BIM Implementation for Safety Control in Building Project

by

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Dissertation submitted in partial fulfilment of
the requirements for the
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CERTIFICATION OF APPROVAL

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BACHELOR OF ENGINEERING (Hons)
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Approved by,

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Ir. Dr. Idris Bin Othman

UNIVERSITI TEKNOLOGI PETRONAS
BANDAR SERI ISKANDAR, PERAK
May 2021

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

(FATIN ANIS SYAKIRAH BINTI MOHD ZAMBRI @ SHAHRIN HILMY)

ABSTRACT

Advance technology in construction has initiated taller and bigger skyscraper in the building projects. However, the revolution of construction industry has significantly increased the number of workplace injury and fatalities. Currently, safety planning is carried out separately from design phases and the utilization of CAD based construction drawing for safety planning purposes will results inaccurate interpretation. Hence, the implementation of BIM in building project will be a great solution to Architecture, Engineering and Construction (AEC) industry in managing safety control aspects. Nevertheless, the implementation of BIM itself in Malaysia is still at low level. Therefore, this study evaluates the safety control aspects that can be executed by using BIM platform as well as the potential barriers in implementing BIM for safety in building project through questionnaires survey involving client, consultant and contractors in Kuala Lumpur and a case study to evaluates the utilization of BIM in managing safety up to construction stage only. The statistical techniques including relative importance index (RII) was used to analyze the data gathered, while the Statistical Package for the Social Sciences (SPSS) was used to measure the data normality by using Kurtosis and Skewness, Pearson correlation test between three different groups of respondents and the Cronbach's alpha for reliability test. From the findings, "site layout and safety plan" is the most prominent safety control aspects that has been practiced by using BIM and "lack of knowledge and skills" has become the major potential barriers for AEC industry to implement BIM. Based on the data collection, questionnaires survey and case study conducted, the authors presented a framework that integrates safety with BIM implementation in building projects as well as provide solutions for the challenges in implementing BIM for safety in Malaysia. This study concludes with the conclusion on the data obtained and recommendation for the improvement in future works, thus more accurate and impactful results can be obtained for the BIM implementation for safety control in building project in Malaysia.

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

Recent advances in digital technology and construction engineering have made it possible for project stakeholders to initiate taller, bigger, and more complex projects. Construction in building projects have become one of the major contributions in escalating the industrial sector in Malaysia. Based on the Trading Economics (2020) Malaysian GDP in construction dropped 12.4 percent in the second quarter of 2020 due to Covid-19 pandemic issues. However, in the third quarter of 2020, the value of construction work done led with 58.6 percent amounting to RM 31.4 billion compared to RM 19.8 billion in the second quarter (Department of Statistic Malaysia ,2020). This results in an increase in GDP from RM 8916 million to RM 14861 million. It can be concluded that the swift recovery in Malaysian construction industry is significant in elevating the economy.

As the construction industry is widely evolving around the world, the number of workplace injury, illness and fatalities is increasing as well (Zhang et al.,2015; Martinez-Aires et al.,2017). An annual report prepared by Department of Occupational Safety and Health (DOSH) (2019) Malaysia, construction sector is the highest contribution towards the number of fatalities in 2019 with 144 cases, and another 4863 cases in accident related. Additionally, based on US Bureau labor statistics (2019), the construction sector recorded the highest number of fatal rate injuries with 1061 cases, and 9.7 percent fatal work injury rate per 100 000 full time equivalent workers. Thus, it is always stigmatized that construction is the most dangerous and hazardous industry.

According to Occupational Safety Health and Administration (OSHA) fall from above level had become the main problem which led to the highest number in fatalities and injuries based on previous data statistics (Liu et al., 2020). In most of existing projects, fall protection plan will only be developed once the construction start (Zhang et al., 2015). Concurrently, construction industry bears the highest fatal injuries than any other industries caused by the lack of safety control in the construction industry (Marefat et al., 2017). According to Zhang et al. (2015), safety planning is the vital aspect in production planning, however in current practices of the building construction industry, safety planning is carried out separately from the design and planning phases in a project. It cannot be denied, there are still construction practitioners' practices that are using Design-Bid-Build delivery methods in a project which there is noninvolvement of contractors since planning phases. Current inventions in technology have given a big impact and provide solutions for the user. Most industrial sectors use technology to improve the efficiency of work and the construction industry is one of them that utilize technology to enhance the productivity of project stages.

"BIM is a modelling technology and associated set of processes to produce, communicate, analyze and use digital information models throughout construction project life-cycle" (CIDB, 2016). In Malaysia, the idea to implement BIM was introduced by the Director of Public Works Department (PWD) in 2007 (Latifi et al., 2013). According to Latifi et al. (2013), Multipurpose Hall of Universiti Tun Hussein Onn Malaysia (UTHM) in Johor was completed in August 2012 and had become the first project in Malaysia that implemented BIM. Malaysia's government had put initiative in encouraging BIM in Malaysia by establishing myBIM Centre in 2017. Datuk Ir.' Asri Abdul Hamid, Chief Executive CIDB Malaysia stated BIM usage in Malaysia is quite low with 17 percent compared with developed countries such as the US with 71 percent and UK with 54 percent (Corporate Communication Unit Ministry of Works, 2017). In conclusion, the development of BIM is still growing in Malaysia, but in transitioning the process rapidly, a great deal of effort is needed as reported in Malaysia BIM Report (CIDB, 2016).

1.2 Problem Statement

To boost the safety performance at construction sites, Othman et al. (2018) has proposed a safety control management framework (see Figure 1.2 (a)). Factors such as worker, material and equipment, workplace and management played a vital role in implementing safety control.

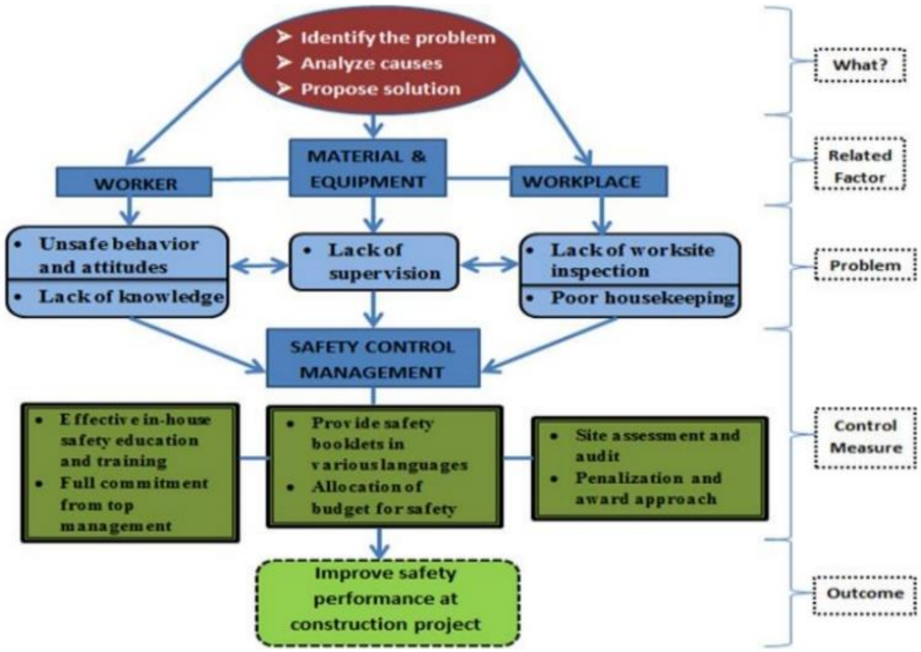

Figure 1.2 (a): The framework of safety control (Othman et al, 2018) .

However, according to Marefat et al. (2017), modern technique of construction and design is preferable as a construction project moves towards complexity. Traditionally, contractors used two-dimensional(2D) construction drawing to identify the needs of utilizing safety equipment at construction sites (Alizadehsalehi et al., 2018). Azhar et al. (2012) claimed that using CAD based construction drawing for safety planning is not accurate to find potential hazards at job sites as the plan view of the building may lead to a different understanding of the object positioning. Unfortunately, as reflected in many literature reviews, traditional safety planning disintegrates the implementation phases with the design phases which there is a tendency for the risk to be eliminated if design for safety measures have been applied in building construction (Kamardeen, 2010; Chan et al. 2016).

During construction of building projects, safety planning is always being planned after the design work is finished. This is because most of the project stakeholders preferred to work in silos and usually only the contractors will be involved in safety planning. Even though the construction workers have been provided with safety knowledge and safety equipment, the potential for hazard to occur is still high as it is unpredictable. According to Kamardeen (2010) designers have a strong impact on construction safety. Based on Figure 1.2 (b), the ability to influence safety is reducing as the stage of the project is moving forward. By using BIM since inception stage, designers can collaborate with the site safety manager to come out with a proper safety planning on the design of the building. The idea to share the knowledge will reduce the future risk.

As BIM is a process that integrates all project stakeholders since the planning phases, thus Marefat et al. (2017) and Kamardeen (2010), strongly believe that BIM will successfully connect the gap between design and safety on site from early stages. However, based on a statistic reported in Malaysia BIM Report 2016 (CIDB, 2016), only 45 percent of the total respondents in Malaysia that have knowledge in BIM and about 17 percent of them utilize BIM. This indicates that the awareness level of BIM in Malaysia is still low (Ashmori et al., 2019) thus the challenge in implementing BIM needs to be highlighted to provide the solution as it will be the same challenges in adopting BIM to manage safety in construction.

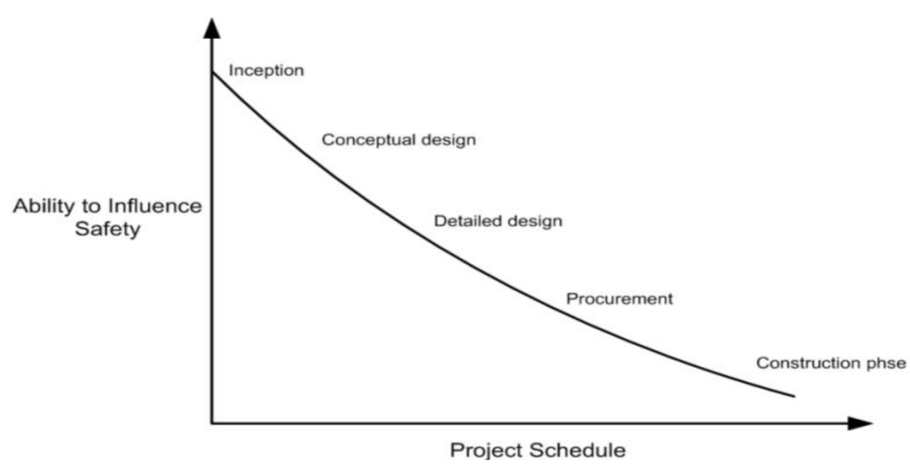

Figure 1.2 (b) : Ability to influence safety against project schedule (Kamardeen, 2010).

1.3 Objectives

The purpose of this study is to establish the implementation of using BIM in safety control for a Building Project through questionnaires survey involving project stakeholders and evaluates the utilization of BIM in managing safety through a case study. The objectives are listed as below:

1. To identify and rank safety control aspects that can be executed by using BIM platform and potential barrier to implement BIM in a building project by conducting questionnaires survey and Relative Importance Index (RII) Method with correlation between project stakeholders.
2. To assess the awareness level and evaluate the implementation of using BIM for safety control in building constructions through interview and a case study project.
3. To propose a framework that integrates safety with BIM implementation in building projects as well as provide solutions for the challenges in implementing BIM for safety in Malaysia.

1.4 Scope of Study

This research aims to identify, rank, and analyze what kind of safety control that BIM could perform in a building project as well as point out the barriers that prevent project stakeholders from implementing BIM through questionnaires. This research will be focused on project stakeholders including (i) owner, (ii) consultants and (iii) contractors in Kuala Lumpur area. By analyzing their perspective, these will help in assessing the awareness level of project stakeholders in utilizing BIM as one of the solutions to manage safety. The ranked factors will be further discussed and investigated through personal interviews based on the case study selected. This study will mainly focus on the implementation of BIM in managing safety from the planning phase up to the construction phase only.

1.5 Case Study

To evaluate the BIM Implementation in managing safety control, a case study is conducted in the research. The case study will be focusing on main contractor of the project with different designation which are site engineer, BIM modeler and safety health officer. The criteria that will be selected for this case study are i) the contractor must utilize BIM tools for the project, ii) safety control in the project must at least use three of the safety control aspects that can be executed by using BIM iii) the project must be a high rise building as the highest fatalities' accident is fall from above level.

1.5.1 Project Details

Figure 1.5.1: Case study of TRX Residences.

Table 1.5.1(a): The details of case study 'TRX Residences'.

Project Address	Lot PT160 (HSD 119927) Seksyen 67, "Tun razak Exchage" Jalan Tun Razak/ Jalan Davis, Bandaraya Kuala Lumpur
Client	TRX City Sdn Bhd
Project Management	Lendlease
Main Contractor	IJM Corporation Berhad
Contract Period	36 months
Status	On going
Date Start	17th August 2020
Date Completion	16th August 2023

Table 1.5.1(b): The details of the consultants for the case study project

Architect	GDP Architects Sdn. Bhd.
Civil and Structural	KTP Consultants Pte Ltd
Mechanical and Electrical	PCR Sdn. Bhd.
Landscape	Pentago Landscape Sdn. Bhd.
Facade	BFG Consulting Sdn. Bhd.

1.6 The Relevancy of Project

Nowadays, many constructions are competing to develop high rise buildings as a symbol of the country's grandeur. Higher building construction will create higher risk thus more preparation on safety planning needs to be made. If project stakeholders still use the old contract model which separates the collaboration between project stakeholders especially in planning safety management, thus it will lead to higher injuries and fatalities. Besides, manual safety checking in complex building projects might lead to confusion and overlooked.

Implementing BIM in managing safety control will be the future of the construction industry. BIM is widely used to visualize the building models and the site layout conditions as well as simulate the construction project. This platform will eventually help in safety planning thus mitigate the risk. Currently, BIM is moving towards 8D (safety) which provides automatic rule checking during modelling and the utilization of advanced technology such as augmented reality, virtual reality, and unmanned aerial vehicles for safety control purposes. However, based on the author study, most of the company in Malaysia that utilize BIM is still in the early phase of managing safety such as clash detection by using visualization. Thus, this research intends to raise awareness among project stakeholders in Malaysia to start implementing BIM especially in managing safety as it will greatly enhance the productivity and benefits the triangle constraints which are time, cost, and scope of the project.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview of Building Information Modelling (BIM)

Currently, most developed countries implement BIM in construction projects: Australia is the most prominent country that utilizes BIM followed by the United States which is the pioneer in BIM, Europe, Middle East, and India (Haron et al., 2017). Recently, there has been a growing interest in using Building Information Modelling (BIM) as a work method statement and to improve construction site safety through a safer design (Azhar et al., 2013). As reported by NewStraitsTimes (2017), Malaysian government has enforced all public projects above RM 10 million to implement BIM by 2019. Even though Malaysian government has put initiative in promoting BIM, the level of BIM adoption is still low, and many organizations do not utilize BIM fully throughout the project stages according to a research conducted by Al-Ashmori et al. (2019).

According to Zhang et al. (2013), BIM is changing the traditional way of construction projects. BIM can be referred to as a virtual process that integrates all aspects, disciplines, and systems of a facility within a single, virtual model, allowing all project stakeholders (clients, consultant and contractor) to collaborate more accurately and efficiently than traditional processes (Azhar et al., 2012a). Besides, BIM allows AEC professionals to schedule, design, create, interact, organize, evaluate, assess, predict cost and time effectively in enhancing execution process and managing construction projects (Rafindadi et al., 2020). In other words, BIM is the integration of intelligent tools and well-structured processes that facilitate the AEC industry throughout the construction stages.

2.2 Safety Control Aspect that can be executed by using BIM platform

According to Mandicak et al. (2019) BIM is more than just 3D modelling. There are numerous literatures mentioned dimensions in BIM consists of 3D (visualization), 4D (schedule), 5D (cost estimation), 6D (facilities and management), 7D (sustainability) and currently 8D (occupational safety and health). BIM helps the AEC industry by giving an overview of the construction project and provide correct tools for more efficient planning and designing building solution (Mandicak et al. 2019).

Zhang et al. (2015), identified four software tools in BIM according to their functionality; (1) Autodesk Revit allow modelling and site layout modelling; (2) Autodesk Naviswork provide scheduling and simulation; (3) Solibri Model Checker accommodate with Industry Foundation Classes (IFC)-based and Rule checking and (4) Tekla Structures allow scheduling, simulation, and modelling. Rafindadi et al. (2020) agrees the tool in BIM will greatly improve safety. Thus, Marefat et al. (2017) pointed out six safety control aspects that can be executed by using BIM which are hazard identification recognition, safety training and education, site layout and safety plan, fall prevention planning, planning work task that include safety works and enhance communication and collaboration between all participants at all stages.

