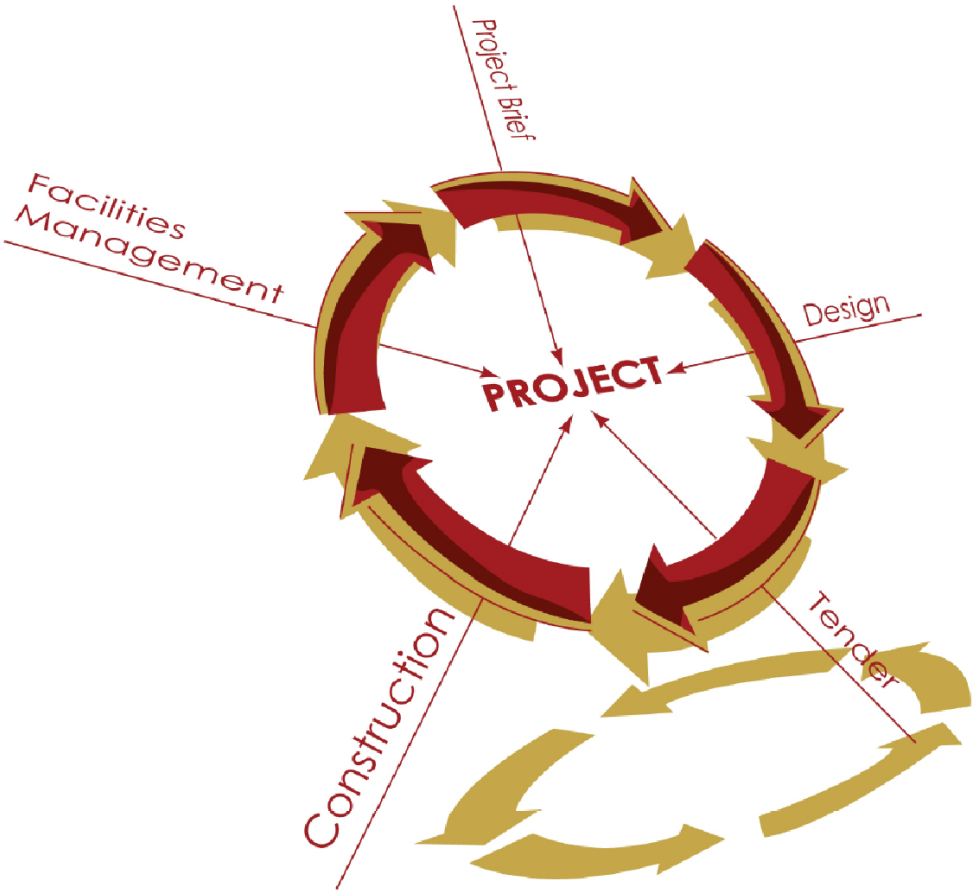
MCRJ SPECIAL ISSUE Volume 9 | No. 1 | 2020 eISSN 2590 - 4140

Malaysian Construction Research Journal

RISM INTERNATIONAL RESEARCH CONFERENCE 2020



CREAM CONSTRUCTION RESEARCH INSTITUTE OF MALAYSIA
CIDB MALAYSIA

MALAYSIAN CONSTRUCTION RESEARCH JOURNAL (MCRJ)

SPECIAL ISSUE Vol. 9 | No. 1 | 2020

RISM INTERNATIONAL RESEARCH CONFERENCE 2020

The Malaysian Construction Research Journal is indexed in
Scopus Elsevier

eISSN No.: 2590 – 4140

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Contents

Introduction

Welcome to this special issue in Malaysian Construction Research Journal (MCRJ) for the RISM International Research Conference 2020 (RISM-IRC2020). This conference has been successfully jointly organised by the Royal Institution of Surveyors Malaysia (RISM) and University of Malaya.

This special issues consists of 20 selected papers reviewed by conference scientific committee and international expert reviewers. The conference main theme is “Exceed the Exceeding” which comprises of the following sub-theme; Digital Construction, Quality Safety and Productivity, Environmental Sustainability, Practice and Professionalism, Engineering Technology, Construction Management, Facilities Management; and Teaching and Learning in Built Environment.

This publication may contribute in giving opportunity by driving the adoption of Industry Revolution 4.0 within the construction industry for greater knowledge growth, improve efficiency and stay in the line with the current demands and global construction trends while executing the institutional views and evocating for better practices in the industry. The teaching and learning also being highlighted to enhance the effectiveness teaching methodologies and thus producing a specific skills and competency in the construction industry.

Editorial Advisory Board

Secretariat Special Issue

Editorial

Welcome from the Editors

Welcome to the Malaysian Construction Research Journal (MCRJ) special issue. This journal provides a forum for dissemination of research activity broadly in the built environment. The RISM-IRC2020 is an outreach platform for surveying postgraduates and researchers with the aim to serve as an open dialogue avenue in the region on contemporary surveying and built environment issues. The conference presents the best of current systems research and practice, emphasizing innovation and quantified experience. It is aim to emerge this platform as the foremost world-wide gathering of academic researchers, Ph.D. and graduate students, top research think tanks and industry technology developers. It would also be the best opportunities for linkages, networking and talent-scout for research institutions and industry around the globe.

This is the second year for the RISM QS Division organising the conference. Previously, the conference was known as RISM Postgraduate Research Conference (jointly organised by RISM and SEGi University); it was successfully brought together researchers in one venue to not only present breakthrough research in future technologies but to also promote practicality and applications and an intra- and inter-field exchange of ideas.

We are very happy to have a team of excellent scientific committee and editorial board members from the national and international league covering in depth the related topics. The abstract of the twenty (20) articles are as follow;

Hanis Athirah Roslan et al., have presented the effect of seismic design consideration to the cost of steel reinforcement. Since this project focused on building in Malaysia, the seismic load derivation had been referred to Malaysia National Annex to Eurocode 8. A total of three stages had been conducted which are generate basic model, structural analysis & seismic design, and then the taking off process. A typical four storey reinforced concrete hostel building had been generated as basic model. In this study, there are two parameters had been considered as design variable which are four soil type namely as soil type B, C, D and E and four level of seismicity representing by the reference peak ground acceleration, αgR equal to 0.04g, 0.06g, 0.07g and 0.09g. Based on result, the cost of steel tonnage for the whole building increases around 1% to 22% depend on soil type and level of seismicity.

Rohanis Ab Ghani et al., have investigated and proposed a notion of establishing a set of value variables in order to contextualize the definition of construction project value. In verifying the identification of value variables from theories, the qualitative research method was adopted using interviews survey and thematic analysis, which has established the variables of construction project value. Hence to define value for a desire of obtaining a product, a process or a service, it is necessary to understand the definition of value that applies within the context. In the construction context, project value is considerably complex, as it constitutes of views on what is important to the client and their multi stakeholders. For an effective management of construction project value, its variables must be made explicit according to the intended context.

Mahmud.Abba Tahir et al., have examined the existing methodological approaches used in understanding the drivers of cost overrun in highway projects and assess whether an alternative approach such as system thinking which considers the complex and dynamic characteristics of cost overrun triggers can be utilized, using secondary data in form of systematic review of existing literature. The findings revealed the utilization of different empirical approaches and analysis methods in the studies of the subject matter. This paper contributes to and enhances the existing methodological approach used in assessing the drivers of cost overrun in highway construction projects. The potential impact of this study will provoke a debate towards using an approach that considers the complex and dynamic characteristics of the drivers, thus aiding in the assessment and better understanding of cost overrun triggers in highway construction projects.

Ahmad Akem Mohamad Said et al., have provided an overview of the basic concepts of the practices of megaproject risk management process by evaluating the management of risks in various infrastructure project organizations in Malaysia. Malaysia has advance on numerous major infrastructure projects which aims at enhancing infrastructure connectivity and boosting investment among countries. Meanwhile, megaprojects are a completely different class of project requires different interpretation and management of risks, extremely complex and costly infrastructure project, had massive implications for the country's fiscal standing and are not industry or sector specific but extend across an institutional field. The risks appear in megaprojects due to its complexity will be exacerbate especially to the Malaysian economy presuming that no proper action is taken.

Usman Musa et al., have showed that improved transparency, increase productivity, cost saving, improved integrity and reduced corruption in the procurement process are the benefits of e-procurement adoption. The findings also revealed that high cost of investment in IT infrastructure and lack of technical expertise and training are the two factors with the most significant effect on the adoption of e-procurement in Nigeria. Others are political, social, and cultural issues; lack of top management support and legal issues. The study is expected to uncover the actual benefits and challenges in order to facilitate the adoption of e-procurement in Nigeria. The methodology used is a conceptual review of literature on e-procurement using a wide range of materials including journal articles, conference papers as well as internet sources. The benefits of, and challenges to e-procurement adoption were divulged.

Badr M. AlMashjary et al., have gave a comprehending for professionals and team members of AECO projects about factors that influence iBIM implementation. The paper emphasized the iBIM implementation perspective and contributed to developing a hierarchical measurement model of iBIM implementation in AECO projects. New initiatives can be proposed by industry players in response to the new perspective of iBIM. Finally, the paper provides a development of iBIM implementation hierarchical models as a measurement latent variable. The aim of this paper is to determine the measurement constructs of Integrated Building Information Modelling (iBIM) implementation within Architectural, Engineering Construction and Operation (AECO) industry. The literature showed some factors influence iBIM implementation in AECO projects under three dimensions, namely Technology, People and process. A hierarchical model was used to comprise the three dimensions of iBIM implementation and their indicators.

Nur Syamimi Zulkefli et al., have explored sustainable indicators that are required to assess the performance of existing building. To ensure the indicators incorporate triple pillars of sustainability, the concept of Life Cycle Sustainability Assessment (LCSA) will be adopted. Comparative methodology was used where six (6) prominent green building rating tools were reviewed and compared with literature to gather preliminary list of indicators and sub-indicators. Among selected tools include BREEAM, LEED, Green Mark, GBI, GreenRE, and MyCREST. Experts validation were conducted to further validate the list of indicators gathered. Upon completion, a total of 87 assessment indicators were proposed to greening existing buildings. These sub-indicators were grouped according to the components of LCSA namely environmental (40 indicators), social (43 indicators), and economic (4 indicators).

Naqiyatul Amirah Mohd Said et al., have identified the current critical issues facing by the Malaysian oil and gas industry. The research applies the qualitative paradigm through pilot semi-structured interviews with the actual practitioners. From the pilot interview conducted, the issues highlighted differs from both client and contractor's thoughts. Contractors are concerned about project risk and project management issues while the client emphasized on the technical issues in the Engineering phase and procurement phase. This research offers a rich understanding in an unsaturated area of EPC contract from the Malaysian perspective and is expected to become the basis to support the future strategy in enhancing the effectiveness of EPC contracts in the Malaysian oil and gas industry.

Lee Kong Hooi, Gan Su Yee et al., have examined the problems with privity of contract in Malaysian construction industry due to conflicting laws and lack of clarity of the Contracts Act 1950 which inflict additional legislative in various systems. It divulged that there is lack of awareness and understanding among the construction industry key practitioners on the doctrine of privity in order to mitigate third parties claim. It also highlights the effect of contract of privity that will serve a platform for further research, honing and nuance comprehension of contractual management and governance in project. Despite the rapid evolution of the norm, experts and law-makers still debate what should be the scope of bodies and rights covered, the scope of permissible exceptions to the right and even the scope of rights holders remain. Sanctity of doctrine of privity means giving recognition to the contractual framework with appropriate legislation. The main issue in contention are the liabilities of parties when there is an agreement for direct payment by the employer to the sub-contractor.

Yoke-Lian Lew et al., have investigated the impacts on the safety performance of subcontractors towards the safety level of Malaysian construction industry. The objectives are to determine the factors that impact the safety performance of subcontractors and compare the perception of main contractors and subcontractors on factors enhancing safety performance of subcontractors in Malaysian construction industry. Quantitative research method was adopted by distributing questionnaire surveys to Grade 7 main contractors and subcontractors that in Klang Valley, Malaysia. It was discovered that the top 3 factors that impact safety performance of subcontractors in construction industry are failure to use personal protective equipment, lack of worker training and lack of management commitment whereas the least important factor is lack of job experience. Besides that, the top 3 factors to enhance safety performance of subcontractors identified are to provide personal protective equipment, health and safety plan preparation and provide safety and health training whereas the least important factor is improving working environment.

Yap Pei Xin and Nur Mardhiyah Aziz, have identified the suitable teaching strategies for incorporating BIM into the curricula. Case study research method was adopted, involving 5 Malaysian higher education institutions that offer a degree in Quantity Surveying programme. Findings revealed that lecture, workshop, collaboration, open learning platform and project-based learning can be used incorporating BIM into the curricula. It is anticipated that findings from this research will serve as a guide for other courses mainly in the Architecture, Engineering and Construction field that seeks to integrate BIM into their curricula in transforming the Malaysia construction industry into a higher level. In addressing the current demand of the industry, it is crucial for the higher education institution to integrated BIM modules into their Quantity Surveying degree programme. However, there is a significant challenge for the higher education institution in educating future professionals due to the lack of information on the right strategies to embed BIM in their curricula.

Myzatul Aishah Kamarazaly et al., have analyzed bachelor's degree level of quantity surveying students' learning styles, as well as the factors affecting students' adoption of blended learning in relation to the types of learning styles. The students' perspective towards current learning approach was also examined. A total of 172 survey questionnaires were collected in this study. The identification of students' learning styles was analyzed through VARK model analysis whereas the factors affecting students' adoption of blended learning were identified according to the mean value. The results revealed that majority of the students are kinesthetic learners where they are inclined towards hands on activities and interactive classes. It was also found that both learner's and lecturer's dimensions are the significant factors that affect the adoption of ICT usage in the learning process. Additionally, the results revealed that students favor more face-to-face sessions in a blended learning environment rather than online learning. Hence, educators should strive to achieve a balance between face-to-face and online learning to accommodate students with different needs.

Suriana Yussof et al., have identified the most frequent construction dispute occurred in relation to the Malaysian standard form of contract and to investigate the most effective dispute resolution expressed in the Malaysian standard form of contract preferred by the industry players. From an observation of 85 court cases (2015 to 2016), it can be concluded that 41.18% (35 cases) of payment disputes and 36.47% (31 cases) of contract disputes were marked as the most frequent disputes occurred in the construction industry. The results were supported by a semi-structured interview of 18 experts, where payment of work done (33%) and extension of time (60%) were marked as the most frequent construction disputes occurred in the construction industry. Based on the findings of the most preferred dispute resolution, 56% of the respondents opted for arbitration because it was clearly written in the Malaysian standard form of contract. Adjudication (33%) also referred to as the most effective dispute resolution in-term of cost and time as CIPAA act allows claimant to claim at any time of the dispute occurred compared to arbitration.

Maisarah Makmor et al., have identified the requirements and legislation on public participation practice for EIA, to analyze the barriers on public participation practice for EIA, to analyze the recommendations to improve public participation practice for EIA and to propose a framework on public participation practice for EIA. A mixture of quantitative and qualitative methods was adapted for this research utilizing questionnaire surveys and semi-structured interviews as the research instruments. Data were collected from three groups of respondents consisted of EIA consultants, environmental NGOs and DOE officers. The data

collected were contextualized and validated to establish the framework on public participation practice for Environmental Impact Assessment (EIA) in Malaysia. The inadequacies in the requirement and legislations on public participation for EIA have resulted to barriers that hinder quality public participation. Thus, recommendations to further improve the application of public participation for EIA in Malaysia are required.

Bee Ling Chong et al., have proposed to rank, examined and developed structural equation model of latent strategies for QS consultancy firms to achieve profitability. The data required will be collected using a structured questionnaire administered through personal interviews with over two hundred company directors each from one of the QS consultancy firms located in Klang Valley, Malaysia. Mean ranking, exploratory and confirmatory factor analyses, and structural equation modelling will be used in the data analyses stage. The findings will comprise the ranking of strategies, identification of latent strategies, and development of a structural equation model of latent strategies for QS consultancy firms to achieve profitability. Ultimately, this research could inform practitioners of the best strategies that would improve profitability. Foreign QS consultancy firms that intend to venture into the Klang Valley Malaysian construction industry may also use the findings to assist them to expand and develop their businesses in this sector.

