objectives need to align with business goals	○	○	○	○	○	○	○	○	○	○
02	Negotiation with business partners essential before implement BIM	○	○	○	○	○	○	○	○	○	○
03	Effective risk management skill need to deal with risks associated with BIM implementation	○	○	○	○	○	○	○	○	○	○
04	Management needs to have an appropriate level of BIM awareness and knowledge	○	○	○	○	○	○	○	○	○	○
05	Management needs to have a clear vision and missions for BIM implementation	○	○	○	○	○	○	○	○	○	○
06	Top-down approach suitable to implement BIM in an organization	○	○	○	○	○	○	○	○	○	○
	Process										
07	Business redesign is an essential part in BIM implementation	○	○	○	○	○	○	○	○	○	○
08	The small and incremental approach most suitable to achieve targets in BIM implementation	○	○	○	○	○	○	○	○	○	○

Q. No	Question	Level of Importance					Level of readiness				
		1	2	3	4	5	A	B	C	D	E
09	Implement incentives and rewards helps to motivate employees which lead to change.										
10	Essential to communicate among all the employees in all the levels to implement BIM successfully in an organization.										
11	Essential to use design and build type of project delivery to implement BIM										
12	The BIM model helps to enhance the accuracy of the model										
13	BIM system helps to find the collision in a design stage										
14	BIM system is an innovative system for design building accurately										
15	The project team can do calculation very efficiently and accurately										

People

16	In successful BIM implementation, it is essential to clearly defined roles and responsibilities										
17	Empowerment for all new roles										
18	All the employees need to have required a set of skills and attitude necessary to carry the roles and responsibilities that are defined by the company										

Q. No	Question	Level of Importance					Level of readiness				
		1	2	3	4	5	A	B	C	D	E
19	A continuous on-job training essential to improve the skills of employees and confidence level										
20.	Work environment and organizational culture should respect knowledge sharing and support to each other										
21.	BIM helps to balance workload in a construction site										

Technology

22	The company should develop well-defined ICT policy for BIM										
23	Considerable ICT infrastructure should implement to support for BIM										
24	The provider needs to provide appropriate technical support to implement BIM										
25	Compatibility and Interoperability of BIM software with legacy and business partners‟ ICT system is essential										
26	Regular review and upgrade of ICT systems to meet changing BIM and Business needs										
27	The company should develop effective coordinations.										

SURVEY QUESTIONNAIRE PART 2

BIM READINESS IN SRI LANKAN ARCHITECTURAL ENGINEERING AND CONSTRUCTION (AEC) INDUSTRY.

INTERVIEW QUESTIONS

1. Do you know about BIM?
2. Please explain BIM according to your view
3. Please explain advantages of BIM for construction according to your view.

Current Status of BIM implementation

4. Please list the software you currently use in your professional practice / Company Example: AutoCAD, Revit, Excel, BlueBeam, PlanSwift, PlanGrid etc.

5. What is the BIM software that the company currently uses? Are these licenses?

6.

a) So far, to what stage has BIM been implemented within the company?
b) How does the company engage BIM approach in the current process flow of design?
c) What types of job scope requires BIM approach to be implemented?

7. Do you think the company creates new roles and responsibilities for BIM implementation? If yes, what are they?
8. What are the challenges of BIM implementation, internally and externally according to your view?
9. Do you satisfy with the current building permit review process? Do you see any advantage from BIM for building permit review process?

BIM Readiness Criteria

Process

1. Do you think that the company needs to change their process flow when implementing BIM? If yes, why?
2. How did the company change the process flow?
3. How long is/was the company target to achieve full BIM implementation? Why is such duration needed?
4. BIM has many applications such as 3D Authoring, Clash Check, Material Take Off, Walkthrough Review, 3D Design Review etc. How did the company priorities/choose which applications to use?
5. Does the company need to develop any BIM implementation plan?
6. If yes, how did the company develop the plan?
7. How useful was the plan to assist BIM implementation?
8. How does the company need to monitor/control the BIM implementation?
9. How important is it to have adequate resources to implement BIM?

Management

1. How important is the investment/implementation of BIM supporting the business objectives/needs?
2. Does the company need to aware of the issues of implementing BIM? What are they? How did the company respond to them?
3. Do you think the client plays an important role in order to support your BIM implementation program? Why?
4. What do you think of management's ability to manage the risks and challenges associated with BIM? Why is it important?
5. Are management's commitment and support important for BIM implementation? Why?

People

1. Does the company need to create any new roles and responsibilities associated with BIM implementation? If yes, what are they?
2. How does the company evaluate the people carrying out the new roles and responsibilities? What type of skills and attitude set must the aforementioned roles have to implement BIM?
3. What types of training and education programs does the company use to develop the BIM competency among the staff? Why each type of training was is important and how it can benefit the company?
4. What are the important criteria of the work environment to support BIM implementation? Why?

Technology

1. Does the BIM implementation cause changes to current hardware and infrastructure? What changes has BIM introduced to the company?
2. What are the technical difficulties when implementing BIM on a real project? How does the company respond to resolve them?
3. How does the company select the BIM software? What are the strategies used in selecting the right software?