2.2.1 Hazard identification and recognition

BIM provide platform for the user to recognize hazard and to virtually assess jobsite conditions through 3D visualization (Marefat et al., 2017). This feature allows the user to address issues on congestion during construction and to detect any spatial conflict (Zhang et al., 2013; Martinez-Aires et al., 2017). Autodesk Naviswork is widely used by project managers to detect any safety clashes and manage schedule by using 4D simulation (Autodesk, 2020). Conclusively, the integration of visualization, schedule and simulation has allowed the user to predict risk at early stage and develop appropriate mitigation plan.

2.2.2 Safety Training and Education

According to Marefat et al. (2017), level of understanding in a construction process for safety planning will be much easier with the aid of 3D visualization and 4D simulation. This visualization tools will greatly help cross the common language of foreign workers. When the level of understanding increase, the construction player can perform thorough constructability analysis to plan construction sequence at jobsite (Azhar et al., 2012a). This was proof in a case study conducted by Azhar et al. (2012a) for a Wellness center Building in Alabama when there are no minor or major accidents reported at the site after the contractor use relevant 4D animation during toolbox meeting to educate the construction worker.

2.2.3 Site Layout and Safety Plan

In preparing practical site safety plan for site logistics and traffic layout, the contractor can use 3D and 4D site coordination models (Azhar et al., 2012a). Besides, BIM technologies greatly helps in excavation risk management plan, crane management plan and emergency response plan through 3D rendering, 3D walk through and fly-through animation, and 4D phasing simulation (Azhar et al., 2013). In addition, the construction worker can also use 4D simulation to identify important equipment and materials and determine the sequence of activities before construction start when developing specific safety plan (Azhar et al., 2013).

2.2.4 Fall Prevention Planning

According to Liu et al. (2020), worker in construction tend to expose to fall hazards during working near the edge slab or on scaffold located outside of the building. Liu et al. (2020) demonstrated the utilization of 3D BIM model for a residential apartment building in Heze, China to identify the feasibility of safety zone by categorizing into danger, high risk zone and lower risk zone for all construction areas. This demonstration has helped the researcher in examining the proposed formwork location in a building project. As the height of building increases, the construction project will become more complicated.

Thus, the determination of formwork is crucial in avoiding any fall incident to occur. Besides, Zhang et al. (2013) has demonstrated the uses of Tekla software by automatically check the design model to detect any holes in slab or walls as well as the edges of slab. This demonstration has helped the researcher to install protection safety system such as guardrail for the area that exposed to the fall hazard.

2.2.5 Planning of work task that include safety works

Kamardeen (2010) has suggested to use Prevention Through Design (PtD) in 8D of BIM to fill in the gap between design and occupational health and safety principles. PtD has significantly proof it effectiveness in eliminating risk during commencing project based on last decades (Martinez-Aires et al., 2017). Lately, the Integrated Project Delivery (IPD) concept came naturally with BIM (Azhar et al., 2012a). IPD is a new procurement process that integrated all project stakeholders for collaboration since early phase and continues until project handover (Eastman et al., 2011). Thus, IPD greatly improve the safety performance by allowing contractor input on safety during planning phase (Li & Hua, 2012). If the safety work can be included since planning phase, thus the contractors not only can manage to plan the safety work but also can incorporated remarkable safety risk as a reminder during construction work.

2.2.6 Enhance Communication and collaboration between all participants at all stages

According to Azhar et al. (2012b), through effective communication, site staff can inform each other about safety arrangements or give warning when there is potential risk. However, Martinez-Aires et al. (2017) stated current construction practices which lack in communication and data sharing about construction sites between practitioners has become the barriers in construction projects. BIM models at jobsite such as BIMX, Bentley Navigator, Buzzsaw and Autodesk 360 have allowed contractors and subcontractors to frequently be used for information extraction and coordination purposes (Azhar et al., 2012a).

Khoshnava et al. (2012) mentioned that the level of communication in all project phases was promoted through BIM based visual 3D presentations for instance during introducing the project to site staff, present safety arrangement related to specific work tasks and for warning about current hazards.

2.3 The barriers to implement BIM in a building project

Despite numerous of advantage that BIM offer in managing safety, there are still barriers for implementing BIM in construction project. According to Haron et al. (2017), the pace of utilizing BIM in Malaysia is still lagged even though Malaysia government has put initiative through series of awareness. Thus, it is a need to study on the barriers. Based on author study, there are six major barriers to implement BIM which are:

(1) High Cost (Haron et al., 2017; Memon et al.,2014a; Rafindadi et al., 2020; Othman et al., 2021)
(2) Lack of Knowledge and Skills (Haron et al., 2017; Rafindadi et al., 2020; Othman et al., 2021)
(3) Lack of Client Demand (Rafindadi et al., 2020; Marefat et al., 2017)
(4) Incompatibility and Interoperability Issues (Rafindadi et al., 2020; Memon et al., 2014b)
(5) Consume Time in Training Personnel (Haron et al., 2017; Memon et al., 2014a)
(6) Resistance to Change (Memon et al.,2014a; Zahiran et al., 2013; Othman et al., 2021)

2.3.1 High cost

Haron et al. (2017) identified cost as the most critical barrier for many countries due to cost of investing in new technology. Besides, Radindadi et al. 2017, agreed technology in BIM is very costly especially for small-medium companies. Memon et al. (2014a) stated that most project stakeholders other than owner are unwilling to make investment unless they received tong term benefit and the training cost will be subsidized by the owner. According to Othman et al. (2021) current construction industry is still lacking in providing evidence that BIM could also save time and cost other that maintenance cost during operation stage which cause construction player to be disinterested in investing in BIM.

2.3.2 Lack of Knowledge and Skill

According to a research conduct by Othman et al. (2021) , both public and private sectors in Malaysia are not clear whether their company is utilizing BIM or not. Besides, based on the author research, there are not much company in Malaysia that utilize BIM specifically for managing safety. This could happen due to insufficient knowledge on understanding what BIM can do within various construction practitioners (Rafindadi et al., 2020). It cannot be denied that lack of knowledge and skill in using new technology will lead to impediment in implementing BIM tools (Zahrizan et al, 2012). Thus, it is a need for all project stakeholders to understand the application in BIM and the functionality of the software to ease the work process.

2.3.3 Lack of Client Demand

As there are not much utilization of BIM in the country, the client tends to think the implementation of BIM in contract conditions will limit the competitive bids thus increase the price of the project (Memon et al., 2014a). Besides, Haron et al. (2017) mentioned that it is always stigmatized the utilization of BIM is only appropriate for large project that have more clients and other project stakeholders. Besides, the client does not want to invest in BIM as BIM in Malaysia is still under experimental level. However, without client demand, the implementation of BIM will be much lower.

2.3.4 Incompatibility and interoperability issues

File incompatibility can happen when different project stakeholders use different software or even different version of same software which consequently lead to delay of the project (Memon et al, 2014b). Besides, there will be interoperability issue in software because of single software tool is developed to accomplished different requirement of field (Memon et al, 2014a). This disadvantages in BIM software have cause many construction players decide to not work together.

2.3.5 Consume Time in Training Personnel

According to Haron et al. (2017), the companies in USA and UK need to allocate more time for training purposes. Besides, Rafindadi et al. (2020) mentioned a lot of time and effort is needed in learning new software. It is undeniable fact that BIM has steep learning curve, but the time consuming will results in more efficient and effective work for the building project in the future. Based on the author view, there are still not many universities are having BIM course for the students. The lacking in education system could be one of the reasons that much time are needed to train personnel.

2.3.6 Resistance to Change

According to Memon et al. (2014), as the BIM process bring new technologies and process, it has caused the people to resist the new concept of construction project as there is a need to employ BIM expert in the company. Besides, Zahrizan et al. (2013) added that complacency with current job scope has caused the employee to resist in learning something new and challenges. Due to uncertainty in BIM, some organizations hesitant to change the business process because afraid it might affect their business in term of cost (Zahrizan et al., 2013). However, BIM implementation will only be significant when the construction industry is ready to adopt new technology and have new business environment.

Table 2.2 : Safety Control Aspects that can be executed by using BIM platform

	Aspects	Researcher	Keys Statement	GAP	Author's POV
Safety Control Aspects that can be executed by using BIM platform	Hazard identification and recognition	1) Marefat et al. (2017) 2) Autodesk (2020)	1) BIM provide platform for the user to recognize hazard and to virtually assess jobsite conditions through 3D visualization 2) Autodesk Naviswork is used to detect safety clashes and manage schedule by using 4D simulation	• What type of BIM software's that allow hazard identification automatically? • What kind of safety clashes that can be detect? • What type of simulation helps in identifying hazard and risk?	• Solibri Model Checker but the user needs to input the rule. • Clashes among architectural, structural, MEP • Simulation of assembled building components etc.
	Safety Training and Education	1) Marefat et al. (2017) 2) Azhar et al (2012a)	1) Level of understanding in a construction process for safety planning will be much easier through 3D and 4D 2) BIM allows planning construction sequence at jobsite	• How the understanding in construction process will greatly help the safety control? • How plan construction sequence by using BIM could improve safety?	• The worker will be much aware on their safety during working. • The worker could give their opinion on the work sequence
	Site Layout and Safety Plan	1) Azhar et al. (2012a) 2) Azhar et al. (2013)	1) 3D and 4D site coordination models help in preparing site logistics and traffic layout 2) BIM technologies helps in excavation risk management plan, crane management plan and emergency response plan	• What is the safety work that can be determine by using BIM during site layout planning. • What type of BIM software's that can be used for safety plan that being mentioned ?	• The people maneuver to not clash with the logistic truck road • Autodesk Navisworks and Autodesk Maya

Table 2.2 : Safety Control Aspects that can be executed by using BIM platform (continued)

	Aspects	Researcher	Keys Statement	GAP	Author's POV
Safety Control Aspects that can be executed by using BIM platform	Fall Prevention Planning	1) Liu et al. (2020) 2) Zhang et al. (2013)	1) Utilize 3D BIM model to identify safety zone such as danger, high risk zone and lower risk zone 2) Tekla Software can detect holes in slab or walls as well as the edges of slab	• How to determine the safety zone? • Other than finding holes in slab or walls, what is other fall prevention planning that can be perform by using BIM?	• Highlight the slab area with red (danger), yellow (high risk)and green (low risk) • Jumping system simulation
	Planning of Work Tasks that include safety	1) Martinez-Aires et al. (2017) 2) Li & Hua (2012)	1) PtD has significantly proof it effectiveness in eliminating risk during commencing project based on last decades 2) IPD allows contractor input on safety during planning phase	• How does prevention through design can help in managing safety? • Other than contractor, who should also be involve in advising safety aspect during planning of work task?	• Include safety aspects since planning phase to ensure all project stakeholders make safety as the first priority • Safety Health Officer for advice
	Enhance communication and collaboration between all project participants at all stages	1) Azhar et al. (2012b) 2) Khoshnava et al. (2012)	1) Site staff can inform each other about safety arrangements or give warning when there is potential risk. 2) 3D in BIM is used to introduce the project to site staff, present safety arrangement related to specific work tasks and for warning about current hazards.	• How communication tools in BIM could improve safety? • As the data shared among all project stakeholders, how to ensure the data that is private and confidential for certain project stakeholders?	• When there is amendment on the design for example, all the project stakeholders will be notified • Use different BIM communication software

Table 2.3: Potential Barriers to Implement BIM for safety in Building Project

Potential Barriers to Implement BIM for Safety in Building Project	Aspects	Researcher	Keys Statement	GAP	Author's POV
	High Cost	1) Haron et al. (2017), Memon et al. (2014a), Rafindadi et al. (2020), Othman et al. (2021)	1) Cost has become one of the main barriers to implement BIM especially for developing countries.	• What type of cost that need to be invested in BIM project? • How to ensure the project stakeholders can see the long-term benefit instead of current investment that they are putting on? • What can be done to reduce the cost investment?	• License for software, BIM expert, BIM tools • Make compulsory for other than public project more than RM 10 million • Need government to subsidize the license
	Lack of Knowledge and Skills	1) Rafindadi et al. (2020)	1) Insufficient knowledge and skills on the application and the benefits that BIM offer	• How to enhance lack in knowledge and skills among project stakeholders?	• Provide more seminars for all project stakeholders and invite experts from outside country to share experience
	Lack of Client Demand	1) Memon et al. (2014a) 2) Haron et al. (2017)	1) It is always stigmatized the utilization of BIM is only appropriate for large project 2) The client does not want to invest in BIM as BIM in Malaysia is still under experimental level	• What can be done to ensure more smaller project to start implement BIM? • How to encourage more client to invest in BIM?	• Government could provide loan/investment • Give incentive if the project reaches certain safety performance when using BIM

Table 2.3: Potential Barriers to Implement BIM for safety in Building Project (continued)

	Aspects	Researcher	Keys Statement	GAP	Author's POV
Potential Barriers to Implement BIM for Safety in Building Project	Incompatibility and Interoperability Issues	1) Memon et al. (2014b) 2) Memon et al. (2014a)	1) The utilization of different software and different version leads to file incompatibility 2) Interoperability issue in software occur when single software tool is developed to accomplished different requirement of field	• How to overcome the incompatibility and interoperability issues? • How to ensure all project stakeholders to use same software packages?	• Ensure all project stakeholders use the same software packages • A standard guideline from the government
	Consume Time in Training Personnel	1) Rafindadi et al. (2020)	1) A lot of time and effort is needed in learning new software	• What can be done to reduce the time in training personnel? • How can government help in training personnel?	• Implement BIM and safety course in university • Provide free training workshop
	Resistance to Change	1) Memon et al. (2014) 2) Zahrizan et al. (2013)	1) Company needs to employ BIM expert if they started to utilize BIM 2) Due to uncertainty in BIM, some organizations hesitant to change the business process	• How to educate the employee of the company itself to use BIM tools? • What is the uncertainty in BIM that need to be clear ?	• Present past ROI of project that utilize BIM • The guideline to use BIM in correct ways because BIM involve all project stakeholders to work together, the regulations on the data shared

CHAPTER 3

METHODOLOGY

An exploratory research was used in this study through literature review, online sources, questionnaires survey and a case study. The sample selection for the questionnaires survey and case study is determine in this section. Next, data from questionnaires survey will be analyses by using Relative Important Index(RII) and Statistical Package for the Social Sciences (SPSS). Lastly, a flowchart representing this research methodology will be presented at end of this chapter.

3.1 Research strategy

This study is categorized as exploratory research as the utilization of safety control by using BIM is still new in construction industry, especially in Malaysia. To gain a depth knowledge of this research, the author had performed two methods which are primary and secondary research method through questionnaires survey, interview and literature review, online sources, case study. According to Bougie & Sekaran (2016), qualitative research is being implemented for data gathering during exploratory research. Thus, this study aims to explore and understand what and how safety control is being executed by using BIM platform and why the implementation of BIM is still lack in construction industry.

3.1.1 Literature Review

To have a good quality of literature review, the selection of published and unpublished materials must be carefully selected. In this research, literature review was done through reading materials such as books, articles, journals and conference paper. More than 20 reading materials have been cited in literature review to ensure the quality of research. A good combination among the resources will results in a specific information.

3.1.2 Online Sources

Most of the information are available on the internet through search engine such as Google. However, it should be noted that the reliability of the information should be consider when citing the reference. In this research, online sources were used to collect statistic data such as history about safety construction and the current implementation of BIM in Malaysia. This data was mostly taken from government’s website or accredited organization’s website.

3.2 Data Collection

3.2.1 Questionnaires Survey

To know the perception of different project stakeholders, a questionnaires survey will be developed through the literature review and distributed among clients, consultants and contractors. The purpose of this survey is to identify the highest safety control aspects that can be executed by using BIM platform and the main barriers to implement BIM for construction safety. Before distributing the actual survey, a pilot survey will be conducted for 12 respondents from industry consists of four representatives from client, four representatives from consultant and four representatives from contractor. This pilot survey act as preliminary survey to gather information about the questionnaires before distributed to a larger scale. The purpose of this pilot survey is to verify the completeness and the understanding of the questionnaires. As this study is about BIM and safety, thus the targeted respondents must acknowledge the concept of BIM to answer the questionnaires.

Sample selection is a crucial aspect in ensuring the precision of this research, therefore it is crucial to get the personal information of the respondent during questionnaires survey as well as the case study. The questionnaires survey will be sent through online platform to the targeted respondents consists of owner, consultant, contractor. The total number of respondents needed for questionnaires survey can be identify by calculating the sample size from population. Israel (2013) has suggested a simplified formula for proportion:

$$n = \frac{N}{1 + N(e)^2}$$

Where, n = sample size, N= population size and e = level of precision (0.05 in this case). Usually, the average respondent rates through online survey reach 30 % of the total population (Fincham, 2008; Nulty, 2008).