Adli Abbas Basaif et al., have determined the level of awareness of the Malaysian construction practitioners of using AI for risk analysis. A survey among 184 construction practitioners found that there are only a number of practitioners who know about AI and its usefulness for risk analysis in the Malaysian construction industry; most of the respondents have a lack of knowledge about AI, majority of them do not practice or use AI in their risk analysis tasks; a large portion do not attend any training on AI or taken some courses at universities; and finally most of the companies in the construction industry in Malaysia do not provide or provide little formal training on AI including follow-up programs. It can be concluded that applying AI for risk analysis still has a long way to go in order to be accepted and recognized in the Malaysian construction industry.

Loo Seong King et al., have investigated the current energy use in Malaysian office building and the importance of energy efficiency to be promoted among building sector. This study aims to investigate how energy-efficient features related to building envelope, lighting system, HVAC system and office equipment can be incorporated at the same time creating a conducive working environment without compromising occupants' satisfaction and well-being. Semi-structured interview was conducted to obtain an insightful picture of the industry regarding the adoption of energy efficiency in the real-world situations. This study aims to investigate how energy-efficient features related to building envelope, lighting system, HVAC system and office equipment can be incorporated at the same time creating a conducive working environment without compromising occupants' satisfaction and well-being. Semi-structured interview was conducted to obtain an insightful picture of the industry regarding the adoption of energy efficiency in the real-world situations.

Lee Kong Hooi et al., have examined the relationship between the effects of ambiguity provisions on extension of time (EOT) claim and the moderating effects of contractual complexity. To achieve the aims, case law is examined to illuminate the judicial approach and highlight the ambiguity of EOT provisions in the existing standard forms of contract. Analysis of EOT provisions of PAM 2006 and 2018 is then made to look at certain specific ambiguous

provisions so as to serve a catalyst for further investigation, honing and refinement. The findings create awareness and offer new insight into the effect ambiguous provisions have upon the contractor contractual rights to extension of time and nuance understanding of contractual management and governance in project. Therefore, a clear and more complete general condition documentation should end up with win-win situation for various parties involved.

Lay Pei Sin et al., have reviewed published literature on methods and techniques of big data analytics and its possible applications in cost estimating, cost management, procurement management, site operative management, cost information etc. in the construction industry. Big Data is often described with five Vs characteristics: velocity, volume, variety, veracity, and value. Big Data analytics tools and techniques are arising in demand. The interest through Big Data increases day by day due to its opportunities in transforming most of the industries and business into an intelligent way of operating. Construction projects involve high volume of data exchange between different stakeholders, which are generated throughout the project's life cycle. Such a huge and complex data set can be collected by smartphone, jobsite sensors and other mobile solutions; however, text data, sound data, image data, video data and sensor data captured are seldom being processed and analysed adequately.

Zi Qian Li et al., have presented a conceptual framework for a Building Knowledge Information Modelling (BKIM) system, whereby the mechanisms for managing construction knowledge will be closely integrated with a Cloud-based BIM system to facilitate the management of higher dimension knowledge. The framework presented focuses only on the management of knowledge related to contractual claims at this stage. It is envisaged that this could improve the current practice with regard to the management of higher dimension knowledge, and help move "Level 1 Lonely BIM" to "Level 2 BIM" or even the higher maturity of BIM, namely "integrated BIM, iBIM". Sharing of information and knowledge effectively and timely among the team members in the construction industry is critical to improving the productivity of the industry. Hence, a new approach to address this problem is needed.

COST EVALUATION OF STEEL TONNAGE FOR REINFORCED CONCRETE HOSTEL BUILDING WITH SEISMIC DESIGN

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Abstract
Peninsular Malaysia was exposed to the Sumatra Andaman earthquake which lead certain areas to experience tremors and cause damage to buildings and injury to people. Reinforced concrete hostel buildings can act as a temporary shelter for community to stay until the disaster dwindle. Thus, reinforced concrete hostel buildings must be able to resist the seismic load whenever earthquake happen. However, in Malaysia seismic precautions are not considered into account for design and construction since Malaysia is not located in active seismic fault zone. Until on 5th June 2015 when Ranau, Sabah was surprised by an unexpected tremor. After the incident, people became aware and starts to reconsider to implement the seismic design on new buildings in Malaysia to ensure public safety. This implementation will affect the cost of construction, especially for materials. Therefore, this paper presents the effect of seismic design consideration to the cost of steel reinforcement. Since this project focused on building in Malaysia, the seismic load derivation had been referred to Malaysia National Annex to Eurocode 8. A total of three stages had been conducted which are generate basic model, structural analysis & seismic design, and then the taking off process. A typical four storey reinforced concrete hostel building had been generated as basic model. In this study, there are two parameters had been considered as design variable which are four soil type namely as soil type B, C, D and E and four level of seismicity representing by the reference peak ground acceleration, α_{gR} equal to 0.04g, 0.06g, 0.07g and 0.09g. Based on result, the cost of steel tonnage for the whole building increases around 1% to 22% depend on soil type and level of seismicity.

Keywords: *Cost engineering; Eurocode 8; seismic design; steel tonnage; soil type.*

INTRODUCTION

Malaysia is one of the countries that are safe from earthquake as it is located at the equator of the globe which are far away from the active seismic fault zone. Therefore, in Malaysia seismic precautions are not considered into account for design and construction, except for several special buildings. However, as the previous recorded earthquakes that occurred in the neighbouring countries which are high seismicity regions such as Indonesia and Philippine, Malaysia is occasionally subjected to experiences minor to moderate earthquakes activities especially in the west coast of Peninsular Malaysia and Sabah. Even though Sabah not located in the Pacific Ring of Fire, few areas included of Tawau, Kunak, Kundasang, Ranau, Pitas, and Lahad Datu have high risk to be hit by earthquakes activities. Peninsular Malaysia also experienced local earthquakes in Bukit Tinggi, Pahang (MOSTI, 2014). According to Latiff and Khalil (2019), the main cause of Bukit Tinggi earthquakes from 2007 to 2009 because the reactivation of the Paleo fault line.

Five years ago, on 5th June 2015, an earthquake had struck Ranau, Sabah with magnitude of M_w6.0 which lasted for 30 seconds. According to Harith et al. (2018), an earthquake with magnitude M_w6.0 occurred in Ranau which followed by more than 100 aftershocks affected 61 buildings such as schools, hospital, and mosque. As reported by Khoiry et al. (2018) from his previous survey, the 2015 Ranau earthquake had caused damages on wall, floor, column, and roof. In their report, the highest damage recorded on brickwall with X-mark crack due to shear failure.

According to Hamid et al. (2018), seismic design practice should be implemented especially in Sabah which is categorized as moderate seismic region in order to reduce the damage to buildings. However, seismic design considerations have their own implications as it directly affecting the cost of materials which the construction industry must adopt (Adiyanto and Majid, 2014). A number of studies had been conducted dealing with seismic design which tends to increase in total usage of construction materials that will directly increase the cost of structure (Faisal et al., 2019; Ramli et al., 2017; Adiyanto et al., 2019; Roslan et al., 2019; Adiyanto et al., 2019; Azman et al., 2019; Mustapa et al., 2019). However, according to Ramli et al. (2017) the cost for repair and maintenance in the future will be reduced by implementation of seismic design. The increment of total steel used as reinforcement for Reinforced Concrete (RC) building is strongly influenced by the level of reference peak ground acceleration, α_{gR} (Adiyanto and Majid, 2014; Adiyanto et al., 2019; Roslan et al., 2019; Adiyanto et al., 2020). Furthermore, the soil type also influencing the seismic performance of building which also makes changes the total steel used for building (Roslan et al., 2019; Adiyanto et al., 2020; Azman et al., 2019; Mustapa et al., 2019).

This paper presents the effect of seismic design consideration on the cost increment of steel reinforcement. For that purpose, a typical four storey RC hostel building had been generated as basic model for analysis, design, and taking off processes. Different soil type and level of seismicity had been considered as variable in this study. The result is presented in term of normalised total steel tonnage used as reinforcement.

MODELS AND METHODS

A total of three stages had been conducted in order to achieve the objective. The three stages are generate basic model, structural analysis & seismic design, and then the taking off process. In stage 1 by using computer software a typical four storey RC hostel building has been generated as basic model as presented by Figure 1. The total height, H of the RC hostel building is around 14.6m from rigid foundation. The fundamental period of vibration, T_1 is estimated to be equal to 0.5 sec. There are several sizes of beam has been considered which is equal to 200 mm x 500 mm, 200 mm x 450 mm, 200 mm x 300 mm, 200 mm x 400 mm and 250 mm x 600 mm depend on the position and span. The columns has been modelled with two sizes which is equal to 400 mm x 400 mm and 375 mm x 375 mm for bottom two stories and top two upper stories, respectively.

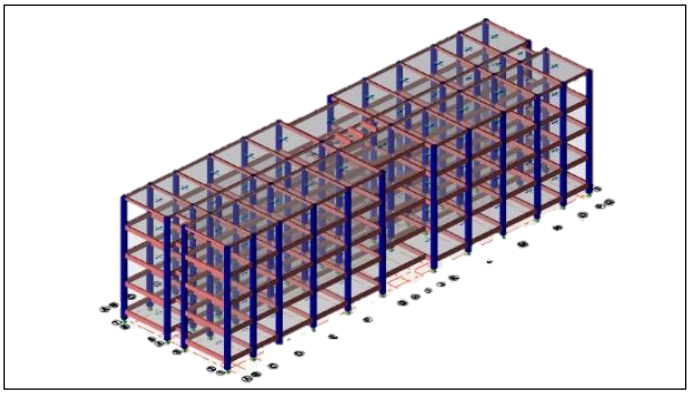

Figure 1. Four storey RC hostel building

In stage 2, the structural analysis and seismic design for all models had been conducted. The building had been designed according to Eurocode 8 (2004) which is with seismic consideration. Thus, the structure classified into important class III. Due to its importance after disaster, the recommended value of importance factor, γI is 1.2 to give better protection of life for such buildings (Fardis et al. 2015). As mentioned in previous subsection, a typical four storey RC hostel building has been analysed and designed repeatedly based on different soil type and level of seismicity. As proposed by Eurocode 8 (2004) a total of four soil type namely soil type B, C, D and E had been considered into the study to represent the variable. Besides, four level of seismicity has been taken into account where the value of reference peak ground acceleration, αgR = 0.04g, 0.06g, 0.07g and 0.09g. According to Malaysian seismic hazard map proposed in National Annex (2017) the values of such reference peak ground acceleration, αgR are representing the seismicity in Alor Setar, Shah Alam, Kuala Lumpur and Bukit Tinggi, respectively. While for the fixed parameter in this analysis, all models have been designed based on concrete grade C30/37 and yield strength of steel, fy = 500 N/mm2.

Based on Eurocode 8 (2004), the building standard allows the design to be conducted for ductility classes low (DCL) or ductility class medium (DCM) based on the product of αg.S as shown in Table 1. For RC moment resisting frame, the behaviour factor, q varies proportionally to 1.5 and 3.9, respectively for DCL and DCM. As proposed by National Annex (2017) every soil type have different soil factor, S. As shown in Table 2, 17 models has been analysed and designed for this study. In this study, regions having the reference peak ground acceleration, αgR = 0.04g & 0.06g had been considered for DCL. The DCM was applied for regions with reference peak ground acceleration, αgR = 0.07g & 0.09g. For control mode one model without seismic consideration has been taken into consideration. By referring to Eurocode 8 (2004) the lateral force method has been applied for the structural analysis on models with seismic design. Previous work by Adiyanto et al. (2019) also conducted this method for his study.

Table 1. Classification of Ductility class on the Seismic zone

Seismic Zone	$\alpha_g.S$	Ductility
Very Low Seismicity	$\alpha_g.S \leq 0.05$	no need seismic design
Low Seismicity	$0.05 < \alpha_g.S \leq 0.10$	DCL
Medium Seismicity	$\alpha_g.S > 0.10$	DCM or DCH

Table 2. Design parameters and RC Hostel models

No	Model Code	Reference peak ground acceleration, α_{gR} (g)	Soil Type	Ductility
1	NS	-	-	-
2	B – 0.04L	0.04	B	DCL
3	B – 0.06L	0.06	B	DCL
4	B – 0.07M	0.07	B	DCM
5	B – 0.09M	0.09	B	DCM
6	C – 0.04L	0.04	C	DCL
7	C – 0.06L	0.06	C	DCL
8	C – 0.07M	0.07	C	DCM
9	C – 0.09M	0.09	C	DCM
10	D – 0.04L	0.04	D	DCL
11	D – 0.06L	0.06	D	DCL
12	D – 0.07M	0.07	D	DCM
13	D – 0.09M	0.09	D	DCM
14	E – 0.04L	0.04	E	DCL
15	E – 0.06L	0.06	E	DCL
16	E – 0.07M	0.07	E	DCM
17	E – 0.09M	0.09	E	DCM

The stage 3 is the taking off process. During this process, the total volume of concrete and total steel reinforcement in weight were measured for all beams and columns. The comparison between nonseismic model and seismic models had been made based on weight of steel reinforcement per 1m3 of concrete.

RESULTS AND DISCUSSION

Earthquake Load, E on Models

The lateral force method (Eurocode 8, 2004) has been conducted on models in order to derives the magnitude of total earthquake load, E imposed on all models with seismic design. The latter had been represented by base shear force, Fb then being distributed on every storey as mentioned by Elghazouli (2009). Hence, the magnitude of base shear force, Fb is directly proportional to the value of spectral acceleration at the fundamental period of vibration, Sd(T1), effective mass of the building, m and correction factor, λ. By referring to Eurocode 8 (2004) the value of correction factor, λ shall be 0.85 for buildings with more than two story and T1 < 2Tc. In this study, the value of spectral acceleration at the fundamental period of vibration, Sd(T1) was obtained from a series of design response spectrums which had been developed for every soil type and level of seismicity. All models have similar effective mass of the building, m and correction factor, λ.

Table 3 shows that the magnitude of base shear force, Fb imposed as lateral loads are differ for each models. The magnitude of base shear force, Fb increases as the magnitude of spectral acceleration at the fundamental period of vibration, Sd(T1), increases. It also shows that once the level of seismicity is similar, the magnitude of base shear force, Fb will be differed for different soil type where softer soil profile tends to have higher magnitude of base shear force, Fb. This result is caused by different soil factor, S for every soil type as proposed by National Annex (2017). As an example, for seismicity with reference peak ground acceleration, αgR = 0.06g the magnitude of base shear force, Fb are equal to 1976.5 kN, 2705.9 kN, 3176.5 kN and 3294.1 kN for models considering soil type B, C, D and E,

respectively. By referring to Table 3, model E-0.06L which considering reference peak ground acceleration, αgR = 0.06g and soil type E is the highest magnitude of lateral load result in highest magnitude of bending moment, M. This means the model had been imposed to the highest magnitude of lateral force on every storey.

Table 3. Base shear force, F_b acting on all models

No	Model Code	Spectral acceleration at the fundamental period of vibration, $S_d(T_1)$ (m/s^2)	Base shear force, F_b (kN)
1	NS	Non applicable	Non applicable
2	B – 0.04L	0.659	1317.7
3	B – 0.06L	0.989	1976.5
4	B – 0.07M	0.444	886.9
5	B – 0.09M	0.570	1140.3
6	C – 0.04L	0.902	1803.9
7	C – 0.06L	1.353	2705.9
8	C – 0.07M	0.607	1214.2
9	C – 0.09M	0.781	1561.1
10	D – 0.04L	1.059	2117.7
11	D – 0.06L	1.589	3176.5
12	D – 0.07M	0.713	1425.3
13	D – 0.09M	0.917	1832.6
14	E – 0.04L	1.098	2196.1
15	E – 0.06L	1.648	3294.1
16	E – 0.07M	0.739	1478.1
17	E – 0.09M	0.950	1900.5

Total Volume of Concrete

In this study, the size of RC beams, columns and slabs are similar for all models regardless the design consideration. Therefore, the volume of concrete is similar for all models which is equal to 526.52 m3.