3.2.2 Case Study

Case study was conducted in this research to know the level of BIM implementation in managing safety control in current construction project and to identify the barriers in preventing the project stakeholders from implementing BIM in construction safety. The case study that has been chosen is TRX Residences which consists of two block residential apartments with 53 and 57 levels respectively. According to Yin (2018), case study helps in determining how and why phenomenon. This could be achieved by interviewing the right person to enhance the knowledge of understanding. A structured interview will be conducted to guide the interview session and to avoid form going out of the scope study.

For the case study, as this research is focusing on the implementation of BIM for safety control in building project, only contractor’s practitioners consist of site engineer, BIM modeler and safety health officer will be evaluated during the interview session (case study) as they are more experienced in managing safety aspect especially by using BIM. However, this project is not a requirement from the client, but the contractor do utilize BIM for safety during construction.

3.3 Data Analysis

After the data from the questionnaires survey was successfully gathered, the data will be analyzing and rank by using RII through SPSS software, to determine the most influential data among different respondents.

3.3.1 Relative Important Index (RII)

RII method is used to determine the relative importance of various aspects for safety control that can be execute by using BIM platform and various factors that cause barriers for project stakeholders in implementing BIM. The RII equation is as below:

$$\mathrm{RII} = \frac{\sum \mathrm{W}}{\mathrm{A \ x \ N}}$$

Where, W = weighting given to each factor determine by the respondent ranging from 1 (Strongly Disagree) to 5 (Strongly Agree); A = Highest Weight (i.e., in this case 5) and N = total number of respondents. The RII value had a range from zero to one (zero is not included). The higher the value of RII, the higher the rank will be. The ranking will be made for owner's view, consultant's view and contractors' view. Lastly, the overall RII ranking will also be determined.

3.4 Statistical Package for the Social Sciences (SPSS)

SPSS is a data management and analysis program designed to do statistical analysis. It is the most popular software package in analyzing statistic results. This study will be using four tests in SPSS program to analyze the safety control aspects that can be executed by using BIM platform and the barriers in implementing BIM for construction safety based on different view of project stakeholders

3.4.1 Data normality test (Kurtosis and Skewness)

According to Kineber et al. (2020) agreed that if the kurtosis result is between -7 to +7 and skewness results is between -2 to +2, the data are normally distributed and vice versa.

3.4.2 Correlation test

If the data is normally distributed, a parametric test will be conducted which is Pearson's Correlation test. This test is usually conducted to know the monotonic relationship between paired data. However, if the data is not normally distributed, a non-parametric test will be conducted which is the Spearman's Correlation test. This test is usually conducted to know the linear relationship between paired data.

For both correlation test, the value ranges from -1 to 1. If the value approaching -1, (negative correlation), 0 (no correlation) and 1 (positive correlation). If the calculated *p-value* < 0.05, the test is significant and vice versa. Higher correlation between paired data will result in higher degree of agreement between the respondents.

3.4.3 Cronbach's Alpha reliability Test

The reliability test is used to determine the consistency and stability of the questionnaires between each section. Besides, it also measures the reliability of the mean in all categories of questionnaires. Cronbach α is the coefficient of reliability. The normal range of Cronbach α coefficient is between 0 to 1. Coefficient more than 0.7 are considered acceptable. If the Cronbach α approaching 1, the higher the internal consistency of reliability.

3.5 Flowchart of Research Methodology

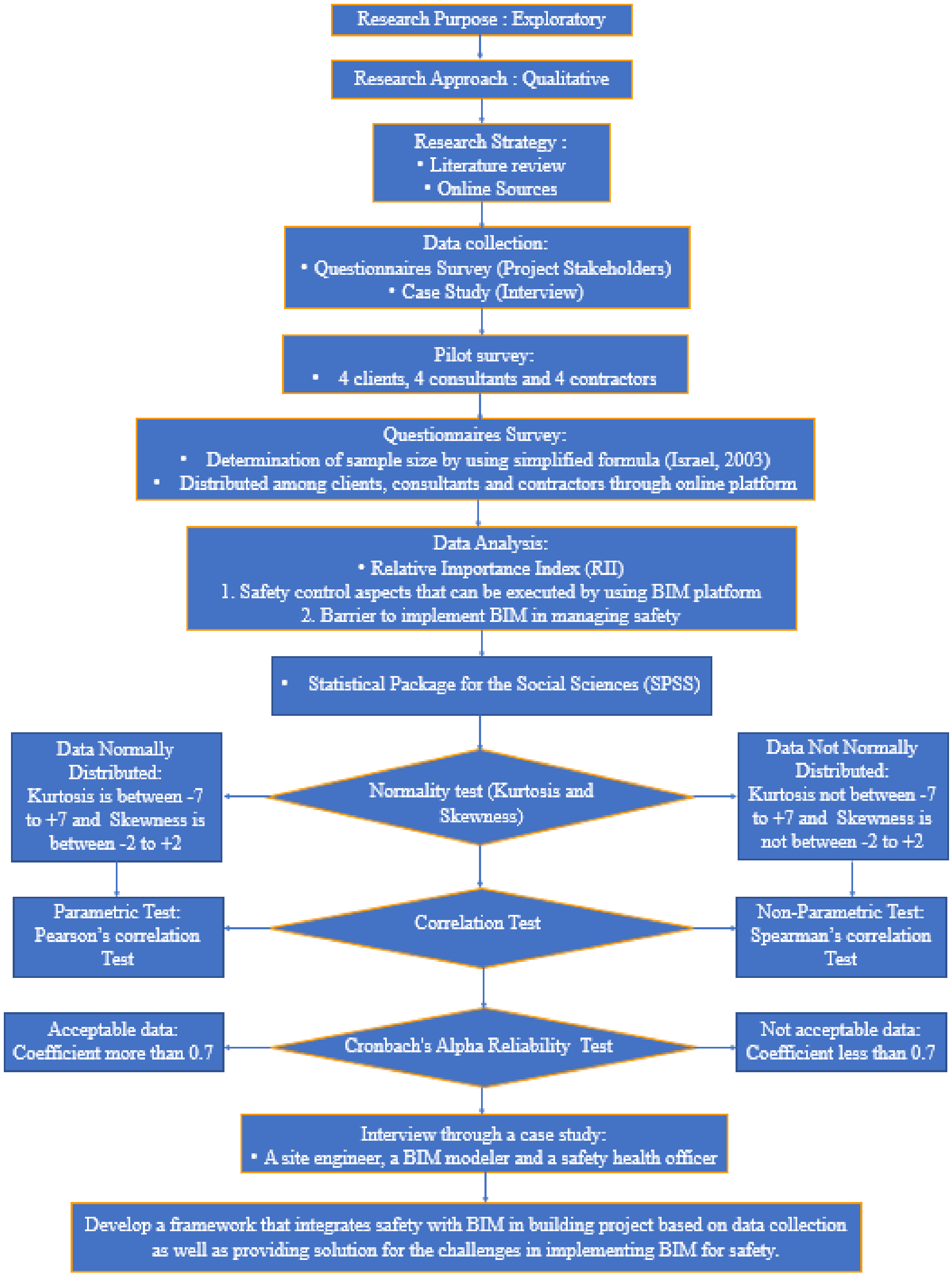

Figure 3.5: Flowchart of research methodology

3.6 Gantt Chart

3.6.1 Final Year Project 1

Table 3.6.1: Gantt Chart of FYP 1

BIM IMPLEMENTATION FOR SAFETY CONTROL IN BUILDING PROJECT																	
JANUARY 2021 - APRIL 2021 (FYP 1)																	
ITEM/WEEK	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Task 1: Selection of project tittle	■																
Task 2: Preliminary research work		■															
Task 3: Reading materials for Literature review and Methodology		■	■	■	■	■	■	■	■	■	■						
Task 4: preparation for proposal defense (record video)							■										
Task 5: Proposal Defense								■								SEM BREAK	
Task 6: Searching project for potential case study								■	■	■	■						
Task 7: Preparation for questionairres survey and interview										■	■						
Task 8: Submission of draft interim report											■						
Task 9: Submission of interim report												■					
Task 10: handling survey													■	■	■	■	■
Task 11: Conduct interview															■	■	■
Task 12: Explore SPSS Software															■	■	■

3.6.2 Final Year Project II

Table 3.6.2: Gantt Chart of FYP II

BIM IMPLEMENTATION FOR SAFETY CONTROL IN BUILDING PROJECT																
APRIL 2021-AUGUST 2021 (FYP II)																
ITEM/WEEK	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
Task 13: Project Work Continues																
Task 14: Analysis on data collected																
Task 15: Submission of Progress Report 3																
Task 16: Submission of Draft Dissertation																
Task 17: Submission of Dissertation (Soft Bound)																
Task 18: VIVA																
Task 19: Submission of Progress Report 4																
Task 20: Submission of Project Dissertation (Hard Bound)																

3.7 Key Milestone

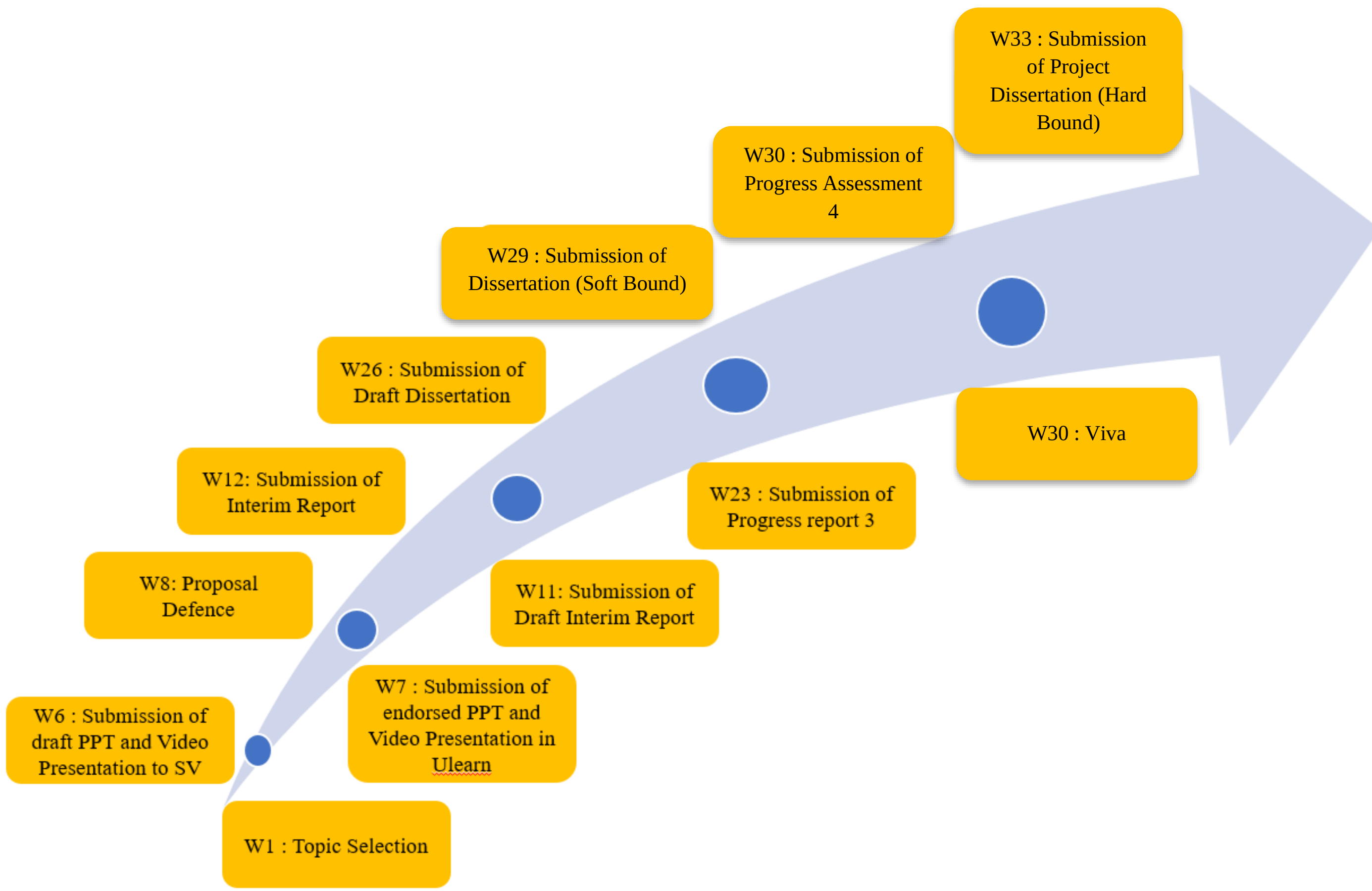

Figure 3.7: Key Milestone for FYP I and FYP II

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

This chapter aim to analyze and further discuss on the findings of this study. The data gathered are interpreted, ranked and correlated to address the objectives of this study. A pilot survey was conducted by distributing to the project stakeholders to verify on the understanding of the questions. A questionnaire was developed to assess the perception of client, consultant and contractor on the relative importance of the safety control aspect that can be executed by using BIM and the potential barriers to implement BIM for safety among project stakeholders. Furthermore, the questionnaires consist of section A (Personal Detail), Section B (BIM implementation for safety control in building project) and Section C (Current practices on safety control by using BIM and the implementation of BIM in building projects). Depth discussion was made on current industry in managing safety by using BIM during interview session. A framework for BIM implementation for safety control in building project and solution for barriers to implement BIM in construction safety will be presented at the end of the chapter.

4.2 Feedback on Pilot Survey

Twelve questionnaires' surveys were distributed for the pilot survey which four of it were given to the clients, another four for consultants and another four for contractors that currently involve in utilization of BIM for building project. The basic purpose of this pilot survey is to get the completeness of the questionnaires in achieving the objectives. Based on the feedbacks, the questionnaire was modified to suits the construction industry environment in Malaysia and can be answered among the project stakeholders that may have different depth knowledge on BIM and safety in construction project.

4.3 Sample Selection

From the pilot survey, the target respondents must need to have knowledge about BIM. Thus, in determining the population of the respondents, the author has identified 727 project stakeholders that involve with BIM in building project in Kuala Lumpur through online platform.

Sample size:

$$n = \frac{N}{1 + N(e)^2}$$

$$n = \frac{727}{1 + (727)(0.05)^2}$$

$$n = 258.03 = 259$$

A total of 260 questionnaires were distributed for this survey, of which 80 questionnaires were returned with valid response. Out of 80 respondents, 14 of the respondents are client, 43 of the respondents are consultants and 23 of the respondents are contractors. The respondents' rates are acceptable as it is more than 30% as mentioned in previous chapter.

Respondents' rates**:**

$$\frac{80}{260} = 30.77\%$$

4.4 Feedback on the questionnaires

Of the 260 sets of questionnaires which were distributed towards potential respondents, 80 sets (30.77%) were returned with valid responses and there were 14 sets (17.5 %) from clients, 43 sets (53.75%) from consultant and 23 sets (28.75 %) from contractor. The demographic characteristic of respondents is illustrated in **Table 4.4(d).**

In term of qualification of respondent ranging from Doctor of Philosophy, PhD holder (1.3%), Master's Degree holder (15%), Bachelor's Degree holder (72.5%), Diploma holder (7.5%) and SIJIL holder (3.8%). From this survey, 20% of the respondents have working experience less than three years. Besides, 40% and 13.8% of the respondents have working experience less than seven and 10 years, respectively. 26.3% of the respondents have more than 11 years working experience.

Based on the survey, as in **Figure 4.4(a)** majority of respondents have little knowledge in BIM which also represent majority from clients, consultants, and contractors. But still, some of the respondents have moderate knowledge in BIM and only few of the respondents have extensive knowledge in BIM. Besides, most of the respondents aware that BIM can be used for safety control in building project as in **Figure 4.4(b)**. Additionally, **Figure 4.4(c)** shows most of the respondents agree that the impact of utilizing BIM for safety control in building project in Malaysia is significantly improved.