Total Steel Tonnage

Total steel tonnage is the summation of steel bar used as flexural and shear reinforcement in all RC beams and columns. According to Adiyanto et al. (2019) the number and size of steel reinforcement strongly influenced by the magnitude of bending moment, M shear force, V and axial load, P. In Figure 2 shows the steel tonnage in 1m3 concrete of beams for all models which considering seismic design is normalized to the nonseismic model. Thus, it shows the comparison of the steel tonnage of beams for seismic models and the current practice which neglecting seismic design. Figure 2 shows that as the seismic design is applied, the steel tonnage used as reinforcement in beam increases. The increment of steel tonnage of beams increased around 12% to 111% higher compared to the nonseismic model. The soil type influencing the increment of steel tonnage. For a similar level of seismicity, models considering soil type E have the highest steel tonnage. As discussed in previous subsection, model E – 0.06L has the highest magnitude of base shear force, Fb result in highest lateral load acting on every storey. Based on structural analysis, the highest lateral force contributed to the highest magnitude of bending moment, M as well as shear force, V which result in highest amount of steel tonnage to be provided as reinforcement.

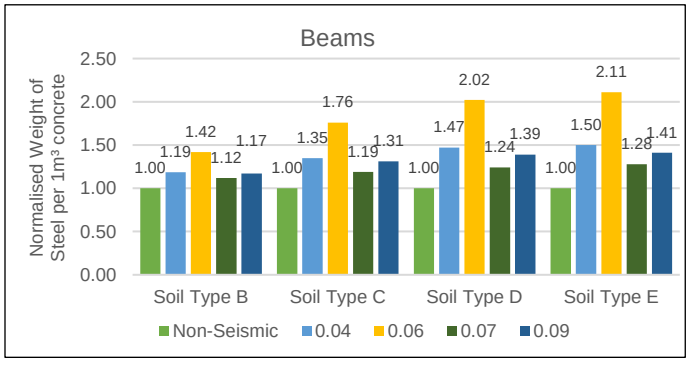

Figure 2. Total steel tonnage for all beams

As mentioned by Noor et al. (2019) the torsional effect tends to caused heavier damage on columns. The seismic design must approach the concept of Strong Column – Weak Beam which means that the column shall be stronger than beam Eurocode 8 (2004). Thus, column really plays important role for stability of structural system. Figure 3 shows the steel tonnage in 1m3 concrete of columns for all models. Figure 3 shows similar pattern to the increment steel tonnage in beams but with higher percentage. The increment of steel tonnage of columns increased around 17% to 157% higher compared to the nonseismic model. This result is strongly relates to the requirement of Strong Column – Weak Beam concept as mentioned before. Through this approach, the strength of column shall be at least 1.3 times the strength of its beam.

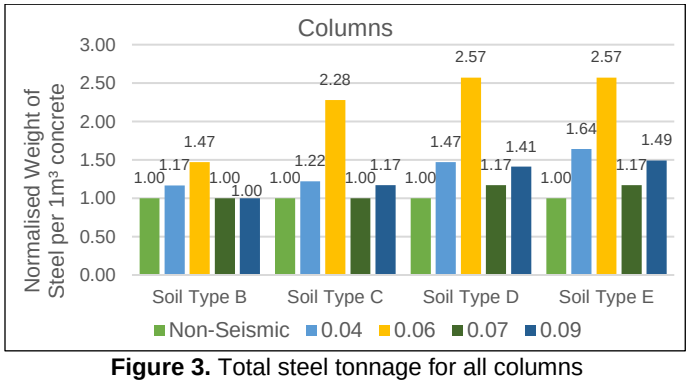

Figure 3. Total steel tonnage for all columns

Figure 4 shows the normalized total weight of steel reinforcement for whole structure for all models. Result for this group also demonstrates that total steel tonnage used as reinforcement are differ for every models. In Figure 4, the increment of steel reinforcement is around 7% to 116% higher compared to the nonseismic model. The increment of steel reinforcement occurred on both beams and columns as discussed by previous studies Adiyanto and Majid (2014); Faisal et al. (2019); Adiyanto et al. (2019); Roslan et al. (2019); Adiyanto et al. (2020); Azman et al. (2019); Mustapa et al. (2019). In Figure 4, the highest total steel tonnage corresponds to model E-0.06L. The result is as expected because the model has the highest magnitude of base shear force, Fb. The latter result in highest magnitude of bending moment, M. Based on design calculation for RC beam and column by Elghazouli (2009), the increasing of bending moment, M lead to increasing of total area of steel required, Asreq as well as the total area of steel provided, Asprov. The latter leads to increase the total weight of steel reinforcement.

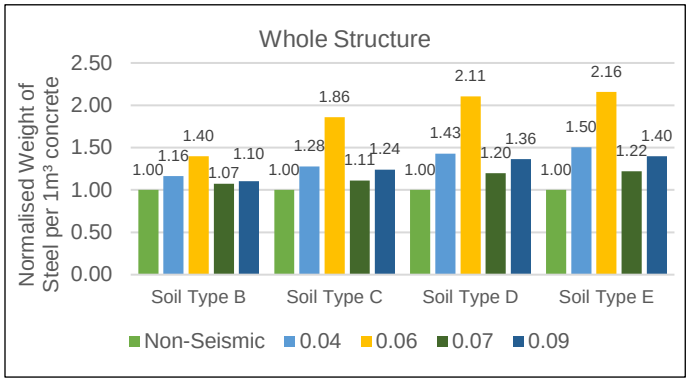

Figure 4. Total steel tonnage for whole structure for all models

Total Cost Estimation for Steel Reinforcement

In this study, the comparison also been made in form of total cost or price of materials. According to Standard Price Malaysia (2017), the standard price for concrete grade C30/37 differ depend on usage. In this study, the total cost of concrete which is summation of beams, columns, and slabs was estimated to be equal to RM194,200.079 for all models with concrete grade C30/37. Thus, the cost of concrete for whole structure is estimated to be similar for all models. While for the standard price of steel reinforcement is RM3.50 per kg.

The normalized total cost of steel reinforcement for beams and columns of all models is shown in Figure 5. Model that consider seismic design caused increment around 1% to 22% to total cost of concrete and steel reinforcement compared to its nonseismic model. Generally, the cost for steel reinforcement increases depend on the soil type and level of seismicity. In this study, models E-0.06L required higher cost of steel reinforcement compared to its other models. Both parameters strongly influencing the magnitude of base shear force, Fb. As discussed in previous subsection, the increase of base shear force, Fb tends to increase the magnitude of bending moment, M which also directly increases the area of steel required, Asreq. For solution, engineers have to use combination of increase number and size of steel bar to increase the area of steel provided, Asprov. This means higher steel tonnage has to be used as reinforcement. The result from this study indicates that soil type and the level of seismicity strongly influencing the cost of steel reinforcement. Therefore, by choosing a suitable selection on site for development can reduce the cost of steel reinforcement.

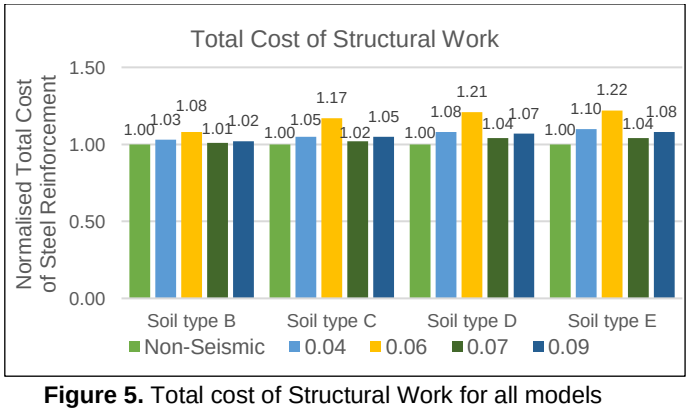

Figure 5. Total cost of Structural Work for all models

CONCLUSION

This study presents the influence of soil type and level of seismicity on amount of steel tonnage. A four storey of RC hostel building with earthquake load consideration is discussed in this paper. A total of four soil conditions namely as soil type B, C, D, and E had been considered to represent the site conditions in Malaysia. Therefore, four level of seismicity has been taken into account where the value of reference peak ground acceleration, αgR = 0.04g, 0.06g, 0.07g and 0.09g. A few conclusions are drawn as follow:

- The increment of steel tonnage was strongly influenced by soil type. Higher amount of steel reinforcement was required for models considering soil with softer profile. Thus, it is important to consider soil type when design the building.

- Total of steel tonnage also was influenced by level of seismicity. Models with value of reference peak ground acceleration, αgR = 0.06g require higher amount of steel reinforcement compared to other models. This model has the highest magnitude of base shear force, Fb result in highest magnitude of bending moment, M as well as shear force, V which result in highest amount of steel to be provided as reinforcement.

- By considering seismic design, total cost of steel reinforcement for beams and columns tend to increase around 1% to 22% depend on soil type and level of seismicity.

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ESTABLISHING VALUE VARIABLES FOR DEFINING CONSTRUCTION PROJECT VALUE

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Abstract
Across sectors, the usage of the word 'value' is too loose and broad. This is due to the value terminology is universal and applicable in various contexts, which often brings different meanings. The value terminology is distinctly applied for relative worth in across fields e.g. economy, commerce, mathematics, sociology, customs, ethics, and even arts and music. Defining value requires cognitive approach; that is the manner, in which an individual sees, perceives and thinks about something or some information takes action and behaves. But the complexity and subjectivity of value makes it more difficult to define explicitly. Moreover, defining value involves complex interpretations that need to be contextualized to an intended perspective. Hence to define value for a desire of obtaining a product, a process or a service, it is necessary to understand the definition of value that applies within the context. In the construction context, project value is considerably complex, as it constitutes of views on what is important to the client and their multi stakeholders. For an effective management of construction project value, its variables must be made explicit according to the intended context. Thus, this study investigates and proposes a notion of establishing a set of value variables in order to contextualize the definition of construction project value. In verifying the identification of value variables from theories, the qualitative research method was adopted using interviews survey and thematic analysis, which has established the variables of construction project value.

Keywords: *Construction project value; value concepts; value variables; context.*

INTRODUCTION

As defined in Dictionary.com (2019), the word 'value' is commonly defined as 'worth', which relates with either the monetary worth, material worth, estimated or assigned worth, equivalent worth or the worth of something for which it can be exchanged. However the value meaning and terminology is universal and distinctly applied for relative worth in multi contexts i.e. the economy, commerce, mathematics, sociology, customs, ethics, art etc. An early principle by Allport, Vernon and Lindsey (1960) mention that value is complex as it is classified in six orientations, i.e. 'Theoretical Values', 'Economic Values', 'Aesthetic Values', 'Social Values', 'Political Values' and 'Religious Values'. Moreover, other philosophies by Laird (1969) and Hall (1952) acknowledge that defining value is abstract and subjective. However, value definition can be referred to a set of beliefs belongs to the 'owner' of the value, whom have influences to make judgements and decisions.

Dealing with the universality, complexity and subjectivity of value, this study aims to explicitly establish the variables of value for contextualizing definition of construction project value. The established value variables from the construction project context are adoptable for defining value from a specific perspective e.g. project briefing or project design etc.

The aim of this paper is achieved by accomplishing two study objectives which are:

i. To identify value variables from relevant theories; and
ii. To establish a set of value variables based on value experts' views using qualitative method.

This paper discusses on value in construction, value concepts and variables, applied research method and analysis, establishment of value variables of construction project value, conclusion and recommendation.

VALUE IN CONSTRUCTION

According to Kerzner and Saladis (2009), value in construction is complex as it is made of a set of beliefs relative to what is significant to the client and their stakeholders associated with the project. For a construction project value to be managed throughout its life cycle, the value objectives must be in line with the client's strategic and project objectives while reconciling and balancing with their multi stakeholders' different expectations and priorities in delivering the project.

In built environment, as mentioned by Saxon (2005) in the "Construction Excellence" document – "Be Valuable. A Guide to Creating Value in the Built Environment", subjectivity of value is the key reason for understanding and grasping the value concept. Again, it implies that the state of value refers to who is judging, which is supposed to understand and able to balance the diverse values of multi stakeholders. In addition, as cited in MoV (2010) by the UK Government, it is highlighted that value is known as a subjective judgement on project goals that makes it essential to manage value deliberately. Dealing with value subjectivity, it is necessary to define and reconcile the multi views of value.

Due to the complexity and subjectivity of construction project value, it is essential to understand what variables implicate value within a specific context. Establishing the construction project value variables leads to defining specific circumstances from the intended perspective being managed, e.g. from project briefing or project design perspective. The explicit variables provide clear value definition, and can be contextualized to specific criteria or conditions for a desire of managing and achieving optimum value delivery from the intended perspective. Thus the construction project value can be well defined and effectively managed.

VALUE CONCEPTS IN CONSTRUCTION

Being thoughtful of various value concepts is fundamental towards understanding the potential of value enhancement. There are various generic value concepts to be adapted and adopted in the construction project environment. In their origins, most of the concepts are from broad viewpoints of value principle, though the concepts are frequently denoted in the discussions on management of value in construction projects.

In the following discussion on value concepts, the meaning of 'variable' terminology in Dictionary.com (2019) defines as something that may or does vary or change. The value concepts have fostered vital thinking towards achieving the expected value and obtain potential enhancement through managing the value variables.

The following value concepts are discussed based on respective equations or diagrams to define the value expressions and each equation comprises of different variables of value that need to be managed:

i. Dell' Isola value concept
ii. Carlos Farlon value concept
iii. Value Concept in the SAVE International Value Methodology Standard
iv. Value Concept in British European Standards (BS EN 12973:2000)
v. Value Concept in the Management of Value (MoV)
vi. The concept of construction project value criteria

Dell' Isola Value Concept

$$\text{Value} = \frac{\text{Function (F)} + \text{Quality (Q)}}{\text{Cost (C)}}$$

Where;

Function	=	**The specific work that a design or item must perform**
Quality	=	**The owner's or user's needs, desires and expectations**
Cost	=	**The life cycle cost of the product or project**

Figure 1. Dell' Isola value concept

This notable concept by value scholar Dell' Isola (1982) is universal yet very well adopted in the construction environment. The concept is represented by an equation of value variables between 'function', 'quality' and 'cost'.

Carlos Farlon Value Concept

$$\text{Value} = \frac{\text{Function}}{\text{Cost}}$$

$$\text{Or} = \frac{\text{Benefits}}{\text{Price}}$$

Figure 2. Carlos Farlon value concept

A prominent value scholar Carlos Fallon (1980) defines value in two different perspectives i.e. from the value producer comprises of 'function' over 'cost' variables; while from value buyer comprises of 'benefits' over 'price'.

Value Concept in the SAVE International Value Methodology Standard

$$\text{Value} = \frac{\text{Function}}{\text{Resources}}$$

Or,
As a fair return or equivalent in goods, services or money for something exchanged.

Figure 3. Value concept in the SAVE International Value Methodology Standard

In the International Value Methodology Standard and Body of Knowledge by the Society of American Value Engineers (SAVE) International (2007), the value concept is represented by the variables of 'function' over 'resources'.

Value Concept in British European Standards (BS EN 12973:2000)

$$\text{Value} = \frac{\text{Satisfaction of Needs}}{\text{Use of Resources}}$$

Figure 4. Value concept in British European Standards (BS EN 12973:2000)

This value concept of British European Standards for Value Management as in British European Standards BS EN 12973 (2000) signifies the relationship between the 'satisfaction of needs' and the 'resources' that need to be balanced between the two variables.

Value Concept in the Management of Value (MoV)

$$\text{Value} = \frac{\text{Function}}{\text{Cost}}$$

$$\text{Or} = \frac{\text{Benefits}}{\text{Price}}$$

Figure 5. Value concept in the Management of Value (MoV)

The Management of Value Guide as cited in MoV (2010) by the Office of Government Commerce (OGC) of the United Kingdom expresses the value concept by the above shown relationships as to be balanced among them. The key variables are 'satisfaction of needs' or 'benefits' (monetary and non-monetary), as against to 'use of resources' or 'expenditure' (money, people, time, energy, materials).

The Concept of Construction Project Value Criteria

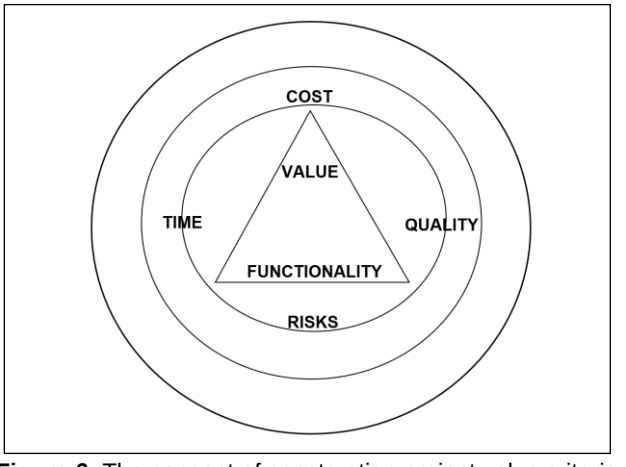

Figure 6. The concept of construction project value criteria

As suggested by Male (2006) and taught in the Master Science Engineering lecture (MSE ICME, 2009), this value concept is contextualized to the construction project environment and in line with asset and project management; and procurement strategy practice. The value variables in the concept represent the typical project objectives set for construction projects i.e. quality, time and cost, and with additional value criteria being incorporated i.e. functionality and risks.

IMPLICATION OF VALUE VARIABLES

The value variables are impacting value dynamic of project. The relationships and interactions among the variables are aimed to balance in achieving best value of the project. Saxon (2005) suggests that positive balance creates value, while the opposite destroys it. Balancing the variables involves the act of optimizing or 'trading off' among them, so that the project value can be managed.

Based on several exemplary value concepts, the following equivalences in Figure 7 indicate the implications of variables on potential value approaches; or how the magnitude of changes (positive or negative) to the variables implicates the dynamics of project value. These implications prove that the variables are flexible to changes and controllable in the manner of achieving the intended value goals.

Variables Implications in Dell' Isola Value Concept

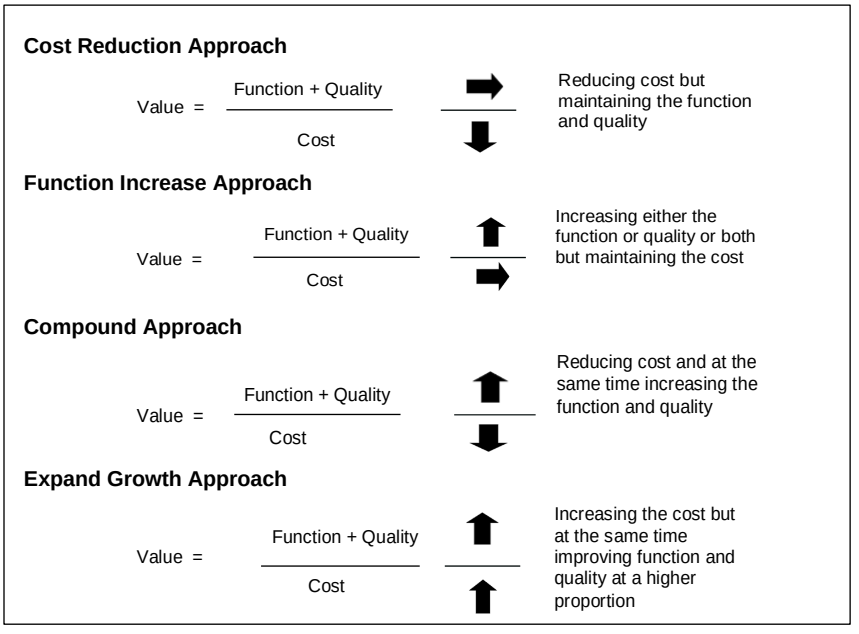

Figure 7. Implications of value variables of value concept by Dell' Isola.

Variables Implications in BS EN (2000) Value Concept

The value concept by BS EN 12973 (2000) uses different value variables in achieving different value optimizations i.e. 'Satisfaction of Needs' and 'Use of Resources'. The following five (5) equations in Figure 8 describe the variants of value optimizations in project, which implicated by the magnitudes of value variables of the value concept.

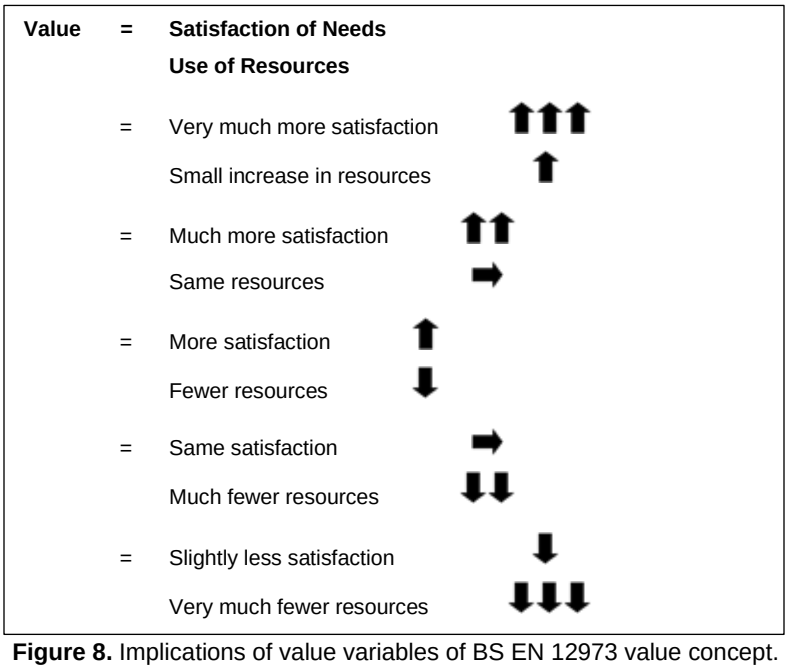

Figure 8. Implications of value variables of BS EN 12973 value concept.

Variables Implications in MoV (2010) Value Concept

The MoV (2010) emphasizes the implications of its value variables towards maximizing value, taking account of and reconciling the views of all stakeholders, and balancing the ratio of 'benefits' to 'expenditure'. Three (3) balancing situations are indicated below involving the value variables:

i. Balancing the needs and benefits (monetary and non-monetary by reconciling different stakeholders on their differing expectations.
ii. Balancing the use of resources or expenditure, taking into account the organization's priorities and availability, including articulating trade-offs among the resources (money, people, time, energy, materials etc.)
iii. Balancing the overall satisfaction of needs (benefits) with the use of resources (expenditure), which to achieve the highest value ratio.

ESTABLISHING VARIABLES OF CONSTRUCTION PROJECT VALUE

Variables of Value Identified from Theories

As resulted from critical reviews and discussions on multi value concepts, value variables and their implications towards project value; Table 1 presents a list of value variables as derived from various value concepts in the identified theories, which applicable in the context of construction project.

Table 1. Value variables identified from theoretical value concepts

Ref.	Variables in Value Concepts	Value Concepts in Identified Theories
a	Quality	Dell' Isola (1982); Male (2006); MSE ICME (2009)
b	Function	Dell' Isola (1982); Carlos (1980); SAVE (2007)
c	Functionality	Male (2006), MSE ICME (2009)
d	Cost	Dell' Isola (1982); Carlos (1980); Male (2006); MSE ICME (2009)
e	Price	Carlos (1980)
f	Benefits	Carlos (1980); MoV (2010)
g	Satisfaction of Needs	BS EN (2000); MoV (2010)
h	Resources	SAVE (2007)
i	Use of Resources	BS EN (2000); MoV (2010)
j	Time	Male (2006), MSE ICME (2009)
k	Risks	Male (2006), MSE ICME (2009)

The identification of value variables from the literature reviews (as in Table 1) needs to be verified through further investigation. Hence subsequently, the qualitative research method was adopted; using interviews survey and analysis.

Variables of Value Identified from Interviews Survey

The interviews with value experts were conducted to investigate and verify the theoritically identified variables of value from the construction project context. The objective of the survey is for identifying value variables from the experts' views on their respective value concepts in construction.

Interview Respondents' Profiles

The interviews respondents' profiles are among value experts whom are based on their professional experiences and involvement, their competencies of relevant certification, academic qualification, and training, and also relates to their practices and consultation in the management of value in construction projects of Malaysia. The total numbers of eleven (11) respondents are selected using purposive sampling, which represent fifty percent (50%) of the twenty-two (22) units of whole population of identified value experts in Malaysia. The selection basis for the targeted sampling of population is:

i. Respondents have professional experiences and/or active involvement as committees of the Institute of Value Management Malaysia (IVMM); and
ii. Respondents have obtained relevant certification (e.g. Certified Value Manager), and/or relevant academic qualification, and/or professional training in the management of value in construction projects.

Analysis of Interviews Survey

The initial thematic analysis on the audio transcription was conducted manually. The objective of the thematic analysis was to identify the variables of value from the construction project context. At the initial round of manual review, the researcher had identified ten (10) themes from the transcriptions. Repeated reviews on the audio recordings and transcriptions have discovered two (2) pairs of themes that refer to same meanings. First pair, the theme 'benefits' by a respondent was alternatively referred to another theme with same meaning, which was 'outcomes'. Secondly, several respondents used similar themes either 'functionality' or 'function' interchangeably.

Initially the manual thematic analysis on the interviews transcriptions was conducted for identifying variables of value of construction project value, which have listed ten (10) potential value variables i.e. Benefits (alternately referred to 'Outcomes'); Outcomes; Cost; Functionality (interchangeable with 'Function'); Quality; Satisfaction; Time; Resources; Function; and Risks.

Subsequent to the manual thematic analysis, similar analysis was repeated using the computer software (Atlas t.i.) on the same transcriptions. The researcher applied the software for repeating thematic analysis with the knowledge of two (2) pairs of themes had same meanings. Hence the computerized thematic analysis had only identified eight (8) themes from the transcriptions by dropping the themes with same meanings.

Result of Interviews Survey

Table 2 presents the results of thematic analysis of the interviews survey's transcriptions. Initially, the value variables are extracted from each respondent's definition of value concept in construction project context. Then the thematic analysis has identified eight (8) value variables, which has eliminated two (2) variables that bring same meanings.

Table 2. Result of interviews survey

List of Respondents	Extracted Themes (Variables of Value Concepts in Construction)	Identified Variables of Value in Construction Project Context
Respondent 1	Benefits (or Outcomes); Cost	1. Quality 2. Functionality 3. Satisfaction 4. Benefits 5. Cost 6. Time 7. Resources 8. Risks Note: The sequence of value variables is NOT arranged to any priority or importance order.
Respondent 2	Functionality; Quality; Cost	
Respondent 3	Satisfaction; Function; Quality; Cost; Benefits	
Respondent 4	Quality; Function; Cost	
Respondent 5	Function; Cost; Benefits	
Respondent 6	Function; Quality	
Respondent 7	Function; Quality; Cost	
Respondent 8	Function; Time; Cost	
Respondent 9	Function; Satisfaction	
Respondent 10	Function; Quality; Cost; Time	
Respondent 11	Benefits; Satisfaction; Functionality or Function; Resources; Risks	

Finally, the analysis result has determined a set of value variables of construction project value as listed in Table 2. However, the list is not intended to prioritize the variables to any importance order. The establishment of those value variables has verified the earlier theoretical findings from literature reviews, which the identified eight (8) variables are cited in several literatures as indicated earlier in Table 1.

Hence, this qualitative verification has established that the variables of construction project value are 'Quality, Functionality, Satisfaction, Benefits, Cost, Time, Resources and Risks'. In defining construction project value, these key variables can be accounted for main attributes of the definition as illustrated by Figure 9 below. The value variables are linked to defining 'worth' in the construction project value context, where these variables can be exchanged (or 'traded-off') among them in achieving the optimum value.

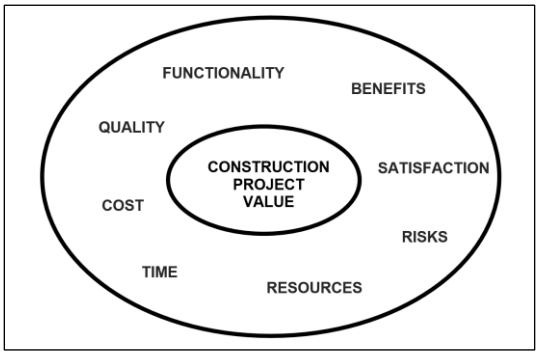

Figure 9. Illustration on the established variables of construction project value

LIMITATION AND DISCUSSION

The limitation of this study finding is the definition of construction project value only focuses on the key variables of the context. The definition of value from construction project context should be describing the circumstances that represent every key variable. Those circumstances will describe the specific criteria or conditions of each key variable, which will further define the respective value variables more objectively. As such, value managers can utilise the descriptions of criteria or conditions of each value variable for defining further construction project value from a specific perspective e.g. from the perspective of project briefing or project design or procurement strategy.

Another limitation is the study is solely obtained through the qualitative research method (interviews survey). The method is applied for an exploratory stage, i.e. to obtain the value experts' views in order to identify key variables of construction project value. This approach is effective in collecting qualitative data, which able to verify the earlier theoretical findings through literature reviews.

However, as suggested by Fellows (2003) it is often the qualitative method is applied as a precursor to quantitative method. In addition, the mixed use of both qualitative and quantitative methods in conducting a research can be more powerful in attaining understandings, verifying findings and establishing conclusions.

CONCLUSION AND RECOMMENDATION

The study finding has established a set of key value variables in the generic context of the construction project value. The establishment of eight (8) key value variables is fundamental for value managers in understanding what attribute may vary or change in quest of delivering or achieving the optimum project value. With the knowledge, construction project value can be effectively managed and maximized through optimizing (or 'trading off') among those variables. This study finding has also fostered the dynamic thinking towards obtaining potential value enhancement and optimizing value through managing the variables.

However for more effective management of value, the definitions of the established key variables of construction project value need to be further researched. It is recommended to extend the definitions of respective variables to the criteria or conditions that specifically describe each variable. Adopting those key variables, a further research will investigate the circumstances that contextualize the definitions of project value to a specific perspective, such as from the project briefing or project design or procurement strategy etc. The contextualization of project value definition in different perspectives is in lined with the Value Chain Management (VCM) concept as discussed by Wong, Cheung and Chan (2004), where the construction project value is transmittable and it weaves to align within the construction project phases that involve multi stakeholders.

For further research, the quantitative method can be applied on the qualitative finding, which will bring to the application of triangulated qualitative and quantitative methods. As such, defining construction project value can be more objective, contextualized and its subjectivity can be minimized. Thus, the intended construction project value can be effectively and efficiently managed, and optimally achieved by the value managers.

ACKNOWLEDGMENT

This piece of work is dedicated to practising value managers. The authors are indebted to the respondents of the interview survey i.e. value experts in Malaysia and the Institute of Value Management Malaysia (IVMM); for their participation and support in undertaking this study. The first author appreciates other authors' guidance and reviews in completing this paper.

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UNDERSTANDING THE DRIVING FACTORS OF COST OVERRUN IN HIGHWAY INFRASTRUCTURE PROJECTS: A REVIEW OF EXISTING METHODOLOGICAL APPROACH

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Abstract

Highway infrastructural projects are important to the socio-economic development of most of the emerging countries, such as Nigeria, Ghana, Jordan etc. However, due to the over-reliance on highways as a major means of transportation, partly due to the inefficiencies of other modes of transportation, countries make significant investment and commitment in the provision of highway infrastructure to the prevailing significant deficits. Albeit intertwined with the progress of any country, these projects are beset with manifold implementation challenges. One such challenges is delivering the projects within contractual budgets due to numerous attributable factors such as changes in scope and delay in progress of work etc. This study is aimed at examining the existing methodological approaches used in understanding the drivers of cost overrun in highway projects and assess whether an alternative approach such as system thinking which considers the complex and dynamic characteristics of cost overrun triggers can be utilized, using secondary data in form of systematic review of existing literature. A total of 29 papers that fulfilled our inclusion criteria were reviewed. The findings revealed the utilization of different empirical approaches and analysis methods in the studies of the subject matter. Questionnaires survey (48.3%) was found to be the primary approach used to examine the subject matter while Index analysis method (55%) was the predominant data analysis technique. This paper contributes to and enhances the existing methodological approach used in assessing the drivers of cost overrun in highway construction projects. The potential impact of this study will provoke a debate towards using an approach that considers the complex and dynamic characteristics of the drivers, thus aiding in the assessment and better understanding of cost overrun triggers in highway construction projects. The paper will finally recommend the use of system thinking approach to evaluate the drivers of cost overrun and simultaneously propose the key strategies for improving cost performance for future research.