Table 4.4(a): Designation of respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Client	14	17.5	17.5	17.5
	Consultants	43	53.8	53.8	71.3
	Contractor	23	28.7	28.7	100.0
	Total	80	100.0	100.0	

Table 4.4(b): Qualification of respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	SPM	3	3.8	3.8	3.8
	Diploma	6	7.5	7.5	11.3
	Bachelor's degree	58	72.5	72.5	83.8
	Master's degree	12	15.0	15.0	98.8
	PHD	1	1.3	1.3	100.0
	Total	80	100.0	100.0	

Table 4.4(c): Working experience of respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Less than 10 years	11	13.8	13.8	13.8
	Less than 3 years	16	20.0	20.0	33.8
	Less than 7 years	32	40.0	40.0	73.8
	More than 11 years	21	26.3	26.3	100.0
	Total	80	100.0	100.0	

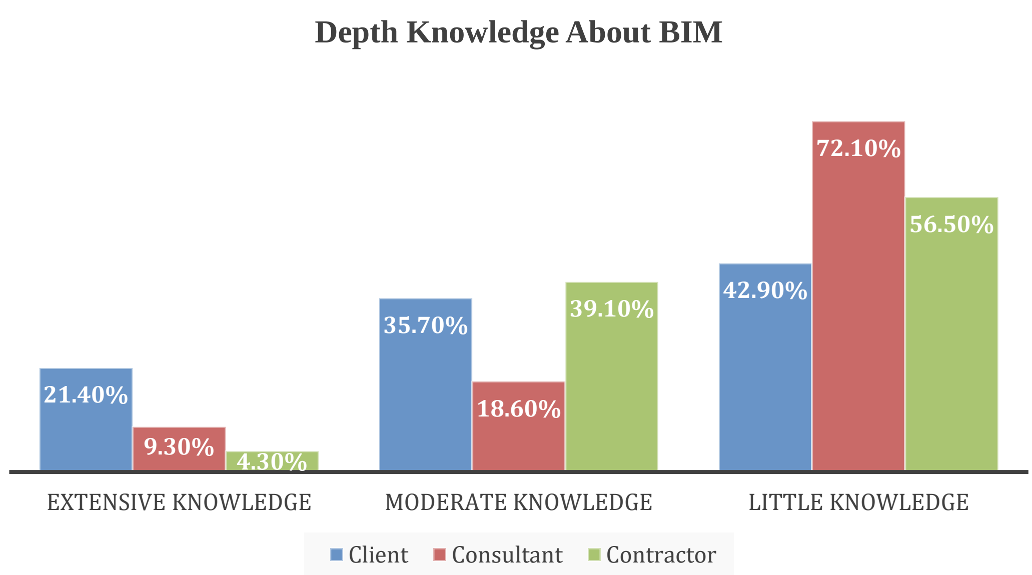

Figure 4.4(a): Depth knowledge about BIM

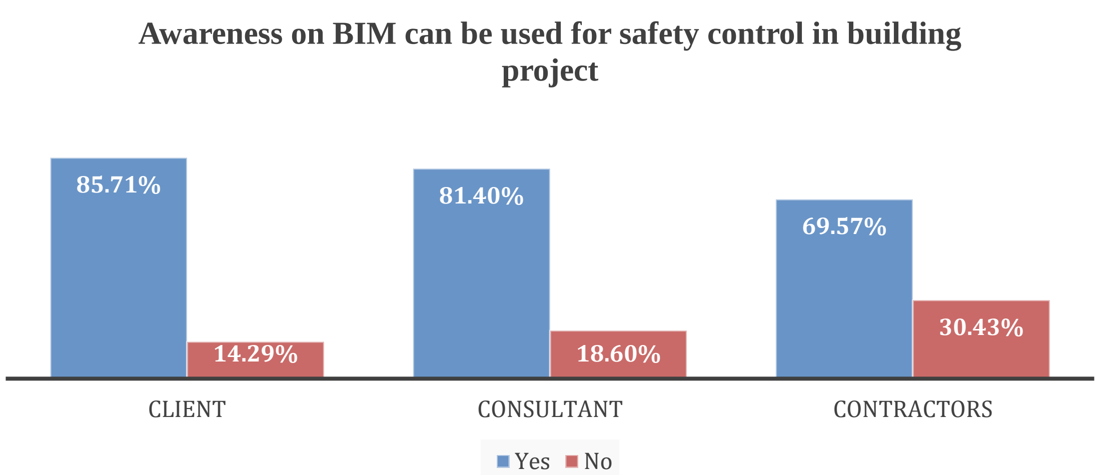

Figure 4.4(b): Awareness on BIM can be used for safety control in building project

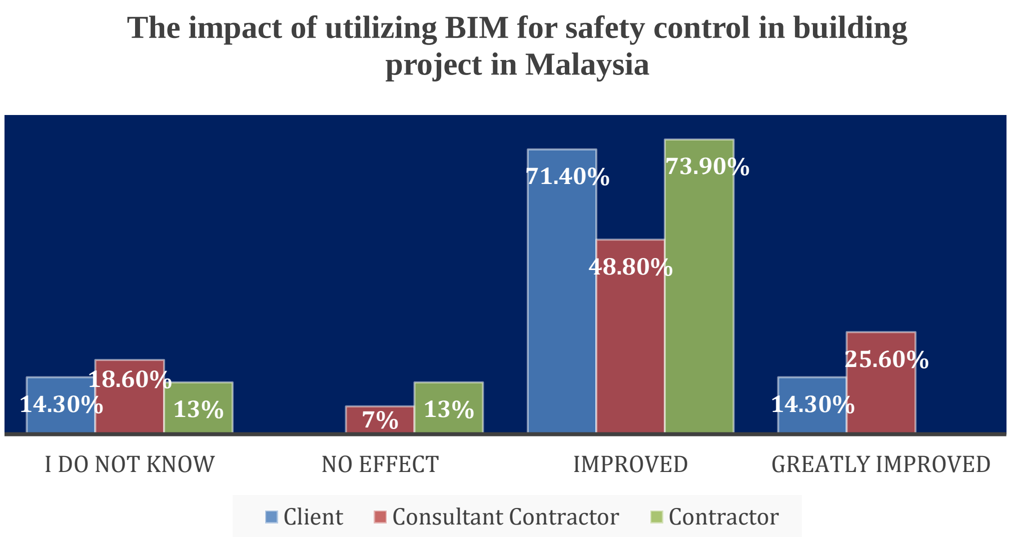

Figure 4.4(c): The impact of utilizing BIM for safety control in building project in Malaysia

Table 4.4(d): The demographic characteristics of respondents

Items	Description	Frequency	Percentage
Designation	Client	14	17.5
	Consultant	43	53.7
	Contractor	23	28.7
Qualification	Doctor of Philosophy (PhD)	1	2.3
	Master's degree	12	15
	Bachelor's degree	58	72.5
	Diploma	6	7.5
	SIJIL	3	3.8
Working Duration	Less than 3 years	16	20.0
	Less than 7 years	32	40.0
	Less than 10 years	11	13.8
	More than 11 years	21	26.3

4.5 Safety Control Aspects That Can be Executed by Using BIM Platform

4.5.1 Clients' Perspective

Table 4.5.1: RII and rank for safety control aspects that can be executed by using BIM Platform from clients' perspective

FC	Safety Control Aspects that can be executed by using BIM platform	Client		
		SD	RII	RANK
A3	Site Layout and Safety Plan	1.0716	0.8143	1
A6	Enhance Communication and Collaboration between all project participants at all stages	1.1411	0.7857	2
A1	Hazard Identification and Recognition	1.1217	0.7571	3
A4	Fall Prevention Planning	1.1883	0.7571	3
A5	Planning of Work Task That Include Safety Works	0.8926	0.7571	3
A2	Safety Training and Education	0.9945	0.7429	6

Based on the ranking shown as **Table 4.5.1** above, the highest rank factor of safety control aspects that can be executed by using BIM Platform from clients' perspective is "A3: Site Layout and Safety Plan" with RII (0.8143). Then, "A6: Enhance Communication and Collaboration between all project participants at all stages" ranked as the second most important aspects with RII (0.7857). Next, "A1: Hazard Identification and Recognition", "A4: Fall Prevention Planning" and "A5: Planning of Work Task That Include Safety Works" shared the same RII (0.7571). Lastly, the lowest RII (0.7429) is contributed by "A2: Safety Training and Education".

4.5.2 Consultants' Perspective

Table 4.5.2: RII and rank for safety control aspects that can be executed by using BIM platform from consultants' perspective

FC	Safety Control Aspects that can be executed by using BIM platform	Consultant		
		SD	RII	RANK
A3	Site Layout and Safety Plan	0.6680	0.9023	1
A6	Enhance Communication and Collaboration between all project participants at all stages	0.8458	0.8744	2
A5	Planning of Work Task That Include Safety Works	0.7537	0.8326	3
A1	Hazard Identification and Recognition	0.7811	0.8186	4
A4	Fall Prevention Planning	0.7868	0.8000	5
A2	Safety Training and Education	0.9240	0.7674	6

Based on the ranking shown as **Table 4.5.2** above, the highest rank of safety control aspect that can be executed by using BIM platform from consultants; perspective is "A3: Site Layout and Safety Plan" with RII (0.9023) while "A6: Enhance Communication and Collaboration between all project participants at all stages" and "A5: Planning of Work Task That Include Safety Works" ranked as the second and third most important aspects with RII (0.8744). and RII (0.8326) respectively. Next followed by "A1: Hazard Identification and Recognition" with RII (0.8186) and "A4: Fall Prevention Planning" with RII (0.8). Lastly, the lowest value for RII is obtained by "A2: Safety Training and Education" at RII (0.7674).

4.5.3 Contractors' Perspective

Table 4.5.3: RII and rank for safety control aspects that can be executed by using BIM platform from contractors' perspective

FC	Safety Control Aspects that can be executed by using BIM platform	Contractor		
		SD	RII	RANK
A3	Site Layout and Safety Plan	0.7029	0.8609	1
A6	Enhance Communication and Collaboration between all project participants at all stages	0.8341	0.8348	2
A4	Fall Prevention Planning	0.8149	0.8261	3
A5	Planning of Work Task That Include Safety Works	0.7332	0.8174	4
A1	Hazard Identification and Recognition	0.7674	0.7913	5
A2	Safety Training and Education	0.7141	0.7304	6

Based on the ranking shown as **Table 4.5.3** above, the highest rank of safety control aspects that can be executed by using BIM platform from contractors' perspective is "A3: Site Layout and Safety Plan" with RII (0.8609) and second highest is "A6: Enhance Communication and Collaboration between all project participants at all stages" with RII (0.8348). Next, followed by "A4: Fall Prevention Planning","A5: Planning of Work Task That Include Safety Works" and "A1: Hazard Identification and Recognition" with the RII 0.8261, 0.8174 and 0.7913 respectively. Then, the least important aspect is "A2: Safety Training and Education" with RII (0.7304).

4.5.4 Overall Perspective

Table 4.5.4(a): RII and rank for safety control aspects that can be executed by using BIM platform from overall perspective

FC	Safety Control Aspects that can be executed by using BIM platform	Overall	
		RII	RANK
A3	Site Layout and Safety Plan	0.8750	1
A6	Enhance Communication and Collaboration between all project participants at all stages	0.8475	2
A5	Planning of Work Task That Include Safety Works	0.8150	3
A1	Hazard Identification and Recognition	0.800	4
A4	Fall Prevention Planning	0.800	4
A2	Safety Training and Education	0.7525	6

Table 4.5.4(b): Ranking comparison based on RII for all project stakeholders and overall perspective

Safety Control Aspects that can be executed by using BIM platform	Client		Consultant		Contractor		Overall	
	FC	RANK	FC	RANK	FC	RANK	FC	RANK
	A3	1	A3	1	A3	1	A3	1
	A6	2	A6	2	A6	2	A6	2
	A1	3	A5	3	A4	3	A5	3
	A4	3	A1	4	A5	4	A1	4
	A5	3	A4	5	A1	5	A4	4
	A2	6	A2	6	A2	6	A2	6

A1: Hazard Identification and Recognition
A2: Safety Training and Education
A3: Site Layout and Safety Plan
A4: Fall Prevention Planning
A5: Planning of Work Task That Include Safety Works
A6: Enhance Communication and Collaboration between all project participants at all stages

As shown in **Table 4.5.4 (a)** above, the highest rank of safety control aspect that can be executed by using BIM platform from overall perspective is “A3: Site Layout and Safety Plan” with RII (0.875) while “A6: Enhance Communication and Collaboration between all project participants at all stages” ranked as the second most important aspects with RII (0.8475). Then, followed by “A5: Planning of Work Task That Include Safety Works” with RII (0.815). “A1: Hazard Identification and Recognition” and “A4: Fall Prevention Planning” shared the same RII (0.8). Lastly, the lowest RII (0.7525) is contributed by “A2: Safety Training and Education”.

First and foremost, all project stakeholders definitely agree that site layout and safety plan can be performed by using BIM. This probably because currently in Malaysia, as most of the project that utilizing BIM has the ability to visualize and simulate the project, thus it is feasible for the site layout and safety plan to be done with the simulation provided in BIM. In addition, the agreement between all project stakeholders on safety aspect is followed by BIM could enhance communication and collaboration between all project participants at all stages. As all the design of the project could be access by the project stakeholders, thus the miscommunication between project stakeholders could be prevented, because all the amendment that changes could be notified through the BIM software.

However, as the client and consultants agree that planning of work task that include safety work as the third highest rank, contractor much agree on BIM could help in fall prevention planning. Planning of work task that include safety work can be done by reviewing the building in 3D modelling and simulate the construction process, hence remarkable safety risk could be include before construction started. On the other side where the contactors are more familiar with the site project, they believe with the better visualization of 3D in the project by using BIM software would help the contractors to identify any risky area that prone to falling thus help in fall prevention planning.

Hazard identification and recognition by using BIM tools for safety seem to be at the fourth rank as in overall’s perspective sharing place with fall prevention planning. One of the examples of hazard identification and recognition is by using clash detection analysis. If clash detection does not be prevented before the construction, thus it will lead to the workers gathering to remove the structural elements, hence exposed the workers to hazard. Lastly, all project stakeholders ranked safety training and education as the last application in safety control aspects that can be executed by using BIM platform. Safety training and education does not seem could really affect the safety as in Malaysia, the worker still having a normal toolbox meeting before starting a construction. By using BIM during toolbox session could have provide a better simulation to the worker on the works that they will be carried out. Thus, they will be more alert on their safety aspect when performing the task.

As most of the construction workers are from foreign country, thus the visualisation in BIM will act as a solution to the communication barriers. In addition, the workers themselves could give their suggestion on which work task that could be carried on first considering their safety and also their hands on experience during construction.

4.6 Potential Barriers to Implement BIM for Safety in Building Project

4.6.1 Clients' perspective

Table 4.6.1: RII and rank for potential barriers to implement BIM for safety in building project from clients' perspective

FC	Potential Barriers to Implement BIM for safety in building projects.	Client		
		SD	RII	RANK
B6	Resistance To Change	1.1767	0.8000	1
B2	Lack of Knowledge and Skills	1.1411	0.7857	2
B3	Lack of Client Demand	1.1411	0.7857	2
B5	Consume Time in Training Process	1.2044	0.7428	4
B1	High Cost	1.2157	0.7285	5
B4	Incompatibility and Interoperability Issues	1.1673	0.6285	6

Based on the ranking shown as **Table 4.6.1** above**,** the clients selected "B6: Resistance to Change" as the highest RII (0.8) of potential barriers to implement BIM for safety in building project. Next, the second highest RII is shared by "B2: Lack of Knowledge and Skills" and "B3: Lack of Client Demand" with RII (0.7857). Then, followed by "B5: Consume Time in Training Process" with RII (0.7428) and "B1: High Cost" with RII (0.7285). Lastly, "B4: Incompatibility and Interoperability Issues" with RII (0.6285) ranked as the last impact barriers.

4.6.2 Consultants' Perspective

Table 4.6.2: RII and rank for potential barriers to implement BIM for safety in building project from consultants' perspective

FC	Potential Barriers to Implement BIM for safety in building projects.	Consultant		
		SD	RII	RANK
B2	Lack of Knowledge and Skills	0.9633	0.8046	1
B3	Lack of Client Demand	1.1850	0.7953	2
B6	Resistance To Change	1.1628	0.7860	3
B1	High Cost	0.9395	0.7395	4
B5	Consume Time in Training Process	1.2017	0.6558	5
B4	Incompatibility and Interoperability Issues	0.9719	0.6465	6

Based on the ranking shown as **Table 4.6.2** above, the consultants selected “B2: Lack of Knowledge and Skills” with RII (0.8046) as the major potential barriers to implement BIM for safety in building project**,** while “B3: Lack of Client Demand” and “B6: Resistance to Change” as the second and third most important barriers with RII (0.7953) and RII (0.7860) respectively. Next, followed by “B1: High Cost” with RII (0.7395) and “B5: Consume Time in Training Process” with RII (0.6558). Lastly, the lowest RII is contributed by “B4: Incompatibility and Interoperability Issues” with RII (0.6465).

4.6.3 Contractors’ Perspective

Table 4.6.3: RII and rank for potential barriers to implement BIM for safety in building project from contractors’ perspective

FC	Potential Barriers to Implement BIM for safety in building projects.	Contractor		
		SD	RII	RANK
B1	High Cost	0.7057	0.8086	1
B2	Lack of Knowledge and Skills	0.7332	0.7826	2
B5	Consume Time in Training Process	0.6683	0.7826	2
B3	Lack of Client Demand	0.7952	0.7565	4
B6	Resistance To Change	0.8100	0.7478	5
B4	Incompatibility and Interoperability Issues	0.7278	0.7130	6

Based on the ranking shown as **Table 4.6.3** above, the contractors selected “B1: High Cost” with RII (0.8086) as the highest RII for potential barriers to implement BIM for safety in building project. Next, sharing the same RII (0.7826) as the second most important barriers are “B2: Lack of Knowledge and Skills” and “B5: Consume Time in Training Process”. Then followed by “B3: Lack of Client Demand” with RII (0.7565) and “B6: Resistance to Change” with RII (0.7478). Lastly, “B4: Incompatibility and Interoperability Issues” with RII (0.7130) contributed to the lowest RII.