Keywords: *Complex; cost overrun; dynamic; emerging country; highway infrastructure; systems thinking.*

INTRODUCTION

The construction of highway infrastructure plays a key role in the socio-economic growth of every country. Its contribution to the overall gross domestic product especially in developing countries cannot be underestimated (Famiyeh et al., 2017). This has resulted in significant commitment by many countries to invest in the provision of highway infrastructures and it becomes imperative to ensure the successful completion of the projects within the time, budget and expected quality. However, meeting these performance targets is quite challenging partly due to the uniqueness, increasing complexity of highway infrastructure projects and the highly competitive and fragmented nature of the construction industry. The performance of construction projects in terms of cost remains the most

important criteria to measure project success as it involves significant financial commitment (Ahiaga-Dagbui and Smith, 2014).

Cost overruns has significant effect on all the project stakeholders involved in a project due to the negative perception attributed to poor cost performance despite an all-encompassing goal of ensuring that the project is delivered within the set performance target (Park and Papadopoulou, 2012). However, cost overruns brings about less return of investments on the part of the public client, if any and significantly exert so much strain on the scarce public funds available and this affects the socio-economic development of a country, particularly developing countries, because it restricts government ability to invest in new public projects. This pervasive problem can undesirably affect the economy and jeopardize public confidence in the ability of government to deliver complex but very critical infrastructure projects (Love et al., 2015b).

In practice, cost overruns occur in most of highway projects and the magnitudes significantly varies with geography, empirical studies and the individual project (Famiyeh et al., 2017). In total, 258 infrastructure projects (including 167 highway projects) that covers a range of countries across the globe, were studied (Flyvbjerg et al., 2003). The study found that only 1 in 10 projects were successfully delivered within budgetary provision. It was further revealed that cost overruns are evident and pervasive in infrastructure projects.

Empirical studies have identified and assessed reasons for cost overruns considering the peculiarity and variation of the countries of studies using different data sources and analysis techniques (Olawale and Sun, 2010). For example, the significant causes of cost overrun in highway projects in Federal Capital Territory, Nigeria were investigated and identified using relative importance index method and thematic analysis (Anigbogu et al., 2019). The key drivers of cost overrun in highway projects in Zambia were analyzed through computation of the weighted averages of key drivers (Kaliba et al., 2009). Besides, the key triggers of cost overrun in transport infrastructure project in the Asian continent were identified and assessed based on index analysis and regression analysis method (Park and Papadopoulou, 2012). Considering studies based on reviews, a systematic review was conducted to identify the determinants of cost overruns in infrastructure projects (Cavalieri et al., 2019). However, these studies are mainly based on transport infrastructure projects but not specific to highway construction projects. Similarly, a state-of-the-art literature review was conducted on the leading cost and schedule performance indicators in the engineering, procurement and construction stages of general construction projects rather than focusing on highway construction (Mohammadreza and Sharareh, 2018). The review has identified methodological approaches i.e. data collection (questionnaire surveys and interviews) and analysis techniques (regression analysis and index analysis method such as relative importance index) of the studied sample.

Although past literature have identified and assessed the drivers of cost overrun in both general construction and transport infrastructure projects using different methodological approaches, none of the above studies was focusing on the efficiency of empirical approaches and analysis methods used for cost overrun studies in highway projects. This study seeks to examine the efficiency of existing methodological approaches used in understanding the drivers of cost overrun in highway projects and assess whether the complex and dynamic characteristics of the key drivers of cost overruns have been considered through the lens of a

general review and synthesis of empirical studies. As cost overrun issues are complex with its dynamic nature, utilizing an approach that considers the complex and dynamic characteristics of the issues is vital, thus, aiding in the assessment and better understanding of cost overrun triggers in highway construction projects.

CONCEPT OF COST OVERRUN

Cost overrun in highway construction is a pervasive issue irrespective of its size and geographic location (Johnson and Babu, 2018). However, the trend is more prominent in emerging countries partly, due to issues related to dishonest practices which sometimes results to projects almost doubled on their budgeted cost (WorldBank, 2012; Durdyev et al., 2012).

Cost overrun has been described by several scholars as the difference between the final actual cost and the initially agreed cost of a project. However, the main difference in the definition lies in the baseline of the initial estimate considered by the authors within the project delivery process i.e. baselines as time of formal decision to build, project definition, contract award (Flyvbjerg et al., 2003; Cantarelli et al., 2012c; and Love et al., 2015a) and the difference is a determining factor to the magnitude of cost overruns.

Moreover, some authors opined that changes in project cost varies with stages of the project development (Cantarelli et al., 2013). They described cost overrun during the various project development phases and explained that cost overrun at the pre-construction stage is measured as the variation between the forecasted costs at the start of construction and at the decision date. On the other hand, cost overrun in the construction stage is measured as the variation between the final construction cost and the forecasted cost at the time of start of construction (Figure 1).

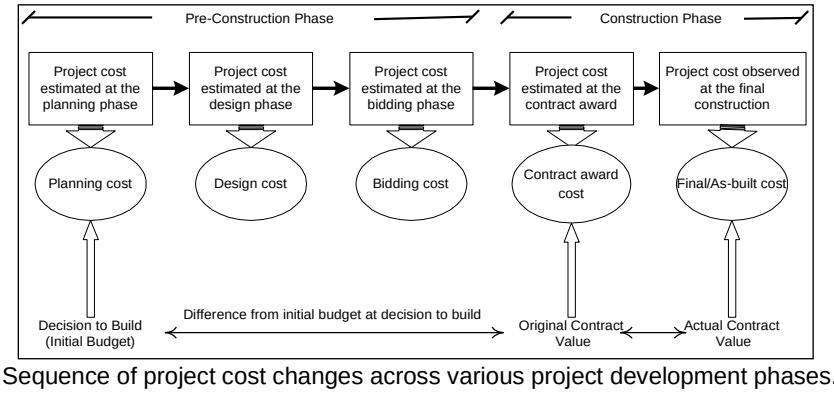

Figure 1. Sequence of project cost changes across various project development phases. Adapted from (Gkritza and Labi, 2008; Love et al., 2013)

Global studies have thus acknowledged the pervasiveness of the issues by revealing a magnitude of cost overrun ranging from 7.9% to over 100% (Flyvbjerg et al., 2003; Cantarelli et al., 2012c; Odeck, 2004; Locatelli et al., 2017). Looking at individual projects cost performance, the channel artery/tunnel project in USA experienced a significant cost overrun of over 400% (Olivio and Shaver, 2014). The significant implication of the variations in the project cost is both economic and political (Singh, 2010). Many studies on highway infrastructure projects have reported huge cost overruns and have been consistent over the years (Creedy et al., 2010). These positive variations are attributed to a plethora of factors

that are unique to different countries which are assessed based on statistical analysis of opinions of project stakeholders and historical project documents.

RESEARCH METHODOLOGY

A systematic review of extant published literature particularly on journal articles and conference papers was conducted to examine the various methodological approaches (data collection instruments and data analysis techniques) utilized in understanding the various drivers of cost overruns in highway infrastructure projects.

Systematic literature review (SLR) is a unique tool for establishing the knowledge boundaries of a given subject (Wuni et al., 2019). It provides a comprehensive foundation for theory development, closes areas where a plethora of research exist and uncovers areas that demand further research (Lachal et al., 2017). Considering its relevance, SLR is widely used in the construction engineering and management (CEM) domain to synthesize published literature e.g. (Osei-Kyei and Chan, 2015; Saieg et al., 2018; Mohammadreza and Sharareh, 2018; Cavalieri et al., 2019; Wuni et al., 2019). This method is used for a systematic description of the content of the literature relevant to the research question and thus, a procedure that is transparent and replicable is of importance. As such this paper implemented SLR using a comprehensive methodological framework of systematic literature search, screening, critical evaluation and relevant information extraction and analysis as presented in Figure 2.

Literature Search Procedure

Prior to conducting the final study literature search, several dominant databases and academic library for construction and engineering management (CEM) were examined in order to identify the one with the highest coverage, accuracy and relevance. Using same search criteria with same set of keywords, preliminary searches were conducted in Elsevier's Scopus & Science Direct, Clarivate Analytics' Web of Science core collection, ASCE library, Taylor and Francis, and Emerald Insight. Google scholar was utilized to identify journal articles and conference papers that are equally relevant, even though, they might not be indexed with the most dominant databases. This was vital because important papers were identified that are specific to developing countries which were limited in the Scopus databases.

Based on the rigorous search, it was discovered that a bulk of the identified articles were repetitively indexed in all the databases except for Google scholar, but the database with the widest coverage was Scopus. Thus, Scopus was solely considered due to its user friendliness and other superior features such as ease with which search results are restricted and its advance functionality in terms of citation and reference tracking. Earlier reviews based on CEM also relied mainly on Scopus for retrieving utilized articles (Wuni et al., 2019); and (Cavalieri et al., 2019). Following the choice of Scopus database, the most widely used synonyms of 'cost overrun', 'causes' and 'highway' and 'projects' were identified in extant literature. The list of keywords was constantly refined and updated throughout the process of the review. Finally, the ideal set of keywords for 'cost overrun', 'causes' and 'highway' and 'projects' were generated at the conclusion of the review process. The full Scopus search procedure is shown below.

TITLE-ABS-KEY ("cost risks" OR "cost overrun" OR "cost escalation" OR "cost deviation" OR "cost growth" OR "cost deviation" OR "cost increase" OR "cost discrepancy") AND TITLE (causes OR drivers OR factors OR determinants OR risks) OR TITLE ("road construction projects" OR "highway construction projects" OR "infrastructure projects" OR "expressway projects" TITLE ("road development" OR "highway development" OR "infrastructure development" OR "expressway development") AND (LIMIT-TO (DOCTYPE, "ar") OR LIMIT-TO (DOCTYPE "cp")) AND (LIMIT-TO (SRCTYPE, "j") OR LIMIT-TO (SRCTYPE, "p")) AND (LIMIT-TO (LANGUAGE, "English"))

Based on the search procedure above, the search was restricted to fulfil the following conditions: the document type was limited to article (ar) and conference paper (cp) only; the language was limited to English only; and the source type was restricted to journals (j) and conference paper (p). This adopted limitations were generic based on the nature of study which focused mainly on journals and conference papers solely written in English which the most widely utilized academic and scientific language. There was no limitation on the publication year because it was deemed useful to cover a wide range of studies that justifies the ubiquity of cost overrun problem. This search query returned 1086 Scopus records. The search was repeated immediately prior to submission to ensure that new published relevant articles were included in the study. However, new publications were identified, but rather were not relevant to the focus of the study.

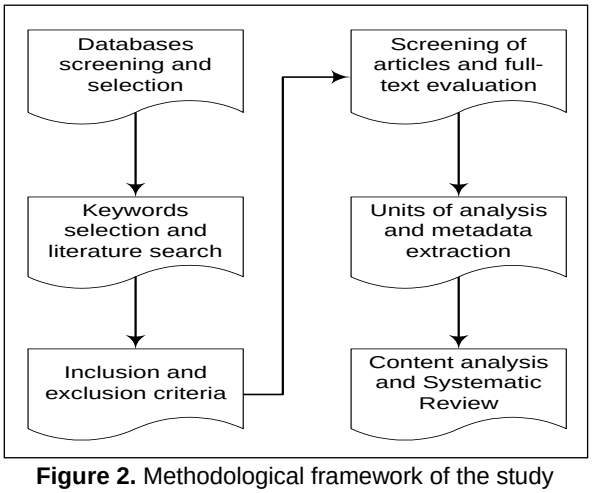

Figure 2. Methodological framework of the study

Inclusion and exclusion criteria

A systematic literature review requires an unambiguous description of the conditions for including and excluding a publication so as to enable verification and replication of the publication (Wohlin, 2014). Therefore, the paper specified explicit criteria to screen, filter and extract the actual sample from the 1086 Scopus records. The inclusion of an article was based on (i) it is an empirical study on the causative factors of cost overrun specific to highway and infrastructure (Highway inclusive) projects and (ii) published in a peer reviewed journal and conference proceedings. The inclusion of conference papers despite not receiving rigorous peer review is based on the importance of the papers to the study context and also because it was also reviewed by experts within the study research area.

Based on the logical outlined criteria, the titles and abstracts of the identified records of 1086 were screened for preliminary inclusion. This swift screening process resulted in the inclusion of 55 papers. Further full text evaluation resulted into the inclusion of 18 papers. Considering the importance of other relevant publications which are outside the coverage and accuracy criteria of Scopus, 10 articles were identified and included from Google scholar resulting in a total of 28 papers. Figure 3 presents the flowchart of the screening process. However, the sample was considered small, but is considerable compared against some previous reviews in CEM such as 27 (Osei-Kyei and Chan, 2015); and 26 (Cavalieri et al., 2019). A snowballing search was conducted by the authors in order to identify relevant papers and increase the sample size considering the recommendation of Webster and Watson (2002); Levy and Ellis (2006); and (Wohlin, 2014). The snowballing search is an iterative process of locating additional studies based on the reference lists (backward snowballing) and citations (forward snowballing) of the previously identified 18 articles from Scopus and 10 articles from Google scholar (Wohlin, 2014). However, several articles were identified and screened which resulted in one (1) additional relevant paper for inclusion because most of the identified papers were a replication of already included publications. In all, a total of 29 papers were considered and synthesized. In comparison against recently published CEM review using a sample of 26 Cavalieri et al. (2019), this sample is considered favorable. The included publications are presented in table 1 with their serial numbers.

Content Analysis

The study adopted a framework of Meta synthesis to integrate the findings of the studies in a single SLR (Wuni et al., 2019). Unit of analysis was specified to guide the Meta data extraction based on the principles of SLR (Cavalieri et al., 2019). However, the information extracted in each study was the reported methodological approach used in each study to collect and analyze data.

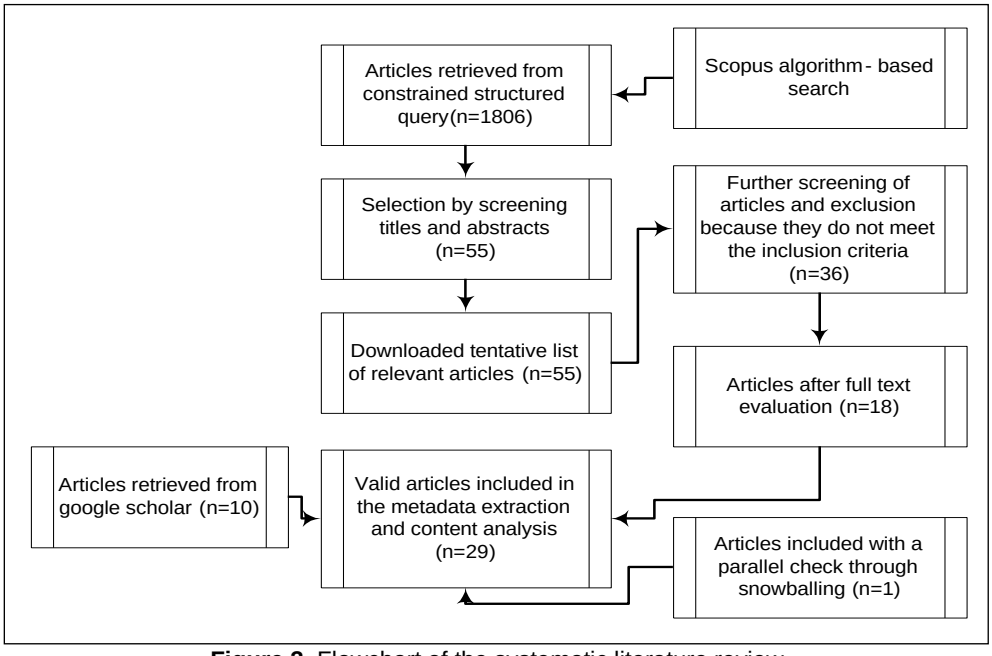

Figure 3. Flowchart of the systematic literature review

Table 1. Legend of serial numbers of publications in tables 1 and 3

S/No	Publications	S/No	Publications
1	Mansfield et al. (1994)	16	Mahamid (2013)
2	Flyvbjerg et al. (2003)	17	Hazim and Abusalem (2015)
3	Flyvbjerg et al. (2004)	18	Zafar et al. (2016)
4	Odeck (2004)	19	Wanjari and Dobariya (2016)
5	Kaliba et al. (2009)	20	Belachew et al. (2017)
6	Chileshe and Danso Berko (2010)	21	Sohu et al. (2017a)
7	Creedy et al. (2010)	22	Al-Hazim et al. (2017)
8	Nasir et al. (2011b)	23	Sohu et al. (2017b)
9	Mahamid and Bruland (2011)	24	Akal et al. (2017b)
10	Cantarelli et al. (2012c)	25	Huo et al. (2018)
11	Cantarelli et al. (2012b)	26	Pai et al. (2018)
12	Cantarelli et al. (2012a)	27	Sohu et al. (2018)
13	Park and Papadopoulou (2012)	28	Andrić et al. (2019)
14	Alinaitwe et al. (2013)	29	Anigbogu et al. (2019)
15	Alhomidan (2013)		

Table 2. Data sources

Data Sources	Study Sources	No of Studies	Percentage
Questionnaires	1,5,6,8,9,14,15,18,19,21,23,24,26,27	14	48.3
Project documents	2,3,4,7,10,11,12,25,28	9	31.0
Questionnaires and project documents	13,16,17,20,22	5	17.2
Questionnaires, project documents and questionnaires	29	1	3.5

Table 3. Data analysis techniques

Data Analysis Techniques	Study Sources	No of Studies	Percentage
Descriptive Analysis	2,3,4,7,10,11,13,25,28	9	31.0
Descriptive Statistics (Index analysis)		16	55.0
- Relative importance index	8,17,22,26		
- Average index	21,27		
- Mean score	18,23		
- Severity index	1,15		
- Frequency index	14,15		
- Importance index	9,14		
- Weighted average	5,24		
- Percentage of maximum score	-		
- Total score	6		
- Frequency of agreement	19		
Regression Analysis and Index Analysis	12,16	2	7.0
Thematic Analysis and Index Analysis	29	1	3.5
Content Analysis and Index Analysis	20	1	3.5

REVIEW FINDINGS AND DISCUSSIONS

Existing Methodological Approaches (Data Sources and Analysis Techniques)

Data Sources

The 29 papers included in the review are based on studies that assessed the causes of cost overrun in highway projects represented by different countries. As such, the retrieved empirical evidences have been synthesized. From the synthesis presented in tables 2 and 3, it can be observed that different methodological approaches were adopted to collect and analyze relevant data used in the studies. As presented in table 2, the most widely used data sources were information from project documents of various highway projects and questionnaire

surveys supplemented occasionally by interviews in order to reaffirm or prioritize the key causes of cost overrun in highway construction projects. Although, some studies used a combination of two or more of the practices to collect the required data. It should be noted that, studies that utilized only questionnaires represents 48.3% of the overall papers which ranks highest among all the data sources. For instance, Mansfield et al. (1994) developed a questionnaire based on identified causes of cost overruns from the literature. The questionnaires were sent to key professionals from client, consultant and contracting organizations involved in the provision of highway projects in Nigeria. The respondents were given the opportunity to identify any factor that is likely to significantly impact the performance of highway projects by giving the response of "strongly agree" or "agree". Similarly, many studies Kaliba et al. (2009); Chileshe and Danso Berko (2010); Nasir et al. (2011); Mahamid and Bruland (2011); Alinaitwe et al. (2013); Alhomidan (2013); Zafar et al. (2016); Wanjari and Dobariya (2016); Sohu et al. (2017a); Sohu et al. (2017b); Akal et al. (2017); Pai et al. (2018); and Sohu et al. (2018) framed their research methodology based on conducting questionnaires survey. Project documents represents the second highest data sources used by the relevant studies accounting for 31%. In one of the largest studies on cost performance of transportation infrastructure projects due to its heterogeneous data sample, Flyvbjerg et al. (2003); and Flyvbjerg et al. (2004) collected project data (historical cost data) of 167 highway projects across different countries in Europe, North America and Japan which formed the basis on which their analysis was conducted. Similarly, Cantarelli et al. (2012a); Cantarelli et al. (2012b); Cantarelli et al. (2012c); Huo et al. (2018); Odeck (2004); Andrić et al. (2019); and Creedy et al. (2010) used similar methodological approach i.e. data source though in a different context. A combination of questionnaires and project documents occupied the third place with 17.2%. Park and Papadopoulou (2012) collected data from 35 transport infrastructure projects, including 7 highway projects, from 11 countries (Malaysia, South Korea, Thailand, Taiwan, India, Vietnam, Bangladesh, Pakistan, Singapore, Hong Kong and Sri Lanka) within the Asian continent and 145 questionnaires. The questionnaires were developed using a four-point Likert scale to accord the key participants to rank the frequency of each factors on a scale from 0 for never to 4 for always and severity of each factors on a scale from 0 for not significant to 4 for very significant. Similar approach was employed by (2013); (2015) ; (Belachew et al., 2017); and (Al-Hazim et al., 2017). Finally, papers that adopted a combination of questionnaires, project documents and interviews as data sources is represented by 3.5%. For instance, data was collected from client, contractors and various consultants' organizations involved in the provision of highway projects in the Federal Capital Territory, Nigeria using a mixed method approach i.e. combination of questionnaire survey, thorough examination of project documents and semi structured interviews (Anigbogu et al., 2019). The stakeholders were requested to indicate the significance of each cause based on a five-point Likert scale in order to measure the range of opinions of the level of significance with 1= least, 2= low, 3=average, 4=significant, and 5=most. It is thus, obvious that majority of the studies utilized questionnaires as the data collection instrument to assess the key causes of cost overrun in highway projects.

Data Analysis Techniques

Similarly, as evident in table 3, different techniques were employed to evaluate the data procured from the questionnaires, project documents and interviews, such as thematic analysis, content analysis, regression analysis and index analysis method including (frequency index (FI), severity index (SI), important index (II), relative important index (RII)), mean

score (MS), average relative weight, weighted average (WA), Frequency of agreement, total score and percentage of maximum score etc. From the synthesis, it can be observed that index analysis including different methods account for 55% of the analytical tool used in the reviewed studies. For instance, questionnaire responses were retrieved from the various stakeholders based on the ranked frequency, severity and importance of each cost and schedule performance factor (Alinaitwe et al., 2013). The stakeholders were asked to indicate the frequency and severity of each of the identified factors, using a four-point Likert scale ranging from 0 (never happened and no effect) to 4 (always happened and very severe). Furthermore, the importance index of each factor was obtained based on the combined effect of the frequency and severity of each factor. According to Asiedu and Alfen (2016), the frequency index (FI) and severity index (SI) expressed the frequency of occurrence and magnitude of each of the variables respectively. The reviewed literature revealed that relative important index (RII) represents the most widely used index analysis method in identifying the most crucial factors of cost overrun (Nasir et al., 2011); (Hazim and Abusalem, 2015); (Al-Hazim et al., 2017); and (Pai et al., 2018). Regression analysis was employed in 31% of all the studies. Based on the study by Flyvbjerg et al. (2003); and Flyvbjerg et al. (2004), the data retrieved from project documents was analyzed using regression analysis to establish the relationship between cost overrun and some descriptive project variables i.e. project size, length of implementation phase and type of project ownership. Similarly, Cantarelli et al. (2012a); Cantarelli et al. (2012b); Cantarelli et al. (2012c); Huo et al. (2018); Odeck (2004); Andrić et al. (2019); and Creedy et al. (2010) used similar methodological approach i.e. data analysis technique, though in a different context. Some other few studies adopted a combination of two different techniques. For instance, regression analysis and index method 7%. Based on a study by Mahamid (2013), the data were analyzed to identify the most significant causes using a combination of index analysis (significance index i.e. frequency index * severity index) supported by Cronbach reliability test and regression analysis. Similarly, the identified variables from the project documents were analyzed using linear regression analysis to establish the relationship between each of the variables and cost overrun. Furthermore, the retrieved questionnaires data were analyzed using index analysis method i.e. importance index to identify the most critical factors (Park and Papadopoulou, 2012). A combined techniques of thematic analysis and index analysis method account for 3.5% of the reviewed papers. For instance, a combined techniques of index analysis i.e. relative importance index and thematic analysis was used to analyze the collected data questionnaires and interview data with relevant stakeholders to establish the significant factors within the context of the study (Anigbogu et al., 2019). The themes identified from the interviews affirms the significance of the key causes from the experienced stakeholders. Finally, content analysis and index method also account for 3.5% of the overall reviewed papers. Based on a study by Belachew et al. (2017), the respondent's evaluation of each of the rated factor from the questionnaire was analyzed using percentage of maximum score or relative importance weight method and Cronbach alpha test and content analysis of the project data to identify the top rated factors.

Though, methodologically, the reviewed studies provide a valid contribution and thus add to the existing body of knowledge relating to cost overrun, it is however inefficient in evaluating the systemic and complex nature of the phenomena. These approaches appear to be one-dimensional and unable to explain the complex interrelationship among the different contributory factors of cost overrun (Ahiaga-Dagbui et al., 2015). It is obvious from the findings that, the reviewed studies adopted methodologies that often infer cause and effect

relationship between factors by excluding the dynamic and complex nature of contributors of cost overrun phenomena. The synthesized methodologies report on the established correlation between cost overrun and key factors or other independent variables such as project type, project size, geographical location and length of project construction phase. Furthermore, the methodologies explained the effect of individual influencing factor on cost performance without accounting for the effect of all influencing factors. Furthermore, it was reaffirmed that the established relationship between cost overrun and key drivers cannot be used to infer causality (Amadi and Higham, 2019).

RECOMMENDATION OF SYSTEMS THINKING PHILOSOPHY

Based on the synthesis, it was evident, that, the reviewed empirical studies commonly adopted statistical analysis as an approach to understanding the cost overrun issues. Hence, the statistical techniques seems to be one-dimensional and unable to accommodate or take into consideration the complex and dynamic nature of the triggers of cost overrun which tends to have a complex interaction with each other consisting of multiple feedbacks, delays and non-linear relationships (Ahiaga-Dagbui et al., 2015).

As such, an approach such as systems thinking that considers the complex and dynamic characteristics of the drivers is required to understand the interrelationship of the key drivers. These drivers could be identified from prior empirical studies or through engagement with the stakeholders that have knowledge about the nature of the problem.

Systems thinking as a branch of system dynamics is a philosophy or approach that takes a holistic view of a problem as a complex system (Sterman, 2000). It is based on understanding the dynamic behavior of the whole system i.e. how a factor in a system interact with one another and how a change in one variable affect the other overtime which in turn affect the original variable (Boateng et al., 2012); and (Leon et al., 2018). For instance, Figure 4 describes a conceptual model that clearly highlights the complex interrelationship between the key drivers which resulted in a balancing loop. The balancing feedback loop is explained by the need to ensure that the funding to projects are improved. As efforts by politicians to meddle into the manner in which projects get funding allocation, particularly in a multi-party-political environment, project funding often becomes a problem. As the shortfall to projects increase, the possibility of a transition in the political environment, say, transition from one government to another, to look at other avenues of finding an improved funding source is increased which then ensures that the funding source is improved upon.

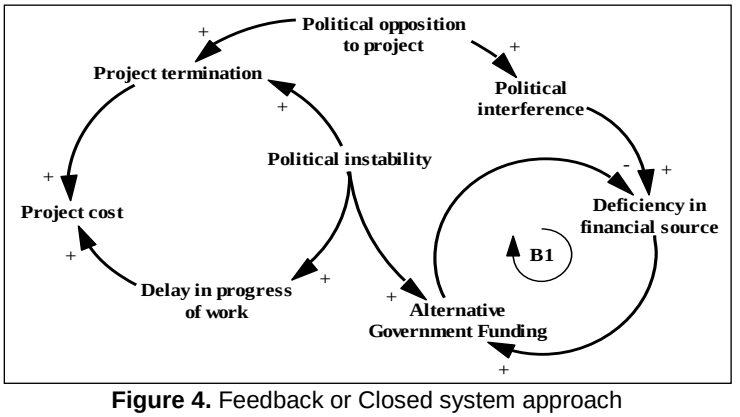

Figure 4. Feedback or Closed system approach

CONCLUSION AND IMPLICATIONS

Cost overruns are systemic and potentially substantial in publicly funded highway projects globally. However, the phenomena of cost overrun have been attributed to several factors which arise during the life cycle of the project. Even though, it is a well acknowledged problem, there has been a lack of agreement on the key drivers from different strands of the academic community, partly, due to the geographic considerations. More so, there has been calls from different quarters on the need to acknowledge the holistic and complex nature of cost overrun phenomena to gain a fuller understanding of the interrelationship between the different drivers of cost overrun. In response, empirical studies have examined the key contributors of cost overruns in highway infrastructure projects from diverse geographical location and using different methodological approaches. As most studies focused on evaluating the key contributors of cost overrun from a range of methodological lenses, there is a need to synthesize the empirical studies to identify the methodologies used and thus, generate a framework of the methodological approaches utilized and inform whether the key characteristics of the phenomena of cost overruns drivers has been actually considered. However, the synthesis of the approaches revealed that, though, the statistical approach is valid in its own right, its discrete nature reveal that the complex characteristics of the drivers has not been accommodated. It reveals that the key drivers are stand alone and independent, occurring at a single point in a network of causal links without consideration of the whole system and how these factors interact with each other. Hence, they cannot be used as a basis for inferring specific cause and effect relationship between the causes. By implication, an approach that considers the holistic and complex characteristic of the phenomena of cost overrun drivers such as systems thinking will be able to address the shortcomings of the statistical techniques.

Despite the relevance of the study, it is worth highlighting some drawbacks. First, despite the application of a structured methodological process, some relevant articles may not have been identified due to the search terms selected and also may have not been included due to the Scopus database and Google scholar database used. Secondly, notwithstanding the adequacy of the sample used, the sample is relatively small, and an update of the review should be conducted to capture new techniques used in understanding the triggers of cost overrun in highway projects.

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A REVIEW OF INTEGRATED RISK MANAGEMENT INFRASTRUCTURE MEGAPROJECTS IN MALAYSIA

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Abstract
Malaysia has advance on numerous major infrastructure projects which aims at enhancing infrastructure connectivity and boosting investment among countries. Meanwhile, megaprojects are a completely different class of project requires different interpretation and management of risks, extremely complex and costly infrastructure project, had massive implications for the country's fiscal standing and are not industry or sector specific but extend across an institutional field. The risks appear in megaprojects due to its complexity will be exacerbate especially to the Malaysian economy presuming that no proper action is taken. This paper provides an overview of the basic concepts of the practices of megaproject risk management process by evaluating the management of risks in various infrastructure project organizations in Malaysia. This paper hoped to contribute to the industry through the conceptual of megaproject risk management procedure to be used as basis for the government and the private parties and as best practice to reassess the management of megaprojects risks, particularly in infrastructure development.

Keywords: *Project risk management; infrastructure; megaproject; life cycle; conceptual.*

INTRODUCTION

Project risk management (PRM) is one of the new management concepts in the Malaysian construction industry. It will take a long time to be fully accepted by the participants in this industry. Most of them are reluctant to change; they are still comfortable with their traditional culture in doing their job without realizing that this new concept will make their job easier (Yusuwan et al., 2008). This statement was supported by Abdul-Rahman et al. (2015) which declared that construction projects in Malaysia mostly do not use risk management techniques and the reason for that is mainly due to the lack of knowledge about the importance of risk management and its implementation in the construction industry amongst the members of a project team. However, recent study performed by Ibrahim and Esa (2018) shows that the current practice for official risk management plan is in moderate level. This illustrate that the local practitioners begin to recognize and understand the PRM process.

On the other hand, infrastructure is a broad scope of long-term and capital-intensive techniques that contribute into a various productive mechanism that generating economic and social benefits, for example, transportation – airports, railways and roads; utilities – power plant, water sanitation and telecommunications (Gil et al., 2019). Whereas, megaprojects are complex and large-scale projects with multifaceted designs; huge cost (normally cost a billion dollars or more) and high risks; require long period for development and construction, difficult contractual provisions, comprise numerous stakeholders from public and private sectors, are transformative, and give great impact to community and economy (Flyvbjerg, 2017; Ma et al., 2017; Qiu et al., 2019). Briefly, it can be decided that infrastructure megaprojects are the infrastructure projects which are huge scale and a complex project.