4.6.4 Overall Perspective

Table 4.6.4 (a): RII and rank for potential barriers to implement BIM for safety in building project from overall perspective

FC	Potential Barriers to Implement BIM for safety in building projects.	Contractor	
		RII	RANK
B2	Lack of Knowledge and Skills	0.7950	1
B3	Lack of Client Demand	0.7825	2
B6	Resistance To Change	0.7775	3
B1	High Cost	0.7575	4
B5	Consume Time in Training Process	0.7075	5
B4	Incompatibility and Interoperability Issues	0.6625	6

Table 4.6.4 (b): Ranking comparison based on RII for all project stakeholders and overall perspective

Potential Barriers to Implement BIM for Safety in Building Project	Client		Consultant		Contractor		Overall	
	FC	RANK	FC	RANK	FC	RANK	FC	RANK
	B6	1	B2	1	B1	1	B2	1
	B2	2	B3	2	B2	2	B3	2
	B3	2	B6	3	B5	2	B6	3
	B5	4	B1	4	B3	4	B1	4
	B1	5	B5	5	B6	5	B5	5
	B4	6	B4	6	B4	6	B4	6

B1: High Cost
B2: Lack of Knowledge and Skills
B3: Lack of Client Demand
B4: Incompatibility and Interoperability Issues
B5: Consume Time in Training Process
B6: Resistance to Change

As shown in **Table 4.6.4(a)** above, the highest rank of potential barriers to implement BIM for safety in building project from overall perspective is "B2: Lack of Knowledge and Skills" with RII (0.7950) while "B3: Lack of Client Demand" and "B6: Resistance to Change" ranked as the second and third most important barriers with RII (0.7825) and RII (0.7775) respectively. Next, followed by and "B1: High Cost" with RII (0.7575) and "B5: Consume Time in Training Process" with RII (0.7075). Lastly, the lowest RII contribute by "B4: Incompatibility and Interoperability Issues" with RII (0.6625).

Lack of knowledge and skills is highlighted as the most potential barriers for the AEC industry to implement BIM. As the project stakeholders does not know on the impact that BIM could benefit the safety construction project, thus there will be no skill to be polish as there is no awareness within the AEC industry. This will consequently lead to many more potential barriers such as it will affect the demand from the client.

When client does not know the knowledge of BIM, the client would be refused from investing in BIM project. This could also happen because the utilization of BIM project in Malaysia is still fewer in number, thus the clients does not see on the profit that BIM would return in the future. Furthermore, AEC industry felt comfortable with currents working way which made the project stakeholders resists to change. Most of them does not prefer to change because BIM not only will alter their working environment but as well as purchasing new licensed software to be implemented and hiring skilled BIM personnel for the projects. All of these changes will increase their cost of their project. Thus, it can be seen that the utilization of BIM is mostly for big project but not for small scale project.

It is undeniable that the learning curve to learn BIM is quite steep as it involves understanding and skill to use advance software that could consume time during the training process, but the skills will be valuable in the future. However, as the advance software is offered from different company, and during the project, different project stakeholders might use different software packages thus it can lead to incompatibility and interoperability issue.

4.7 Correlation's between Project Stakeholders' Perspective

As finding the correlation between project stakeholders is one of the main objectives in this study, the test of the correlation is determined based on the normality of data. As mentioned in previous chapter, if the kurtosis result is between -7 to +7 and skewness result is between -2 to +2, thus the data are recognized as normal. Based on **Table 4.7(a)** both data from Safety Control Aspects that can be executed by using BIM platform and Potential Barriers to Implement BIM for safety in building projects ranged from -1.524 to 0.412 for skewness and the kurtosis ranged from 4.631 to 4.143 reveled that the data are normally distributed. Thus, as the data is normal, a parametric measure is conducted by using Pearson Correlation test to identify the strength and direction of association that exist between two variables. For this project, the correlation is done to determine the relationship between project stakeholders including i) client, ii) consultant and iii) contractors. The test is conducted through SPSS.

Table 4.7(a): Results of normality test on SPSS

Section	Skewness	Std. Error	Kurtosis	Std. Error
Safety Control Aspects that can be executed by using BIM platform	-1.524	0.269	4.631	0.532
Potential Barriers to Implement BIM for safety in building projects	-1.412	0.269	4.143	0.532

Based on **Table 4.7(b)** obtained from the Pearson correlation between project stakeholders for safety control aspect that can be executed by using BIM, it is identified that the clients and consultants have the highest degree of agreement compared to others correlation. There is a strong, positive correlation between clients and consultants' rate, at which Pearson coefficient is 0.948 which is very close to 1, thus it is statistically significant at (*p=0.004)*. In addition, there are also strong correlation between client and contractor with Pearson coefficient (0.802) and consultant with contractor with Pearson coefficient (0.856).

Besides, based on the data obtained from the Pearson correlation between project stakeholders for Potential Barriers to Implement BIM for safety in building projects, it is notified that the relationship between client and consultant has the highest correlation. There is a strong, positive correlation between clients and consultants' rate, at which Pearson coefficient is 0.821 which is close to 1, thus it is statistically significant at (*p=0.045)*. However, there is no correlation between client and contractor, and consultant and contractor.

Table 4.7(b): Results of Pearson Correlation test on SPSS

Safety Control Aspect that can be executed by using BIM platform

		Client	Consultant	Contractor
Client	Pearson Correlation	1	.948**	.802
	Sig. (2-tailed)		.004	.055
	N	6	6	6
Consultant	Pearson Correlation	.948**	1	.856*
	Sig. (2-tailed)	.004		.030
	N	6	6	6
Contractor	Pearson Correlation	.802	.856*	1
	Sig. (2-tailed)	.055	.030	
	N	6	6	6

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Potential Barriers to Implement BIM for safety in building projects

		Client	Consultant	Contractor
Client	Pearson Correlation	1	.821*	.445
	Sig. (2-tailed)		.045	.376
	N	6	6	6
Consultant	Pearson Correlation	.821*	1	.273
	Sig. (2-tailed)	.045		.600
	N	6	6	6
Contractor	Pearson Correlation	.445	.273	1
	Sig. (2-tailed)	.376	.600	
	N	6	6	6

*. Correlation is significant at the 0.05 level (2-tailed).

As mentioned in the results, there is high degree of agreement between client and consultant on safety control aspects that can be executed by using BIM platform but the degree of agreement between the contractors and other project stakeholders is slightly lesser. This could happen due to different working environment during construction itself. As contractors are always working at the construction site, their understanding on safety could be much deeper and their perspective on BIM could have been different compared to clients and consultants that mostly work offsite. In addition, as the clients are involved since planning phase and consultants are more towards planning and designing the structure of the building , thus their theoretical concept about BIM tools could be broader. Hence, the correlation between consultants and clients could be higher.

Furthermore, the correlation between project stakeholders on potential barriers to implement BIM for safety in building project between consultants and clients are quite high but the degree of agreement between contractors and other project stakeholders are quite low. This could happen due to different project stakeholders would have difference requirement and preference. For example, based on **Table 4.6.4(b)** contractors agree that the main barrier is the high cost to implement BIM for safety as to provide a good safety performance at site, thus more cost will be needed. However, for the clients and contractors that not really exposed to safety, might be lack in knowledge and skills on how BIM does could help in safety construction.

Table 4.7(c): Results of Cronbach's Alpha reliability test on SPSS

Safety Control Aspect that can be executed by using BIM platform

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.900	.902	6

Potential Barriers to Implement BIM for safety in building projects

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.794	.797	6

Based on **Table 4.7(c)**, the reliability of the questionnaires is assured as the results shown is greater than 0.7. Cronbach's alpha coefficient for Safety Control Aspects that can be executed by using BIM platform and Potential Barriers to Implement BIM for safety in building projects equal 0.9 and 0.794 respectively.

4.8 Current practices on the implementation of BIM for safety control in building project

4.8.1 Survey Questionnaires

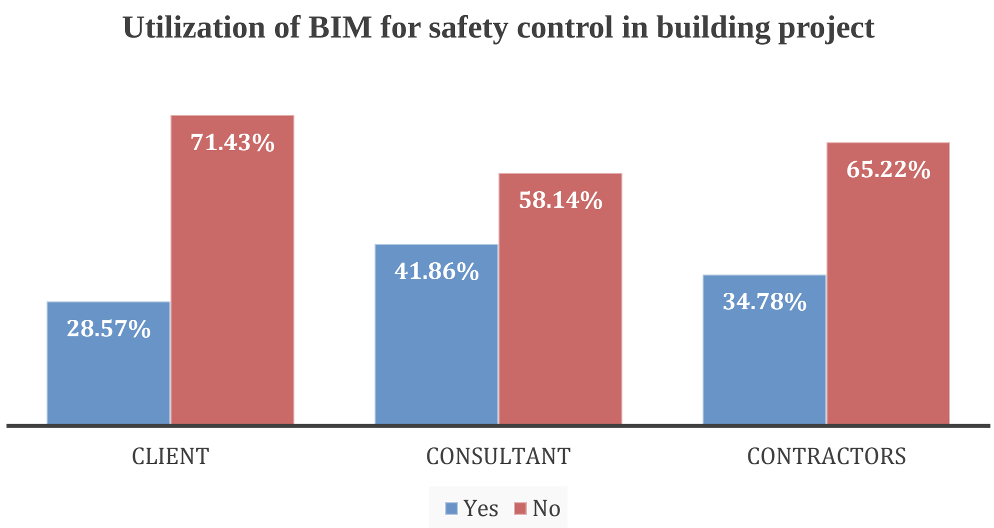

Figure 4.8.1: The utilization of BIM for safety control in building project

Based on Section C, which is open ended questionnaires, despite most of the respondents are aware that BIM can be used for safety control in construction as in **Figure 4.4(d)**, however only 37 percent from the total respondents are currently practicing using BIM for safety. The percentage based on the respondents for the utilization of BIM for safety control in building project is illustrated in **Figure 4.8.1**. From these results, as Kuala Lumpur is the leading states that implement BIM in construction project, thus it can be determined that Malaysia is still in the early level of implementing BIM for safety. Most of the respondents stated that application provided by BIM software such as 3D modeling and visualization, scheduling and simulation has helped them to manage safety for their project.

For instance, the respondents use visualization and simulation for logistic planning at site and clearance height, performing clash detection analysis in building design and having weekly design review among all project stakeholders. 3D modelling of the building has been done by using Revit, Tekla, E-tabs, Prota, ArchiCAD, EcoDomus, Prokon, Fuzor, Sketchup and Vectorworks. Besides, some of the respondents has involve in 4D scheduling by using Autodesk Navisworks, Tekla and Fuzor software. Site layout planning could also be performed by using Civil 3D and Autodesk Revit, whereas BIM to Field has been used for coordination. To ensure a good collaboration between project stakeholders, BIM 360 has been utilizing which helps the project stakeholders to upload their file in clouds and if there any amendment on their work performance could be noticed by other project stakeholders as well.

In addition, the respondents also justified on the current situation that give challenges in AEC industry to implement BIM for safety. Majority of the respondents claimed that most of the people in the construction industry are still lack in knowledge and skills about how to use BIM for safety control in building project. This problem could occur due to less of awareness being provided to the AEC industry such as less training and course offered in Malaysia. Besides, the cost that need to bear by the project stakeholders to support for training, licensing and hiring BIM personnel are also high which has prevented the AEC industry to realize the cost saving in long term duration.

Some of the respondents claimed that BIM in Malaysia is still new and under experiment which cause most of the clients to reluctant from investing in BIM project. This has cause major issues as the client demand is the only way to ensure the construction industry to adopt BIM in the project as there are only selected public projects that require BIM. Besides, the respondents claimed that BIM implementation is not part of statutory requirements and felt that for smaller scale project in Malaysia is not cost effective to use BIM. To make changes in conservative working environment is also a challenge as the project stakeholders felt comfortable with current working ways and resist to change as the project stakeholders could only focus on their objective in construction. In addition, current construction industry is still preferring traditional way of safety control approached such as physical monitoring and coordinating physical response.

Besides, to train the worker to become BIM personnel also time consuming as many of the project stakeholders are not exposed to BIM during studies and adaption to learn new software required competent skills. However, on the other hand where there are fresh graduates that equipped with skilled and knowledge in BIM but does not have the opportunity to enhance their skill as there is lack of demand of using BIM in projects. Nevertheless, in Malaysia has yet to have national BIM standard that shall control and standardize the quality of BIM implementation to ensure the BIM uses and objectives are met. As most of the works are stored in clouds, thus there is ambiguity on the clouds file once the project is completed.

Lastly, one of the respondents claimed that even though currently there is improvement of using BIM software in Malaysia for 3D modelling, but the project stakeholders are still preferring to work in silos without coordination within discipline. Thus, this might cause none of the respondents claimed incompatibility and interoperability issues as one of the potential barriers in open ended questionnaires because not many of them utilize BIM in correct way thus they do not experience any problems of different software from different disciplines.

4.8.2 Interview

To validate the questionnaires survey results regarding current safety control aspects that can be executed by using BIM platform and also to identify the level of utilization of BIM for safety in current construction industry, three interviews have been conducted within contractor's representative which is a BIM modeler, a site engineer and a safety and health officer that work together in the case study project. Only contractors are selected for the interview because contractors' practitioners are more exposed to safety and only the contractors' practitioners utilize BIM tools in this project. From the interview session there are balance between BIM and safety aspect as the BIM modeler is more expert in BIM scope but less into safety, and the safety health officer is vice versa, but the site engineer has moderate knowledge in BIM and safety as well. The BIM modeler and site engineer are aware that BIM could be used for safety, but the safety health officer is not much aware on it because lack of knowledge in BIM.

All of the interviewees agree that all six safety control aspects that has been mentioned are relevant to be demonstrated by using BIM because BIM help the construction industry to properly plan without overlooked any aspect in safety. However, current Malaysia construction industries are not really utilized BIM for safety, and they are still comfortable using the conservative way of managing safety control. In this case study, all the safety control aspects that can be executed by using BIM has been used in this project except for “safety training and education” but the utilization of BIM for safety is not to its fully extend.

This case study has used BIM tools such as Autodesk Revit for 3D modelling and walk-through animation to provide better visualization and Autodesk Navisworks has been used to manage clash detection between the architectural, structural, mechanical, electrical and plumbing elements. In addition, the 3D modeling has helped the project to visualize their tower crane and jumping system sequence to prevent any collision between those two. Besides, the layout of the building and the 3D modelling has helped the safety officer to identify any potential hazard such as slab area that exposed to risk and they could plan for fall prevention planning in advance without overlooked any aspects. Consequently, advance planning by referring to 3D modelling has helped to plan for work task that include safety risk. For example, which area are capable to place heavy load and which area does not. Communication and collaboration among stakeholders by using BIM tools in this project only happened among contractor with sub-contractor and clients. As some files are private and confidential for certain project stakeholders in construction, thus different communication software has been used in this project which are Oracle Aconex for client and BIM 360 for sub-contractor. In this case study, only 3D modelling and visualization has helped to improve safety performance at site.

Based on the interview, the interviewees have given their opinion on how safety control aspects can be executed by using BIM. For instance, BIM could produce 3D modelling as well as site layout and safety plan. By using advance BIM software, the site layout and safety plan could even be simulated as per construction site. During visualizing the 3D model, hazard identification and recognition can be performed and at the same time, planning for safety could be done early. Planning for safety could involve storage arrangements, logistic plan and movement access of the constructions' practitioner. As planning for safety is perform together with the hazard identification, thus planning for work task that include safety could be done as the remarkable safety risk can also be integrate together.

Besides, the visualization in 3D modelling has assists the contractor's practitioners to plan in advance for the fall prevention planning as they could locate the edge position of the building as well as the hole location. When the visualization of the 3D model and simulation of the project completed, it can be shown towards the construction worker for better understanding of the work sequences and their safety aspect on site. This training is where the communication comes. Additionally, the communication is not within the construction worker itself but also between clients, consultants and subcon where the project stakeholders could improve their communication and collaboration through common data environment, CDE. Here, all the information, files or models of the project are shared in one platform. In this platform, all parties are able to retrieve information and even offer suggestion on their own.

From, the interview that have been conducted, the knowledge about implementation for safety need to be combine between the three interviewees as different interviewees has different expertise area. Thus, it is suggested for BIM personnel to be exposed about safety in construction and for safety personnel to understand about the concept of BIM itself and the site engineer to enhance the knowledge about BIM and safety. With this, safety by using BIM in construction project will be more relatable and the contractors' practitioners could plan their safety aspect by using BIM.