Risks in infrastructure megaprojects construction are usually complicated and uncertain. Flyvbjerg et al. (2003) stated that the preparation and implementation of megaproject is extremely hazardous where events happen only with a certain possibility and seldom happen as initially intended in the reality. Furthermore, this type of project has been identified as an extremely complex project with various construction difficulties, high costs and excessive technical demands (Kamar et al., 2019). In Malaysia, Edgeprop (2018) reported due to the previous government inherited debt, it is compelled the proper evaluation of each mega infrastructure projects. Recently, the government have magnificently reduced the costs for megaprojects in order to support poorly managed government institutions (Malay Mail, 2019). Hence, it is predominantly significant to comprehend the risk events dynamical and develop efficient risk management approaches in megaprojects (Erol et al., 2018). This circumstance draws an aim of this paper which is to explore risk management practices for infrastructure megaprojects, especially in Malaysia.

LITERATURE REVIEW

Project Risk Management

The Importance of PRM

The purpose of PRM is to define, evaluate, manage and track project-related risks systematically by minimizing the possibility and consequence of negative (threats) event and enhancing the possibility and consequence of positive (opportunities) event throughout the project (Lima & Verbano, 2019; Project Management Institute (PMI), 2017). PRM pervades not merely the project management practice but turn into an governmental advantage that supports and influences on the whole project collection in the past, present and future if taken into account comprehensively (Bissonette, 2016). In addition, PRM could direct to sounder project performance if well comprehended and managed but can lead also to a corporate disappointment and eventually harmful fiscal and business outcomes if not completely comprehended and handled.

Furthermore, as reported by Chapman (2016), the Olympic Games in London 2012 were one of the fresh examples of successfulness of risk management for megaproject. Over the years, the International Olympic Committee (IOC) and London Organizing Committee (LOCOG) have considered the negative risk activities. Protection simulations have been prepared and contingency plans have been set up for bulk evacuations or emergencies situation to ensure the games proceed successfully. Hence, the application of PRM could address both threats and opportunities issues in the project to have a great advantage, that comprising efficiency in applying a method to vigorously cope both threats and opportunities to prevent and minimize issues and maximize advantages.

Process of Managing Risks

The process of identifying, analysing, and responding effectively to project risks is the core of the PRM process. These methods can, however, differ according to private or organizational practise. The procedure is usually introduced in a more iterative manner, although described as discrete sequential stages (Bissonette, 2016). The way for managing risks encompasses common systematized management actions, which incorporates risk

identification, risk analysis, risk responses and risk monitor and control in accordance with the assessment execute on the information associated to PRM.

Different Approaches to PRM

The development of a comprehensive and holistic risk management approach is a pitfall because the risks are often described inconsistently at various levels, at different stages of the project life cycle, and by different managerial functions (Govan & Damnjanovic, 2016; West et al., 2018). This indicates that there is an insufficiency of robust risk management insight over the entire life cycle of a project. In addition, Nawaz et al. (2019) reported various research have created numerous frameworks of risk management in different areas to befit with their environment. Based on the finding from Crispim et al. (2019), there are variations in the use of PRM practices in relation to the geographical area and project complexity. From above studies, little research has been done on the comparison of risk management between different infrastructure industries. It is crucial to perceive the pattern and general practices of PRM across the infrastructure industries with the aim that a generic overview of the risk management process can be produced as a basis and reference for any infrastructure field.

For this paper, a total of nineteenth separate documents which are employed to handle the risk were evaluated which consist of International and Local (Malaysian) guidelines and documents to compare their processes. These documents include guidelines and reports on the management of risk concerned to project, programme and project management area, particularly in relation to infrastructure megaprojects for local context since it is the focus of this paper. This literatures also attempts to present several major companies' practices of risk management in various infrastructure megaprojects areas in Malaysia, as a sample for the local context as a whole because it is impossible and unmanageable to include all related companies for this paper since there is a very large number to be included. Such major companies were selected based on their core business in infrastructure projects.

The involved documents and guidelines regarding the PRM particularly; Project Management Institute - Project Management Body of Knowledge, Association for Project Management - Body of Knowledge, Institution of Civil Engineers - Risk Analysis and Management for Projects, ISO 31000:2018, Management of Risk (M_o_R), Department of Defense (United States of America) - Risk, Issue, and Opportunity Management Guide, Malaysian Public Works Department (Jabatan Kerja Raya) - Pengurusan Risiko Projek and Malaysian Standard (MS) ISO 31000:2010. Whereas, for relevant Malaysian infrastructure companies namely; roads - UEM Berhad, railways – Gamuda Berhad and China Communications Construction Company, airports - Malaysia Airports Holdings Berhad, power plant - Tenaga Nasional Berhad and Malakoff Corporation Berhad, water treatment plant - Indah Water Konsortium and Salcon Berhad, telecommunication - Telekom Malaysia Berhad, and oil and gas - Sapura Energy Berhad and Dialog Group Berhad. The comparison for those documents were summarized in Table 1.

Table 1. Summary of PRM process from various documents

Authors	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5	Phase 6	Phase 7	Phase 8
Project Management Institute	Plan risk management	Identify risks	Qualitative analysis	Quantitative analysis	Risk response	Control risks		
Association for Project Management	Define project, Focus RM	Identify	Assess – Structure, Ownership	Assess – Estimate, Evaluate	Plan responses	Implement responses	Manage process	
Institution of Civil Engineers	Organize & define strategy	Establish baseline	Plan, initiate & identify	Evaluate, respond & assess	Plan & communicate responses	Implement strategy	Control risks	Review process
ISO 31000:2018	Scope, context & criteria	Risk assessment - identification	Risk assessment - Analysis	Risk assessment - Evaluation	Risk treatment	Monitoring & review	Recording & reporting	Communication & consultation
Management of Risk (M_o_R)	Identify - context	Identify - risks	Assess – estimate	Assess - evaluate	Plan - responses	Implement - action		
Department of Defense	Process planning	Risk identification	Risk analysis	Risk mitigation	Risk monitoring			
Jabatan Kerja Raya	Establish context	Identify risk	Risk assessment - Analysis	Risk assessment - Evaluation	Risk treatment	Monitoring & review	Communication & consultation	
MS ISO 31000:2010	Establish context	Risk assessment - identification	Risk assessment - Analysis	Risk assessment - Evaluation	Risk treatment	Monitoring & review	Communication & consultation	
UEM Berhad	Clarify objective	Establish context	Identify risk	Assess risks	Respond to risk	Monitor, review & report risks	Communicate	
Gamuda Berhad	Establish objective	Risk identification	Risk evaluation & ranking	Risk mitigation measures	Risk reporting & monitoring			
China Communications Construction Company	Risk identification	Risk analysis	Risk evaluation	Risk response	Risk reporting & monitoring			
Malaysia Airports Holdings Berhad	Establish context	Risk assessment - identification	Risk assessment - Analysis	Risk assessment - Evaluation	Risk treatment	Monitoring & review	Communication & consultation	
Tenaga Nasional Berhad	Establish context	Risk assessment - identification	Risk assessment - Analysis	Risk assessment - Evaluation	Risk treatment	Monitoring & review	Communication & consultation	
Malakoff Corporation Berhad	Establish context	Risk assessment - identification	Risk assessment - Analysis	Risk assessment - Evaluation	Risk treatment	Monitoring & review	Communication & consultation	
Indah Water Konsortium	Scope, context & criteria	Risk assessment - identification	Risk assessment - Analysis	Risk assessment - Evaluation	Risk treatment	Monitoring & review	Recording & reporting	Communication & consultation
Salcon Berhad	Establish context	Risk assessment - identification	Risk assessment - Analysis	Risk assessment - Evaluation	Risk treatment	Monitoring & review	Communication & consultation	
Telekom Malaysia Berhad	Establish context	Risk assessment - identification	Risk assessment - Analysis	Risk assessment - Evaluation	Risk treatment	Monitoring & review	Communication & consultation	
Sapura Energy Berhad	Establish context	Risk assessment - identification	Risk assessment - Analysis	Risk assessment - Evaluation	Risk treatment	Monitoring & review	Communication & consultation	
Dialog Group Berhad	Establish context	Risk assessment - identification	Risk assessment - Analysis	Risk assessment - Evaluation	Risk treatment	Monitoring & review	Communication & consultation	

The stages of the procedure of risk management which were extracted from the reviewed guidelines and documents are summarized in Figure 1. A rigorous and well understood phase of risk management can comprise until eight comprehensible phases based on the review. However, this paper tries to split it into nine particular stages namely; Establish Context,

Identification, Assessment, Analysis, Evaluation, Treatment/Response, Record and Report, Monitor and Review, and Communicate and Consultation. This overview designed to help reader to understand each method more practical. The process begins by defining the objective or context of the project before identifying the risks. This will improve the insight of the project's context, commitments and setting. Identification phase involves recognizing the potential risks sources that could help or prevent achieving the project objectives. Afterward, the phases of assessment, analysis and evaluation were largely affected because the multiple documents were defined and performed these phases in different ways. With this theoretical PRM procedure, every phase is independent and evidently sets out the actions to be performed. The following phases include responding/treatment, record/reporting, monitoring/review and communication/consultation. As for monitoring/review and communication/consultation phases, this paper understand that it involves understanding the feedback and examines the approach implemented for every phase of the risk management, along with the overall process. The backward arrow represented the iterative risk management process which appraisals would be carried out again until every phase was performed. Precisely, if the new risks appear, it must be coped via the similar process.

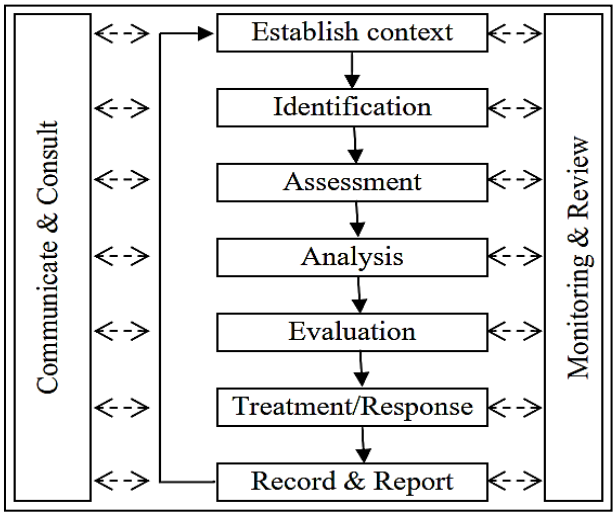

Figure 1. Theoretical PRM Process (Adapted by author)

Infrastructure Megaprojects

Overview of Infrastructure Megaprojects

Infrastructure projects can be described as a civil works that grant benefits to the nation for instance in term of social and economic whereas megaprojects are a large-scale project with complexity in nature. In general, large-scale infrastructure projects are megaprojects (Kostka & Fiedler, 2016). According to Flyvbjerg (2017), megaprojects are being increasingly exercised as the favoured delivery model for products and services within a variety of businesses and sectors, including infrastructure, water and energy, industrial power plants, information technology, mining and others. Moreover, infrastructure projects are a mechanism for investing into resources that is beneficial at local, regional or even international level and have a long-term impact on society (Vuorinen & Martinsuo, 2019). It also has been a concern to numerous stakeholders because of their large size and impact on the country.

Risks in Infrastructure Megaprojects

Practically the entire infrastructure projects are time and cost consuming and even degraded in terms of quality (Khodeir & Nabawy, 2019). Furthermore, due to the large investment amount, the huge participation of the community, challenging decision-making process, and the engagement of numerous stakeholders, the mega-project is the wild beasts of the project environment, which are difficult to drag their feet (Ma et al., 2019; Zidane et al., 2013). Many potential risk elements can influence the development of megaprojects. Accordingly, Boateng et al. (2017) are examine about the risks facing by megaprojects associated with social, technical, economic, environmental and political (STEEP) risks that can lead to massive overruns in costs and time compared to earliest estimates of budget and schedules. According to them, STEEP risks are the major classification of risk assessment criteria that established to represent generic circumstances in various development of megaprojects construction. Those STEEP risks criteria can reflect all associated risks throughout lifecycle of project (Chen et al., 2011). This reflects that various risks that happen due to the complexity feature of megaprojects. Williams (2017) mentioned that risk management is important for the complex projects to obtain the project success. Thus, it is necessary to understand the development of infrastructure megaprojects in an effort to employ risk management effectively. In order to understand infrastructure megaprojects clearly, the life cycle involved during its development are essential to be discovered.

Infrastructure Megaprojects Life Cycle

All projects have a starting and finish stages of life cycle, in conjunction with several activities, such as planning, implementation and commissioning. The functions of each stage and descriptions used to define the activities associated differ according to the project type and the organization's managerial strategy. Massive control levels are essential for large and complicated projects and work is split into stages suited to each project's unique criteria (Association for Project Management [APM], 2019). All life cycles of projects are comparable and follow generic pattern but may be demonstrated in various ways. In accordance with previous studies, the paper found that the life cycle of project is in the sequential procedure which constantly begin with planning phase and finish with decommissioning phase. In other word, the downstream stage begins at the end of an upstream stage. Before the infrastructure megaproject can move to the next phase, rigorous entry and exit conditions of the phase must be fulfilled. All discovered phases are essential in the life cycle. No phase should be ignored, but it can be adapted to suit with the implementation approach and the work context. Based on the Academy of Sciences Malaysia (ASM, 2016) which have investigated about infrastructure projects in Malaysia, they proposed the life cycle process involves sequential phases, namely, Planning, Design, Procurement, Construction, Operations and Maintenance, and Decommissioning (Figure 2). This life cycle provides a general outline on the process of infrastructure projects step by step. Each stage inherited risks and uncertainty events due to complication of infrastructure megaprojects. Erol et al. (2018) argues that complexity of megaprojects needs to be control by developing effective risk management strategies.

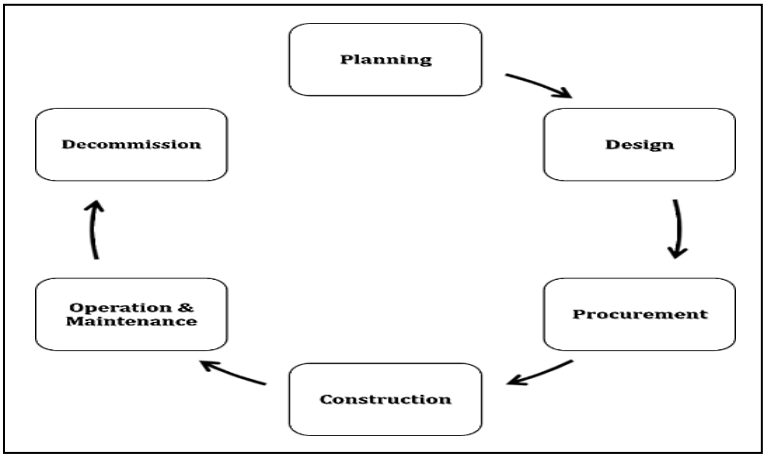

Figure 2. Life cycle of infrastructure megaproject (ASM, 2016)

METHODOLOGY

The objective of this paper is to examine how to adopt PRM in infrastructure megaprojects life cycle, considering PRM phases and procedures that enable the effective implementation of PRM in infrastructure megaprojects. This involves documentation of a rigorous review of the literatures and industrial reports as sources of information, with the intention of identifying and underlining relevant PRM practices and examining the preliminary data of previous paper in the area of particular interest to the scholar. Research papers were extracted from a variety of platforms, predominantly from the online database of the University of Malaya and Google Scholar. Newspaper and reports were also referred to obtain the current and recent information. Keywords employed to search the literatures were "project risk management", "risk management", "infrastructure project", "megaproject" and "infrastructure megaproject", with using Boolean search. The sources acquired comprise of journal articles, news, books and technical reports that are encompasses two areas which is Project Risk Management and Infrastructure Megaprojects. Besides, the reference lists of each paper are examined in depth for supplementary articles. This paper has limitation as it only covers Malaysian construction industry and based on databases of the University of Malaya such as EBSCO Discovery Service, Emerald, SAGE Journals, ScienceDirect, Springer etc and Google Scholar.