4.9 Proposed Safety Control by Using BIM for Building Project Framework

From previous research, Azhar et al. (2013) had incorporated safety elements in BIM model by developing a flowchart as in **Figure 4.9(a)** to outline the study's workflow utilizing the BIM software that can assist safety. As this BIM model was enhanced by the researcher from communication and visualization purposes, thus, the author has proposed a framework to improvise the current framework.

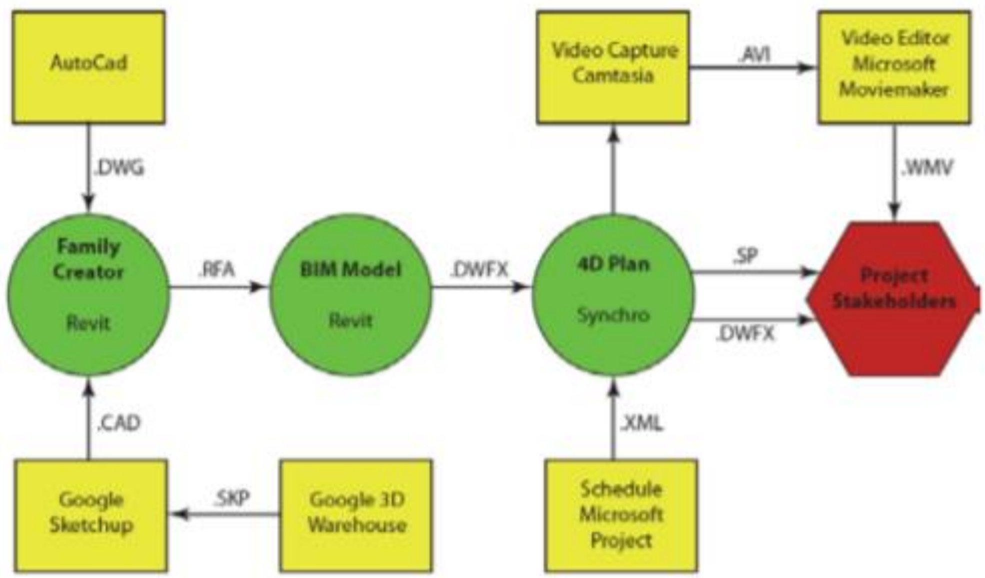

Figure 4.9(a) : *The "BIM + Safety" workflow* (*Azhar et al., 2013).*

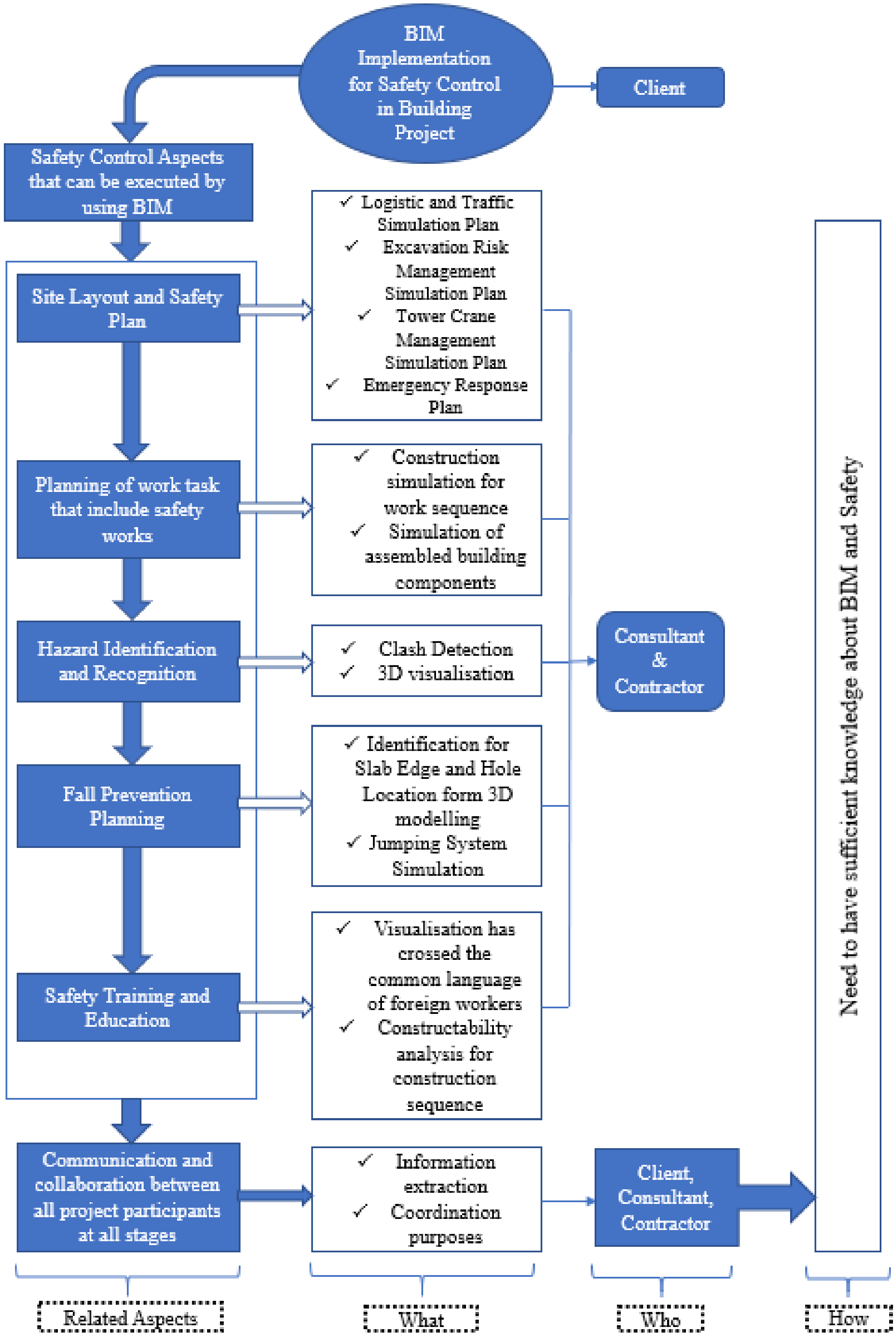

Figure 4.9(b) : Framework to implement BIM for safety control in building project

Based on the data collection through questionnaires survey among client, consultant and contractors and a case study through three interviews among BIM modeler, site engineer and health and safety officer, the author has proposed a framework to implement BIM for safety in building project based on **Figure 4.9(b)** above.

First and foremost, to ensure the implementation of BIM for safety control in building project, the client must made it as one of the requirements in the project. Thus, the consultants and contractors will ensure safety as the top of priority of the construction project. As there are six safety control aspects that has been ranked from the questionnaires, five of the aspects are technical safety control aspects, and only "communication and collaboration between all project participants at all stages" is an ethical safety control aspect. Therefore, these ethical aspects need to be performed by project stakeholders throughout the technical safety control aspects sequence. All five technical safety control aspects are arranged according to the overall ranking in **section 4.5.4.**

Site layout and safety plan will be the first safety control aspect need to be prepared when entering a construction site, thus by using BIM, not only 3D modelling of the layout could be produced, but as well as simulation of the site layout and safety plan. In 4D dimension of BIM which mention about time, it allows the user to schedule the construction work by displaying the simulation of the construction work. Such software that allows simulation currently are Tekla and Navisworks. The site layout simulation that can be executed are logistic and traffic, excavation risk management, tower crane management simulation plan and emergency response plan. By having simulation of the construction work before the construction work starts, early problem that can happen in the future could be predicted and prevented. For example, the simulation for deep excavation project could portrayed if there any possibilities for the excavation and lateral support (ELS) elements to collide with structural elements. The consultants and contractors need to work together as the structural elements is in charged for the structural elements and the contractors need to locate on the correct and suitable position of the ELS.

Secondly, planning of work task that include safety work could be done as the simulation in BIM can simulate all the construction work sequence, thus the mockup that always be done by safety personnel as a conservative way does not to be done anymore. Besides, for building project that utilize Industrialized Building System (IBS), BIM could also provide the simulation of the assembled building components. Throughout planning the work task, remarkable safety risk could be incorporated for every work that will be performed. This aspect could also be including during designing process where the design produced by the consultants should get advice from the contractors whether the design is safe or if there any suggestion from the contractors to improve the design for safety (prevention through design).

Thirdly, throughout the visualization and simulation of the construction work, the safety and health officer could identify any hazard and can start planning for standard operation procedure. In addition, BIM tools allow the user to model structural, architectural, mechanical and electrical system, fire protection system and plumbing and drainage system elements. For complex project, all these elements could be clash within one another, thus BIM software such as Navisworks allow the BIM modeler to detect any clash by combining all the elements and run for clash detection analysis. Clash detection is contributing to the safety as it reduces potential risk for the construction worker as renovation of the elements might cause danger.

Fourthly, fall prevention planning could be done thoroughly by visualizing the 3D model and identify the possible area that can lead to fall such as slab edge and slab hole. The BIM modeler can highlight the area such as danger (red), high risk (yellow) and low risk(green) area to ease the identification for area that are prone to falling for safety health officer. Besides, by highlighting the area with color not only assists the safety health officer to plan for fall prevention planning but also for the construction worker to be aware of the three areas. Furthermore, simulation of jumping system could also be performed by using BIM software.

Last but not least, as the construction going to start, toolbox kit has been a routine for current construction industry. However, as the construction worker mostly coming from foreign country thus the worker might not be able to fully understand during the toolbox kit. Thus, as BIM provide visualization and simulation of the project, the construction worker will be understood well as they can foresee the sequence of work and predict any safety precaution that they need to be aware during working. Besides, as the construction workers are more aware with the construction site, thus they can also suggest which work sequence that can be done first considering high priority for safety.

As the ethical safety control aspect is having good communication skill, thus BIM could enhance the collaboration and communication between all project stakeholders throughout the project stage by using common data environment such as Autodesk BIM 360 which the software allows all information or modelling of the project to be shared in one platform. This platform could update and acknowledge any changes or amendments made by other project stakeholders and the other project stakeholders could also give feedback and suggestion for improvement. All the information could be extract anywhere at any time thus consequently improve the coordination of work. By doing so, any miscommunication could be prevented especially between project stakeholders.

In conclusion, the application that provided by BIM such as visualization, simulation and communication really help to improve the safety performance in building project. Based on **section 4.7** shows high correlation among owner and consultant but not for contractor due to different depth of knowledge in BIM and safety because of current working environment, thus the implementation by using BIM for safety control will be successfully execute if all project stakeholders have sufficient knowledge not only about BIM but as well as safety. In addition, safety health officer should also cooperate to understand about application that BIM provided so that they can advise on the safety aspect to the project stakeholders for more efficient and accurate results. Thus, the safety problem in construction industry could be reduce significantly by using BIM as BIM greatly offer advance safety planning.

4.10 Proposed Solutions for the Barriers in Implementing BIM for Safety in Malaysia

4.10.1 Support from Government

The government should enforce the utilization of BIM not only for public project above RM 10 million but as well as for private project in order to increase the implementation of BIM in Malaysia. By doing so, the project stakeholders will be exposed about BIM, and they will experience themselves on how BIM will ease their working method. Besides, the government need to subsidize the license of BIM software to encourage many projects to use BIM. In addition, the government could provide incentive such as free training for company that interested to implement BIM for their project. Furthermore, the government could provide campaign about BIM and invite project stakeholders to be part of the campaign. During this campaign, past project that have utilize BIM could take part during exhibition and present their return of investment after using BIM in their project. Strong support from government will essentially create the awareness within project stakeholders on the advantages of using BIM in long term duration

4.10.2 Implement BIM and Safety as the Courses in University

As the learning curve to use BIM tools is high, thus it is suggested to implement BIM as one of the courses in all universities that involve with AEC industry so that the project stakeholders are exposed to BIM since they were students. As a result, the newcomers in construction industry just need to polish their skill and adapt with the new working environment of BIM. Besides, safety course during construction should also be implemented to acknowledge the students on how their design could also be plan for safety. Therefore, the project stakeholders will have the knowledge to use BIM for safety control in a building project. If the skills and knowledge has been cultivated since they were students, the future project stakeholders will not be resists to change as they have been provided with capabilities and competencies.

4.10.3 Provide a National Standard Guideline

The government should provide a national standard guideline for the BIM project throughout the whole life cycle from planning phase to designing, construction phase until defect liability period. Therefore, the project stakeholders will be clearer and convinced on the process. Besides, there is a need to standardize the software packages use among project stakeholders to avoid incompatibility and interoperability issues within software that can cause delay on the project. Besides, an authorize body shall be introduced to enforce, guide and audit the BIM implementation within the project to ensure adherence to BIM standards and implementation working method. Therefore, the BIM implementation could be foreseen with its full potential.

4.10.4 Promote Safety in BIM through Training and Seminar

In Malaysia, the utilization of BIM for safety is still very low, thus it is a need to provide training for the beginners especially for the safety personnel to explore on the correct way to implement BIM for safety. The training itself could be done separately, for example training for client could be explaining on the essence of using BIM and the advantage that can be seen in long term run, and respective BIM tools to be used for consultants such as civil and structural engineer, architects, mechanical and electrical engineers, quantity surveyor as well as for contractors. Besides, the correct working method by using BIM should also be explain during the training session so that all project stakeholders will work together and not in silos. In addition, organizing more seminar about safety in BIM would expand the knowledge within project stakeholders where the presenter could be from someone that experience about BIM in safety coming from other country. By inviting an expert that can share on the correct tools to use BIM for safety control in construction project and presents the profit that they gain from the BIM investment, the project stakeholders in Malaysia will be attracted and get the big picture of implementing BIM for safety in building project.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

In conclusion, the questionnaires survey has identified "site layout and safety plan" as the highest RII for safety control aspects that can be executed by using BIM platform and "lack of knowledge and skill" as the most potential barrier to implement BIM for a building project in Malaysia. Besides, high correlation could be seen between client and consultant for safety in BIM project and potential barriers to implement BIM for construction. This could happen due to different understanding about BIM and safety and different self-interest respectively. From the questionnaires, even though most of the project stakeholders are aware that BIM can be used for safety control in building project, but the implementation is still at a low level. From the interview conducted in a case study, the BIM modeler and site engineer are aware that BIM could be implement for safety but the safety health officer not really much due to lack in knowledge about BIM. But all of the interviewees agree that BIM really help in improving safety control in a building project for all six safety controls aspects that been mentioned. Even though five safety control aspects have been used by using BIM in this project, but the utilization is not to its fully extend. Lastly, the author successfully develops a framework for BIM implementation for safety control in building project to be implement by engineers and safety health officer together and proposed four solutions for tackling six barriers in implementing BIM for safety control in Malaysia as mentioned previously.

5.2 Recommendation

To ensure this study to be more significant in the future, thus it is suggested to enlarge the scope of the study instead from planning to construction phase only, this study could be extending towards facility management stage of a construction process as BIM also provide application for facility management. Besides, as a construction project does not only involve building, thus in future reference, this study could also cover for drainage, road, mechanical, electrical, plumbing and sewerage as safety is important in all aspects. In addition, as BIM for safety in construction project in Malaysia is still recent, thus this study could also involve respondents outside Kuala Lumpur and the number of case study for interview need to be increased to get the opinion and information on current situation in construction industry. In conclusion, with the above recommendation stated, the construction industry will be ready to implement BIM for safety in construction project to its full potential.

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APPENDIX A

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QUESTIONNAIRE SURVEY

BIM IMPLEMENTATION FOR SAFETY CONTROL IN BUILDING PROJECT

Disclaimer:

I am a final year final semester Bachelor of Engineering (Hons) Civil Engineering, student of Universiti Teknologi PETRONAS (UTP). In partial fulfilment of the requirements of this degree, I am required to complete final year project (FYP). The questionnaire is intended to gather information about the Implementation of BIM for Safety Control in Building Project.

Objectives:

To identify and rank safety control aspects that can be executed by using BIM platform and potential barrier to implement BIM in a building project by conducting questionnaires survey and Relative Importance Index (RII) Method with correlation between project stakeholders.

Instructions:

1. Please answer ALL the following questions.
2. Please fill in the blank and tick ✓ in the respective box.
3. All information treated as CONFIDENTIAL and shall be used for academic purpose only.
4. All data will be on aggregated basis and no individual data will be published

SECTION A
PERSONAL DETAIL

Q1 Name : ....

Q2 Gender : ☐ Male ☐ Female

Q3 Age :
- ☐ 20 – 29 years old
- ☐ 30 – 39 years old
- ☐ 40 – 49 years old
- ☐ > 50 years old

Q4 Highest Qualification :

Q5 Designation :
- ☐ A. Client
- ☐ B. Consultant
- ☐ C. Contractor

Q6 Working duration :
- ☐ Less than 3 years
- ☐ Less than 7 years
- ☐ Less than 10 years
- ☐ More than 11 years

Q7 Depth knowledge about BIM :
- ☐ No Knowledge
- ☐ Little Knowledge
- ☐ Moderate knowledge
- ☐ Extensive Knowledge

Q8 Highest Level of work used in BIM Dimension :
- ☐ 2D (CAD Drawing)
- ☐ 3D (2D + Visualization)
- ☐ 4D (3D + Schedule/Simulation)
- ☐ 5D (4D + Cost)
- 6D (5D + Lifecycle)
- ☐ 7D (6D + Operation and Maintenance)
- ☐ 8D (7D + Safety)
- ☐ None of the above

Q9 Do you aware that BIM can be used for safety control in building project :
- ☐ Yes
- ☐ No

Q10 From your P.O.V, what is the impact of utilizing BIM for safety control in building project in Malaysia :

☐ I do not know
☐ No effect
☐ Improved
☐ Greatly Improved

SECTION B

BIM IMPLEMENTATION FOR SAFETY CONTROL IN BUILDING PROJECT

<u>Safety control aspects that can be executed by using BIM platform</u>

Please answer the questions below based on your preference.

1: Strongly disagree 2: Disagree 3: Moderately 4: Agree 5: Strongly agree

Code			Safety control aspects that can be executed by using BIM platform	1	2	3	4	5
A1	B1	C1	Hazard Identification and Recognition	☐	☐	☐	☐	☐
A2	B2	C2	Safety Training and Education	☐	☐	☐	☐	☐
A3	B3	C3	Site Layout and Safety Planning	☐	☐	☐	☐	☐
A4	B4	C4	Fall Prevention Planning	☐	☐	☐	☐	☐
A5	B5	C5	Planning of Work Task that include Safety Works	☐	☐	☐	☐	☐
A6	B6	C6	Enhance Communication and Collaboration between all project participants at all stages	☐	☐	☐	☐	☐

<u>Potential barriers to implement BIM for safety in Building Project</u>

Please answer the questions below based on your preference.

1: Strongly disagree 2: Disagree 3: Moderately 4: Agree 5: Strongly agree

Code			Potential barriers to Implement BIM for safety in Building project	1	2	3	4	5
A1	B1	C1	High Cost	☐	☐	☐	☐	☐
A2	B2	C2	Lack of Knowledge and Skills	☐	☐	☐	☐	☐
A3	B3	C3	Lack of Client Demand	☐	☐	☐	☐	☐
A4	B4	C4	Incompatibility and interoperability issues	☐	☐	☐	☐	☐
A5	B5	C5	Consume Time in Training Personnel	☐	☐	☐	☐	☐
A6	B6	C6	Resistance to Change	☐	☐	☐	☐	☐

SECTION C

CURRENT PRACTICES ON SAFETY CONTROL BY USING BIM AND THE IMPLEMENTATION OF BIM IN BUILDING PROJECTS

1. Does your building project utilize any BIM application to manage safety control (Yes/No)

2. If yes, state the BIM application used and for what kind of safety practice (example: 3D modelling, visualization, simulation, scheduling, etc.)?

3. Nowadays, there are still barriers in implementing BIM for safety control in construction industry. From your point of view, what are the factors contributing to this problem?

4. What are your suggestions towards implementing BIM in construction industry for safety control especially for building project?

SECTION D

PILOT SURVEY FEEDBACK

1. Suggestion on the improvement to ensure the completeness of the questionnaires survey. Give opinion.

2. May I contact you again for future involvement in another questionnaire form regarding the implementation of safety control practices in your company ? (You may include your contact no/ email)

APPENDIX B

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INTERVIEW

BIM IMPLEMENTATION FOR SAFETY CONTROL IN BUILDING PROJECT

Disclaimer:

I am a final year final semester Bachelor of Engineering (Hons) Civil Engineering, student of Universiti Teknologi PETRONAS (UTP). In partial fulfilment of the requirements of this degree, I am required to complete final year project (FYP). The questionnaire is intended to gather information about the Implementation of BIM for Safety Control in Building Project.

Objectives:

To assess the awareness level and evaluate the implementation of using BIM for safety control in building constructions through interview and a case study project.

Instructions:

1. Please answer ALL the following questions.
2. Please fill in the blank and tick ✓ in the respective box.
3. All information treated as CONFIDENTIAL and shall be used for academic purpose only.
4. All data will be on aggregated basis and no individual data will be published

SECTION A
PERSONAL DETAIL

Q1 Name : ....

Q2 Gender : ☐ Male ☐ Female

Q3 Age :
- ☐ 20 – 29 years old
- ☐ 31 – 39 years old
- ☐ 41 – 49 years old
- ☐ > 50 years old

Q4 Highest Qualification :

Q5 Designation :
- ☐ Project Director
- ☐ Project Manager
- ☐ Project engineer
- ☐ Site Engineer
- ☐ Safety Health Officer
- ☐ BIM Manager
- ☐ BIM Coordinator
- ☐ BIM Modeler

Q6 Working duration :
- ☐ Less than 3 years
- ☐ Less than 7 years
- ☐ Less than 10 years
- ☐ More than 11 years

Q7 Depth knowledge about BIM :
- ☐ No Knowledge
- ☐ Little Knowledge
- ☐ Moderate knowledge
- ☐ Extensive Knowledge

Q8 Highest Level of work used in BIM Dimension :
- ☐ 2D (CAD Drawing)
- ☐ 3D (2D + Visualization)
- ☐ 4D (3D + Schedule)
- ☐ 5D (4D + Cost)
- ☐ 6D (5D + Lifecycle)
- ☐ 7D (6D + Operation and Maintenance)
- ☐ 8D (7D + Safety)
- ☐ None of the above

Q9 Do you aware BIM can be used for safety control in construction project :

- ☐ Yes
- ☐ No

Q10 From your P.O.V, what is the impact of utilizing BIM for safety control in building project in Malaysia :

- ☐ I do not know
- ☐ No effect
- ☐ Improved
- ☐ Greatly Improved

SECTION B

QUESTIONS

Q1 What is your view on the current safety performance in your project?

Q2 Based on your experience and knowledge, what do you understand about BIM?

Q3 How BIM is used in your construction project and what kind of tools do you use?

Q4 How BIM give impact towards your current project?

Q5 Based on your experience, are there any differences between project that utilizing BIM with project without utilizing BIM for safety control?

Q6 Based on your experience or from you point of view, how do you think BIM can help safety control aspect below:

- hazard identification and recognition
- safety training and education
- site layout and safety plan
- fall prevention planning
- planning of work task that include safety work
- enhancing the communication and collaboration between all project participants in all stages

Q7 Based on question number 6, which one do you think BIM give a big impact in managing the safety control? Please explain your answer.

Q8 Based on the potential barrier to implement BIM such as: (1) high cost; (2) lack of knowledge and skill; (3) lack of client demand; (4) incompatibility and interoperability issues; (5) consume time in training personnel and (6) resistance to change, which factor do you think is the most crucial in preventing project stakeholders from implementing BIM for safety control and why?

Q9 What is your suggestion in making sure more project stakeholders interested to implement BIM especially in managing safety purposes for building projects?

APPENDIX C: INTERVIEW TRANSCRIPT

Interview Transcript (BIM modeler)

Duration: 40 minutes　　　　Date: 9/7/2021

Interviewer:	How long have you been in this industry?
Interviewee:	3 years
Interviewer:	What is your current designation?
Interviewee:	BIM Modeler
Interviewer:	What do you think the impact of utilizing BIM for safety control in building project?
Interviewee:	I think it is improved now than before
Interviewer:	What is your highest level of work used in BIM dimension?
Interviewee:	Currently, we are approaching 5D dimension in BIM. But in 4D where the BIM can produce simulation of the project site, we are still learning on it.
Interviewer:	What is your view on current situation of the safety performance at construction project?
Interviewee:	Based on my observation in my current project, I think safety performance is important to ensure that project runs smoothly. Safety personnel play important roles in ensuring all staffs and workers to comply with safety policies.
Interviewer:	Based on your experience and knowledge, what do you understand about BIM?
Interviewee:	BIM is not just about the tools but also the working environment to work together among all project stakeholders.
Interviewer:	How BIM is used in your construction project and what kind of tools do you use?
Interviewee:	As this project is not requirement to use BIM from the clients, but as main contractors we decided to use BIM to ease our workflow but as for now, only our side that utilize BIM. We used tool such as Autodesk Revit for3D Modelling, Autodesk Navisworks Manage for Clash detection and Cubicost TASC-II - BIM 5D (Cost estimation)
Interviewer:	How BIM give impact towards your current project?
Interviewee:	I think BIM really ease our workflow and save cost in long term run. Besides, as this project is high rise and complicated, thus BIM really helps us to visualize the project and used walk through animation function to present to other staff.
Interviewer:	Based on your experience, are there any differences between project that utilizing BIM with project without utilizing BIM for safety control?
Interviewee:	From my opinion, it is a great difference as implementation of BIM can improve safety performance in construction industry such as planning of tasks, equipment, etc can be planned and scheduled by using BIM in order to avoid any injuries or incident at site as BIM offered visualisation and simulation of the project.

Interviewer: In your point of view, how BIM help in hazard identification and recognition?

Interviewee: In my project (TRX Residences), BIM was only used at the initial stage of the construction where we used BIM to visualise our tower crane and LUBECA jumping system sequence in order to avoid collision between those two. Although BIM is not fully utilised for safety purposes in this project, I think potential hazard can be identified at early stage with the help of 3D model.

Interviewer: How do you think BIM helps in safety training and education?

Interviewee: Safety personnel can study BIM model to identify any potential hazards and they can conduct training prior what to be done in order to avoid any incident or injuries.

Interviewer: What is your opinion in using BIM for site layout and safety plan?

Interviewee: Yes, BIM can be used to produce logistic layout simulation as well as material arrangement which falls under safety plan. But in our project, we only have crane management plan by using BIM.

Interviewer: In your point of view, how BIM helps in fall prevention planning?

Interviewee: BIM can help to plan works before physical works start, hence avoiding any unwanted incident.

Interviewer: What do you think on planning work task that include safety work by using BIM?

Interviewee: BIM enables advance planning such as where to place heavy materials on site, can determine the right positions for material arrangement, hence give accuracy for the planning.

Interviewer: What do you think on utilizing BIM for enhancing the communication and collaboration between all project participants in all stages?

Interviewee: BIM improves collaboration and communication as all information, files or models are shared in one platform (also known as common data environment, CDE). In this platform, all parties are able to retrieve information and even offer suggestions of their own. We use Oracle Aconex to communicate with our client and Autodesk BIM 360 with our subcontractor. We use different communication software because certain files is private and confidential which we cannot give access to other parties.

Interviewer: Based on the safety control aspects that can be executed by using BIM above, which one do you think BIM give the biggest impact in managing safety control.

Interviewee: Planning work task that include safety work by using BIM because BIM really helps in advance planning. When we plan, perhaps we can also include remarkable safety risk that the worker could face during construction. With this, the worker will be much more alert with their work.

Interviewer: Based on the potential barrier to implement BIM such as: (1) high cost; (2) lack of knowledge and skill; (3) lack of client demand; (4) incompatibility and interoperability issues; (5) consume time in training personnel and (6) resistance to change, which factor do you think is the most crucial in preventing project stakeholders from implementing BIM for safety control and why?

Interviewee: Resistance to change because it is time consuming, and some people just do not want to accept new things without any reasons.

Interviewer: What is your suggestion in making sure more project stakeholders interested to implement BIM especially in managing safety purposes for building projects?

Interviewee: Educate safety personnel about how BIM can help in improvising safety performance and government should make implementation of BIM up to 8D as obligation.

Interview Transcript (Site Engineer)

Duration: 30 minutes | Date: 16/7/2021

Interviewer: How long have you been in this industry?

Interviewee: About 9 years

Interviewer: What is your current designation?

Interviewee: Site Engineer

Interviewer: What do you think the impact of utilizing BIM for safety control in building project?

Interviewee: I think it is improved

Interviewer: What is your highest level of work used in BIM dimension?

Interviewee: I know about BIM, but I am not into BIM area but currently as far I know we already utilize BIM for cost.

Interviewer: What is your view on current situation of the safety performance at construction project?

Interviewee: Good

Interviewer: Based on your experience and knowledge, what do you understand about BIM?

Interviewee: BIM is the model which we use to incorporate all information on structure, architecture, ID, M&E, façade and in one system/model.

Interviewer: How BIM is used in your construction project and what kind of tools do you use?

Interviewee: BIM is used for construction planning and for visualization purposes on finishing product

Interviewer: How BIM give impact towards your current project?

Interviewee: BIM can increase efficiency and eliminates problems at early stage hence ensuring work to be run smoothly on site

Interviewer: Based on your experience, are there any differences between project that utilizing BIM with project without utilizing BIM for safety control?

Interviewee: Yes, if we can plan on the method of construction by having the visualization of finishing product and simulation of the project means we can control on the safety aspect.

Interviewer: In your point of view, how BIM help in hazard identification and recognition, safety training and education, site layout and safety plan, fall prevention planning, planning work task that include safety work by using BIM and enhancing the communication and collaboration between all project participants in all stages?

Interviewee: Based on my knowledge, actually, all the elements related to each other. For example, implementing BIM for safety, we can come out with the BIM models and the drawings which include all site layout and safety plan. In that model, we can perform hazard identification and recognition at the same time we can start planning because we already got the visualization of the buildings in 3d. Here, we can plan for storage arrangements, logistic plan and movement access. When we already have the model, we can come out with a plan for training the workers at the early stage of the construction where we can explain about all the plans, the dos and don'ts etc. This training is where the communication comes. Additionally, the communication is not within the construction worker itself but also between clients, consultants and subcon.

Interviewer: Based on the safety control aspects that can be executed by using BIM above, which one do you think BIM give the biggest impact in managing safety control.

Interviewee: Planning of work task that include safety. As we can plan on the method of construction and the coordination with all relative parties, so we can determine the potential hazard which we can eliminate during the planning stage.

Interviewer: Based on the potential barrier to implement BIM such as: (1) high cost; (2) lack of knowledge and skill; (3) lack of client demand; (4) incompatibility and interoperability issues; (5) consume time in training personnel and (6) resistance to change, which factor do you think is the most crucial in preventing project stakeholders from implementing BIM for safety control and why?

Interviewee: High cost. Some of the project client did not required BIM because they need to allocate some budget for contractor to have a BIM team. For contractor, they need to have a BIM team, software and hardware to operate the team which need to be in the project budget.

Interviewer: What is your suggestion in making sure more project stakeholders interested to implement BIM especially in managing safety purposes for building projects?

Interviewee: Government should make BIM implementation to be an obligation in all projects, educate everyone in construction about BIM, not only BIM personnel and provide more training for BIM personnel

Interview Transcript (Safety Health Officer)

Duration: 57 minutes Date:18/7/2021

Interviewer:	How long have you been in this industry?
Interviewee:	7 years
Interviewer:	What is your current designation?
Interviewee:	Safety Health Officer
Interviewer:	What do you think the impact of utilizing BIM for safety control in building project?
Interviewee:	To be honest, I am not really aware that BIM could be used for safety control as I only know that BIM could generate 3D modelling so I would say it is improved, but I think in Malaysia is still not much
Interviewer:	What is your highest level of work used in BIM dimension?
Interviewee:	As a safety officer for this project, I do not really use BIM for conducting my work as BIM does not liaise with safety, but the visualization provided by BIM modeler during meeting really helps our safety planning.
Interviewer:	What is your view on current situation of the safety performance at construction project?
Interviewee:	Current safety performance in our project is quite good and high standard as our client is international company so their safety standards is quite high, and our safety performance is among the best.
Interviewer:	Based on your experience and knowledge, what do you understand about BIM?
Interviewee:	I would say BIM could model the building layout in 3D and in BIM we can definitely know the exact number of materials needed such as how many doors, windows, room, and exactly the position. The visualization is much better when using BIM.
Interviewer:	How BIM is used in your construction project and what kind of tools do you use?
Interviewee:	In this project, BIM is used by the BIM modeler, but for safety officer myself, I did not used BIM
Interviewer:	How BIM give impact towards your current project?
Interviewee:	Actually, safety is about identifying hazard. This is the basic things in safety. And in my opinion, BIM helps us to know the potential hazard in the future. When the 3D modelling is completed, so the safety officer can identify where does the potential falling object can happened. So, in advance we can take precaution for that. For example, when reach different level, the protection needed might be different so we can figure it out earlier. But safety does not liaise with BIM modeler, we liaise with engineer for example we ask the engineer on the size of the project, the height of the building, and engineer will liaise with BIM to get the details, and after they made their calculation, then

only they will inform us. So, in everything we do, we will put minimum 5% of the safety factor. Safety personnel only look for the basic drawing to know the area, location and the condition of the workplace but other than that we will ask the construction manager or the engineer. For example, when we wanted to put heavy load on the slab, we will ask the engineer how much the maximum load can cater. Then, the construction manager will ask the BIM modeler to make the calculation.

Interviewer: Based on your experience, are there any differences between project that utilizing BIM with project without utilizing BIM for safety control?

Interviewee: In term of safety there are differences if we are using BIM. If we do not have BIM modeller at site, maybe our work will be left behind, so our engineer is more aware on the condition of workplace when the BIM modelling is established. So, the engineer will ask us on our opinion on safety once the modelling layout is prepared. So, our job scope is to eliminate or substitute the hazard. If there is no BIM modelling, we wight overlooked for example there might be no edge protection at certain level. To simplify, BIM helps us to know in advance to properly plan for the safety.

Interviewer: In your point of view, how BIM help in hazard identification and recognition, safety training and education, site layout and safety plan, fall prevention planning, planning work task that include safety work by using BIM and enhancing the communication and collaboration between all project participants in all stages? If you are not familiar with BIM, you can also give opinion based on current situation for safety control in the project.

Interviewee: So, as we do not use BIM, we usually make HIRAC, so any works that will starts, it will start with the HIRAC first. So, this is about sequence of work. For example, plastering work, we need to ask the engineer or supervisor, the sequence of work for plastering, and from every sequence of work that was stated, we will identify the hazard logically. After identify hazard, then only we made the standard operation procedure (SOP). In term of safety training and education, every day and every new work that will be done, there will be toolbox session and also we did on job training which is a mockup for every new work that the construction worker will be done. From there, we will revise back the HIRAC that will already identify and is it suitable for the sequence that we analyze during mockup. Besides, under job scope of BIM modeler they need to do a site layout planning, but the drafter will produce the drawing. And we always layout with the drafter for layout. In addition, for HIRAC we always have fall prevention planning, but we also add another one height mitigation plan, which it is more specific on fall prevention planning such ach anything relates with edge protection and planning working at height. For planning of work task that include safety work is include as I mention just now about the sequence of work, HIRAC and SOP. Lastly about communication and collaboration, sometimes there will be workers that do not understand the language, so usually we will have translator especially during toolbox session.

Interviewer: If I suggest for safety personnel to use BIM, what is your opinion?

Interviewee: For now, I do not think it is a necessary, as a safety personal on site is an advisor, such as advising towards safety, and our job scope is monitoring the workers, engineers and other employees and record what is not safe to be done and inform the others that the action is not safe. But I do not really know what BIM is but I had watched a video about tandem crane simulation, which if it is one of the utilization by using BIM, thus I think BIM will greatly help safety in construction.

Interviewer: Based on the potential barrier to implement BIM such as: (1) high cost; (2) lack of knowledge and skill; (3) lack of client demand; (4) incompatibility and interoperability issues; (5) consume time in training personnel and (6) resistance to change, which factor do you think is the most crucial in preventing project stakeholders from implementing BIM for safety control and why?

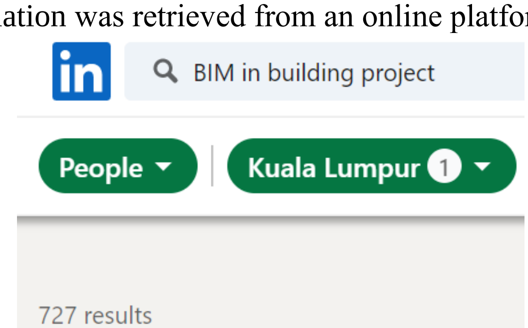
Interviewee: Whenever we talk about safety, it always relates with cost. So high cost might be the most potential barriers. Honestly, in Malaysia, we do not really see the advantage of BIM for safety management. I know it helps but I think it is not really necessary to go deep in learning BIM because I have others way to get the same result.

Interviewer: What is your suggestion in making sure more project stakeholders interested to implement BIM especially in managing safety purposes for building projects?

Interviewee: BIM actually really helps in advance to visualise the potential hazard at certain point. So, I think we need to create awareness among project stakeholders on the good side of BIM especially for safety so that they will be more interested.

APPENDIX D: Sample Population

- The sample population was retrieved from an online platform “LinkedIn”



APPENDIX E: RELATIVE IMPORTANT INDEX CALCULATION

- Overall

A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	B5	B6
4	4	4	4	4	4	5	5	5	5	5	5
1	1	1	1	1	1	1	1	1	1	1	1
4	4	5	5	4	4	4	4	4	4	4	4
4	5	5	5	4	4	2	2	3	2	2	3
4	5	5	3	4	5	5	5	4	3	5	5
5	4	5	5	4	5	3	4	5	3	3	4
3	3	4	4	3	3	4	4	3	4	4	4
3	4	3	4	4	3	5	5	5	5	5	5
3	4	4	4	4	3	3	4	4	3	3	3
4	4	4	4	4	4	3	4	4	3	3	3
5	4	5	5	5	5	5	4	5	2	4	5
5	3	4	4	4	5	3	5	5	2	4	5
5	3	4	3	4	5	4	4	3	3	5	5
3	4	4	2	4	4	4	4	4	4	4	4
4	5	4	5	4	4	4	5	4	4	4	4
5	5	5	5	5	5	4	4	3	4	2	2
4	4	5	4	3	5	3	4	3	3	4	3
5	5	5	5	5	5	4	4	5	5	3	5
3	3	5	3	5	5	5	3	5	3	3	1
3	2	5	3	5	5	3	5	5	1	1	5
5	5	5	3	5	5	2	4	5	4	5	5
4	4	5	4	4	5	5	5	5	5	4	5
5	3	5	4	5	5	2	5	4	2	2	4
4	4	5	5	5	4	4	3	4	3	3	3

4	5	5	4	4	5	4	5	5	5	3	5
4	4	5	5	4	4	4	3	4	4	3	4
4	4	5	4	5	5	4	4	2	3	4	5
4	2	4	3	3	3	3	4	5	2	3	5
4	5	5	5	4	5	5	4	5	2	2	5
4	3	4	3	4	4	3	2	2	3	3	4
4	4	5	4	4	5	3	4	4	3	2	2
4	4	4	4	4	5	4	4	3	2	3	5
4	3	4	3	3	3	3	3	4	3	4	3
5	3	5	5	4	5	5	5	4	3	1	4
4	3	4	4	4	3	5	5	3	4	5	2
3	3	4	4	4	5	4	4	5	3	5	4
3	3	3	3	3	3	2	3	3	3	2	3
4	4	4	4	4	4	3	4	4	2	3	4
5	4	5	5	5	5	5	4	3	4	4	5
5	5	5	5	5	5	3	3	1	3	1	3
3	2	4	4	4	3	4	5	5	4	4	5
5	5	5	5	5	5	4	4	4	3	3	4
4	4	4	4	4	3	5	5	5	5	2	5
4	4	5	4	5	4	4	5	5	2	3	5
4	3	4	3	4	4	4	4	4	4	4	4
5	4	4	4	4	5	4	4	4	3	4	3
4	4	5	4	4	4	3	5	5	3	4	5
2	2	2	2	2	2	1	1	1	1	1	1
2	3	4	4	3	3	4	5	4	4	5	4
5	5	5	5	5	5	3	4	5	3	5	4
4	4	5	3	4	5	4	5	4	4	4	5
5	4	4	4	3	4	4	5	5	3	5	5
5	5	5	5	5	5	3	3	5	3	3	4
4	4	4	4	4	5	4	2	5	3	4	4
4	4	4	4	4	4	4	5	1	3	4	4

	4	4	5	4	4	5	3	4	5	4	2	2
	5	5	5	3	5	5	5	4	4	4	5	5
	5	4	5	5	5	5	4	4	3	3	3	4
	4	3	3	3	3	3	4	3	3	3	4	3
	3	3	3	3	3	3	4	4	4	4	4	4
	4	3	4	4	4	5	4	4	2	4	4	4
	4	4	4	4	4	4	4	4	4	4	4	4
	5	3	5	5	5	5	5	4	4	4	5	3
	4	4	4	4	4	4	3	4	3	4	4	4
	4	3	5	4	4	4	5	4	5	3	4	4
	4	4	4	4	4	4	4	4	4	4	4	4
	4	4	4	5	5	4	4	4	3	3	4	3
	4	4	4	4	3	4	3	3	3	3	3	3
	5	5	5	5	5	5	4	5	5	5	4	5
	4	4	5	5	5	5	5	5	4	4	5	4
	3	4	4	4	4	4	3	4	4	4	3	3
	3	3	4	3	3	5	4	2	4	3	3	3
	3	3	5	3	4	5	5	4	4	4	5	5
	4	4	5	3	4	3	4	4	5	5	5	5
	4	4	5	4	4	5	5	5	4	3	4	3
	2	2	3	3	3	3	3	3	4	4	3	4
	5	5	5	5	5	5	4	4	4	3	4	4
	4	4	4	5	4	3	3	3	3	3	3	3
	5	4	4	5	5	5	4	4	3	3	4	5
	4	3	5	5	4	3	5	5	5	2	4	2
RII	0.8	0.7525	0.875	0.8	0.815	0.8475	0.7575	0.795	0.7825	0.6625	0.7075	0.7775

- Client

	A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	B5	B6
	4	4	4	4	4	4	5	5	5	5	5	5
	1	1	1	1	1	1	1	1	1	1	1	1
	4	4	5	5	4	4	4	4	4	4	4	4
	4	5	5	5	4	4	2	2	3	2	2	3
	4	5	5	3	4	5	5	5	4	3	5	5
	5	4	5	5	4	5	3	4	5	3	3	4
	3	3	4	4	3	3	4	4	3	4	4	4
	3	4	3	4	4	3	5	5	5	5	5	5
	3	4	4	4	4	3	3	4	4	3	3	3
	4	4	4	4	4	4	3	4	4	3	3	3
	5	4	5	5	5	5	5	4	5	2	4	5
	5	3	4	4	4	5	3	5	5	2	4	5
	5	3	4	3	4	5	4	4	3	3	5	5
	3	4	4	2	4	4	4	4	4	4	4	4
RII	0.7571	0.7429	0.8143	0.7571	0.7571	0.7857	0.7286	0.7857	0.7857	0.6286	0.7429	0.8

- Consultant

A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	B5	B6
4	5	4	5	4	4	4	5	4	4	4	4
5	5	5	5	5	5	4	4	3	4	2	2
4	4	5	4	3	5	3	4	3	3	4	3
5	5	5	5	5	5	4	4	5	5	3	5
3	3	5	3	5	5	5	3	5	3	3	1
3	2	5	3	5	5	3	5	5	1	1	5
5	5	5	3	5	5	2	4	5	4	5	5
4	4	5	4	4	5	5	5	5	5	4	5
5	3	5	4	5	5	2	5	4	2	2	4

4	4	5	5	5	4	4	3	4	3	3	3
4	5	5	4	4	5	4	5	5	5	3	5
4	4	5	5	4	4	4	3	4	4	3	4
4	4	5	4	5	5	4	4	2	3	4	5
4	2	4	3	3	3	3	4	5	2	3	5
4	5	5	5	4	5	5	4	5	2	2	5
4	3	4	3	4	4	3	2	2	3	3	4
4	4	5	4	4	5	3	4	4	3	2	2
4	4	4	4	4	5	4	4	3	2	3	5
4	3	4	3	3	3	3	3	4	3	4	3
5	3	5	5	4	5	5	5	4	3	1	4
4	3	4	4	4	3	5	5	3	4	5	2
3	3	4	4	4	5	4	4	5	3	5	4
3	3	3	3	3	3	2	3	3	3	2	3
4	4	4	4	4	4	3	4	4	2	3	4
5	4	5	5	5	5	5	4	3	4	4	5
5	5	5	5	5	5	3	3	1	3	1	3
3	2	4	4	4	3	4	5	5	4	4	5
5	5	5	5	5	5	4	4	4	3	3	4
4	4	4	4	4	3	5	5	5	5	2	5
4	4	5	4	5	4	4	5	5	2	3	5
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5	4	4	4	4	5	4	4	4	3	4	3
4	4	5	4	4	4	3	5	5	3	4	5
2	2	2	2	2	2	1	1	1	1	1	1
2	3	4	4	3	3	4	5	4	4	5	4
5	5	5	5	5	5	3	4	5	3	5	4
4	4	5	3	4	5	4	5	4	4	4	5
5	4	4	4	3	4	4	5	5	3	5	5
5	5	5	5	5	5	3	3	5	3	3	4

	4	4	4	4	4	5	4	2	5	3	4	4
	4	4	4	4	4	4	4	5	1	3	4	4
	4	4	5	4	4	5	3	4	5	4	2	2
	5	5	5	3	5	5	5	4	4	4	5	5
RII	0.8186	0.7674	0.9023	0.8	0.8326	0.8744	0.7395	0.8047	0.7953	0.6465	0.6558	0.786

- Contractor

	A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	B5	B6
	5	4	5	5	5	5	4	4	3	3	3	4
	4	3	3	3	3	3	4	3	3	3	4	3
	3	3	3	3	3	3	4	4	4	4	4	4
	4	3	4	4	4	5	4	4	2	4	4	4
	4	4	4	4	4	4	4	4	4	4	4	4
	5	3	5	5	5	5	5	4	4	4	5	3
	4	4	4	4	4	4	3	4	3	4	4	4
	4	3	5	4	4	4	5	4	5	3	4	4
	4	4	4	4	4	4	4	4	4	4	4	4
	4	4	4	5	5	4	4	4	3	3	4	3
	4	4	4	4	3	4	3	3	3	3	3	3
	5	5	5	5	5	5	4	5	5	5	4	5
	4	4	5	5	5	5	5	5	4	4	5	4
	3	4	4	4	4	4	3	4	4	4	3	3
	3	3	4	3	3	5	4	2	4	3	3	3
	3	3	5	3	4	5	5	4	4	4	5	5
	4	4	5	3	4	3	4	4	5	5	5	5
	4	4	5	4	4	5	5	5	4	3	4	3
	2	2	3	3	3	3	3	3	4	4	3	4
	5	5	5	5	5	5	4	4	4	3	4	4
	4	4	4	5	4	3	3	3	3	3	3	3
	5	4	4	5	5	5	4	4	3	3	4	5
	4	3	5	5	4	3	5	5	5	2	4	2
RII	0.7913	0.7304	0.8609	0.8261	0.8174	0.8348	0.8087	0.7826	0.7565	0.713	0.7826	0.7478

APPENDIX F: STANDARD DEVIATION (SD) CALCULATION

Overall Statistics

		A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	B5	B6
N	Valid	80	80	80	80	80	80	80	80	80	80	80	80
	Missing	0	0	0	0	0	0	0	0	0	0	0	0
Std. Deviation		.8419	.8750	.7693	.8715	.7758	.9035	.9372	.9274	1.0696	.9493	1.1017	1.0673

Clients' Statistics

		A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	B5	B6
N	Valid	14	14	14	14	14	14	14	14	14	14	14	14
	Missing	68	68	68	68	68	68	68	68	68	68	68	68
Std. Deviation		1.1217	.9945	1.0716	1.1883	.8926	1.1411	1.2157	1.1411	1.1411	1.1673	1.2044	1.1767

Consultants' Statistics

		A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	B5	B6
N	Valid	43	43	43	43	43	43	43	43	43	43	43	43
	Missing	0	0	0	0	0	0	0	0	0	0	0	0
Std. Deviation		.7811	.9240	.6680	.7868	.7537	.8458	.9395	.9633	1.1850	.9719	1.2017	1.1628

Contractors' Statistics

		A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	B5	B6
N	Valid	23	23	23	23	23	23	23	23	23	23	23	23
	Missing	0	0	0	0	0	0	0	0	0	0	0	0
Std. Deviation		.7674	.7141	.7029	.8149	.7332	.8341	.7057	.7332	.7952	.7278	.6683	.8100

APPENDIX G: NORMALITY TEST BY USING SPSS

Descriptive

			Statistic	Std. Error
Safety Control Aspect That Can be Executed by Using BIM Platform	Mean		4.0750	.07674
	95% Confidence Interval for Mean	Lower Bound	3.9223	
		Upper Bound	4.2277	
	5% Trimmed Mean		4.1296	
	Median		4.1667	
	Variance		.471	
	Std. Deviation		.68637	
	Minimum		1.00	
	Maximum		5.00	
	Range		4.00	
	Interquartile Range		.67	
	Skewness		-1.524	.269
	Kurtosis		4.631	.532
Potential Barrier to Implement BIM for Safety in Building Project	Mean		3.7354	.07932
	95% Confidence Interval for Mean	Lower Bound	3.5775	
		Upper Bound	3.8933	
	5% Trimmed Mean		3.7870	
	Median		3.8333	
	Variance		.503	
	Std. Deviation		.70944	
	Minimum		1.00	
	Maximum		5.00	
	Range		4.00	
	Interquartile Range		.83	
	Skewness		-1.412	.269
	Kurtosis		4.143	.532