FINDINGS AND DISCUSSION

Innovation in the implementation of megaprojects is crucial to the management team and an efficient risk management strategy could provide a structure for identifying and evaluating possible risks so that action on risk mitigation can be taken (Boateng et al., 2017; Davies et al., 2014). The complexity of megaprojects is the major cause of significant performance challenges (Erol et al., 2018). Hence, risk management approaches particularly for infrastructure megaprojects need to be developed thereby complex issues faced by those projects can be handled (AlSanad, 2017; Erol et al., 2018; Irimia-Diéguez et al., 2014).

Arguments about the suitable period to employ risk management into life cycle of project was debatable. Yazid and Abdullah (2014) states that risk management must be carried out well in advance before implementing an acceptable risk management strategy at the critical

stage. This is essential for infrastructure projects to be successful. Anyhow, Yazid and Abdullah (2014) did not specifically mention which stage in infrastructure projects was a critical stage. Debatably, according to Alfalla-Luque et al. (2015), risk management procedures must be continually implemented throughout the project life cycle. They were employing an analysis of nine case study of different infrastructure megaprojects across the European countries. Most risk practitioners (44%) declared that they fully integrate risk management throughout project life cycle for achieving project outcome. This argument supported by Mathuthu et al. (2017) in which risk management should be implemented at each life cycle phase of projects. That data obtains from an analysis of systematic literature review of risk management strategies in infrastructure projects, based on the American Society of Civil Engineers, IEEE, Science Direct, Springer, Taylor and Francis, Emerald Insight and Knovel, and UJOOGLE databases. Hence, it shows that risk management procedures should be conducted continuously throughout each phase of infrastructure megaprojects life cycle, from the start until end of project life cycle.

In addition, infrastructure megaprojects were a difficult project which involve with various parties and individual. PMI (2017) state project manager was accountable for overall process of risk management. However, AlSanad (2017) argues that megaprojects also require expert management for reducing risks event due to its size and complex nature. Based on Cambridge Dictionary, expert is an individual with a high level of experience or knowledge related to a specific topic or activity. This indicate that project manager in infrastructure megaprojects requires support from expert that have a high level of knowledge or expertise about risks in infrastructure megaprojects to monitor and control complex risks. Apart from the experts, the participants or individuals which can affect the successfulness of infrastructure megaprojects are the stakeholders, based on Alfalla-Luque et al. (2015). Moreover, stakeholders also one of the information resources for infrastructure megaprojects, for example on the demand, design and related requirement for the project. Based on the review and finding from the literature, Figure 3 represent the conceptual framework on how to implement risk management into infrastructure megaprojects life cycle. The life cycle of infrastructure megaprojects was synchronized in relation to the level of the risk based on the degradation of colours to represent the amount of uncertainty which is predicted to be greatest in initial phase and tend to decline toward the completion of a project (Alfalla-Luque et al., 2015). For this case, Planning phase was expected to inherit the highest risk and decline toward Decommission phase.

The white arrows depict that each phase of consecutive infrastructure megaprojects life cycle need to initiate the risk management processes, starting from Planning until Decommission phase. Furthermore, throughout the iterative risk management process, project team's compulsory to assess and focus on major risks factor particularly, Social, Technical, Economic, Environmental and Political areas. Furthermore, the involvement of experts/professionals and stakeholders also compulsory throughout the risk management process as well as in infrastructure megaprojects life cycle to offer and provide the proper and appropriate risk response and mitigation measures in order to minimize the risk occurrences and deliver the projects in optimize cost and planned schedule. Moreover, they can offer valuable input and judgement regarding the management of both infrastructure megaproject life cycle and risk management.

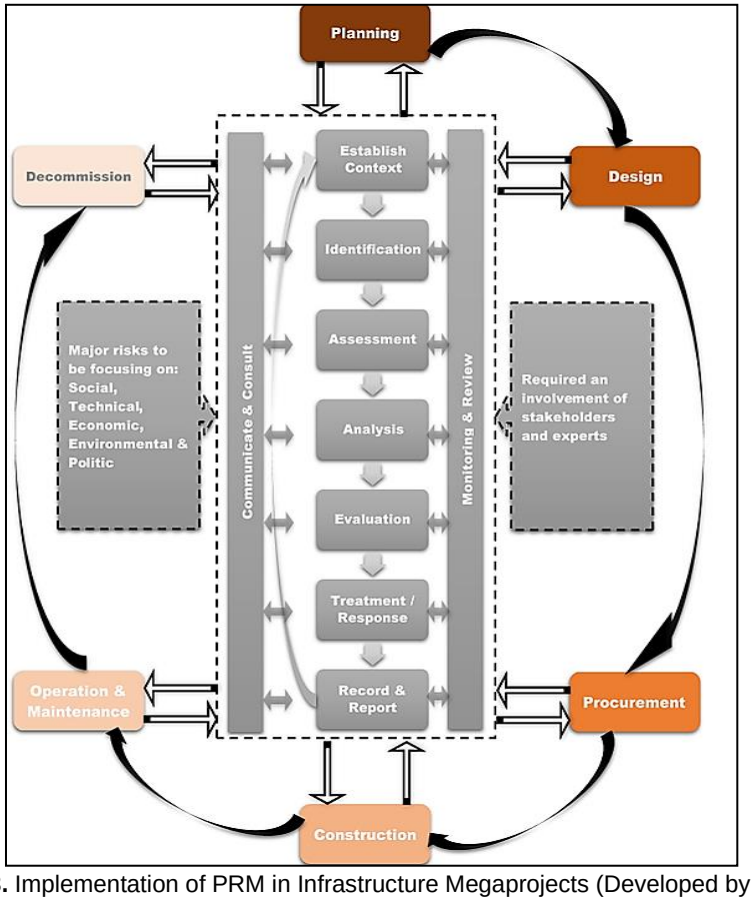

Figure 3. Implementation of PRM in Infrastructure Megaprojects (Developed by author)

The brief overview for the implementation of project risk management into infrastructure megaprojects life cycle were as follows:

Communication and Consultation

To understand the grounds of the decision making, effective communication and consultation must be created by project teams before initiating the risk management process. All phases of the life cycle shall be performed communication and consultation. The risk degree is highest in the project planning phase and the variation along with changes of costs continue to be significantly increased over the life cycle until the completion (PMI, 2017). Hence, project teams should communicate and seek consultation about the occurrence and information about the risks that could lead to cost overrun and project delay throughout infrastructure megaprojects life cycle.

Establish Context

The establishing context step consists of establishing project risk priorities, defining obligation of project risk management criteria, and more precisely outlining the risk parameters for the entirety of the procedure (International Organization for Standardization [ISO] 31000, 2018). The relevant information from the experts, stakeholders and other project teams contribute to a better project risk context for infrastructure projects.

Identification

Risk identification is intended at identifying, recognizing and describing threats and opportunities that could influence the goals of an organization (ISO 31000, 2018). The early identification of risk allows crucial project decisions to take proper account of the risks associated with the project and can result in project strategy changes (PMI, 2017). To related with the literature, project teams should identify the risks associated with Social, Technical, Economical, Environmental and Political (STEEP) since these risk categories could give high impact in infrastructure megaprojects development as reported by Boateng et al. (2017). The identification of risk throughout the life cycle of the project is important since not entire risks can be recognized at any stage in the project.

Assessment, Analysis and Evaluation

Assessment, Analysis and Evaluation phase was the fundamental process of risk management. Based on the literature, those phases were defined differently. However, this paper found most of the industrial reports declare ISO 31000 as a reference for their risk management processes. Risk assessment phase is arguable because ISO 31000 (2018) defined it as overall process of identifying, analysing and evaluating risks whereas PMI (2017) did not specifically mentioned about such phase yet describing about Qualitative Risk Analysis and Quantitative Risk Analysis. From review, ISO 31000 (2018) did not clearly explain about categorization of risks activity which is one of step in Qualitative Risk Analysis under PMI (2017). Meanwhile, Risk Analysis and Quantitative Risk Analysis define about the similar process in both documents. Hence, this paper describes Risk Assessment as risks categorization based on their sources or causes. In infrastructure megaprojects, risks should be specifically categorize based on STEEP to enhance the effective analysis and responses of the project risk. Furthermore, risk analysis includes a comprehensive understanding of the nature and aspects of the risk, including the risk level, where applicable. Whilst, the risk evaluation comprises comparing risk analysis outcomes to the risk parameters designed to facilitate decision-making. This could result in a decision either not to do anything further; to examine risk treatment solutions; to perform further analyses to adequately understand the risks; to maintain current controls, or to revise objectives (ISO 31000, 2018).

Treatment/Response

The risk treatment process involves selecting and implementing one or more options to address the risk occurrences as well as to enhance the chances of project success. The risk treatment strategies suggested by ISO 31000 (2018) involves avoid, taking, remove, changing or sharing the risks. For infrastructure megaprojects life cycle, project teams should focus the treatment on the risks that could lead to cost overrun and delay based on STEEP categories since those risks give a high impact as discovered in the literature. The selection of treatment should consider the experts and stakeholders opinion due to infrastructure megaprojects involve multiple parties which have implication and consequences to every project teams. Based on PMI (2017), each risk should have been assigned to the risk owner, and each corresponding treatment should then be delegated to the associated risk action owner.

Recording and Reporting

The process of risk management and its results should be recorded and communicated through effective procedures (ISO 31000, 2018). This involves communicating risk management actions and performance to provide decision-making input and to enhance risk management exercises. This step is important in the entire process because infrastructure megaprojects deals with various of risk events and a proper record and documentation can facilitate to track down relevant risks in the future.

Monitoring and Review

Monitoring and reviewing encompasses efficient and reliable controls of risk management, achieving more enhancement through risk assessment, reviewing and learning things from risk incidents, detecting external and internal alterations and recognizing emerging risks throughout the project life cycle (ISO 31000, 2018). This phase also should incorporate with the information and recommendation by the experts and stakeholders regarding the risk experiences in infrastructure megaprojects and underlining any possible measures to be implemented.

CONCLUSIONS

Technically, this paper is undertaken to expanding the area of study of PRM by developing a conceptual basis that incorporates PRM into life cycle of infrastructure megaprojects. The conceptual paradigm is developed on the basis of the assessments of several documents, industrial reports and previous papers that concern two fields, namely PRM and infrastructure megaprojects. It also presents an overview of the main concepts of the practices of megaproject risk management process by evaluating public publication and the management of risks in various infrastructure project organizations in Malaysia. In order to improve and further explore its reliability and capability, the established conceptual framework must be tested thus assessing its adequacy and potential to offer benefits toward industry.

This conceptual approach is intended to produce a practical structure for the application of infrastructure megaproject risk management. It is hope could help to enrich the understanding and implementation of PRM between all of the practitioners for coping risk in infrastructure megaprojects construction in Malaysia. Rationally, practitioners could refer to the conceptual paradigm to meticulously incorporate PRM into the life cycle of infrastructure megaprojects with comprehensively. This constructive management of infrastructure megaprojects allows practitioners to make more realistic and reliable decisions in risk management to improve project efficiency in order to minimize project conflicts and lead to successfulness of project.

ACKNOWLEDGMENT

Authors acknowledge the Ministry of Higher Education (MOHE) for funding under the Fundamental Research Grant Scheme (FRGS) (FRGS/1/2018/SSI11/UM/02/7).

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THE BENEFITS AND CHALLENGES OF E-PROCUREMENT ADOPTION IN NIGERIA

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Abstract
Most countries around the world are adopting e-procurement in order to enhance transparency, integrity and accountability in their procurement processes. The current traditional procurement system being carried out in Nigeria is conducted manually and is replete with various problems such as elongated tendering time leading to corruption, time wastage, interference, excessive paper work and manipulation of the tender process resulting in lack of transparency in the entire procurement processes. The methodology used is a conceptual review of literature on e-procurement using a wide range of materials including journal articles, conference papers as well as internet sources. The benefits of, and challenges to e-procurement adoption were divulged. The findings of the study showed that improved transparency, increase productivity, cost saving, improved integrity and reduced corruption in the procurement process are the benefits of e-procurement adoption. The findings also revealed that high cost of investment in IT infrastructure and lack of technical expertise and training are the two factors with the most significant effect on the adoption of e-procurement in Nigeria. Others are political, social, and cultural issues; lack of top management support and legal issues. The study is expected to uncover the actual benefits and challenges in order to facilitate the adoption of e-procurement in Nigeria.

Keywords: *Public procurement; E-procurement; benefits; challenges; Nigeria; E-procurement adoption.*

INTRODUCTION

Public Procurement according to the United Nations (UN) can be defined as the overall process of acquiring goods, civil works and services which includes all functions from the identification of a need, selection of potential sources, contract award and its administration to the end of service or life of asset by a procuring entity using public funds (Thai, 2005). Public procurement can also be referred to as the process of assessing, buying and receiving goods, works and services (Thai, 2005), in a timely and cost effective manner (Thai, 2001). Public procurement accounts for 18.42% of the world's GDP (Ahmed and Mahmood, 2010). Public procurement is widely considered to be one of the most significant tools capable of solving the world's social, environmental and economic challenges (Malolitneva and Dzhabrailov, 2019). Hence, it has to satisfy the basic recipes of good governance: transparency, accountability, and integrity (Vaidya et al., 2006; Wittig and Org, 2003).

Considering the huge amount of resources involved in public procurement and that these resources are owned by the public, government therefore need to ensure accountability and transparency in the process (Hui et al., 2011). Therefore, developed and developing countries need to have a well-functioning public procurement system (Agaba and Shipman, 2007). This has led to the institutionalization by many countries both in the developed and developing countries of various forms of procurement reforms. In Nigeria, the reforms in public procurement started in 1999 after the world bank's report known as the Country Procurement Assessment Report (CPAR, 1999) indicated that prior to 1999 Nigeria lost $10 billion USD on a yearly basis to corruption via award of contracts (Odulana et al., 2019). The objective of the report according to SA Ekpenkhio (2003) was "to reduce the scope of corruption in public procurement and so improve the efficiency in the management of Nigeria's public

expenditures". The reforms got under way when in June 2007 the country passed in to law, the Public Procurement Act 2007 (Act, 2007). The act which is now the current procurement law of the country is in compliance with recommendations of World Bank and to ensure economy, efficiency, competition and ethical standard in the entire procurement processes (SA Ekpenkhio, 2003; Tabish and Jha, 2011). Chikwe and Obi (2016) reported that the Public Procurement Act is set out to achieve the following principles of good procurement objectives: Professionalism, Transparency, Competitiveness and Fairness, Value for Money in the Procurement Process, Efficiency, Accountability, Ethical Approach and Technology. Like most developing countries, e-procurement implementation in Nigeria is at the infancy level. According to Abdullahi et al. (2019), Some organizations have recently automated some aspect of their procurement processes like tender process i.e. tender advertisement, registration of prospective companies and online communication using telephone and e-mail plat forms. However, despite this development, majority of the procurement/tendering processes are still carried out manually. The attendant consequences of which include insufficient utilization of procurement resources, longer procurement cycle and favoritisms among others. Therefore this necessitates the reforms in the entire procurement system.

Despite the reforms however, Adebiyi et al. (2010) maintained that the current traditional system of procurement being carried out in government Ministries, Departments and Agencies (MDAs) through the normal manual ways, suffer from various problems such as excessive delays of approximately 4 to 6 months in tendering or ordering processes, substantial amount of paper work, multi-level scrutiny that result in excessive time wastage, various forms of threats to bidders, human interface at various stages, lack of transparency, preferential treatment in the entire tender process, etc. Traditional procurement system has also been criticized for its lack of efficiency in applying innovations that will bring about industry development (Jalil et al., 2017). This clearly explains the procurement processes in Nigeria which starts with the advertisement for invitation to tender/prequalification of contractors to the tender evaluation to selection of successful bidders to award of contract and finally to the completion of the project in a manual manner. This procedure does not guarantee a timely processing of purchase order and meeting up of the delivery/completion date.

Various researchers have alluded to the myriads of problems bedeviling the traditional procurement systems. In South Africa, Pooe et al. (2015) identified four major problems in militating against the achievement of procurement objectives. These were: lack of training; lack of capacity; lack of transparency; and the failure to comply with existing procurement policies. In Uganda, (Agaba and Shipman, 2007) submitted that the major barriers to the success of procurement reforms were: extremely vested interests and lack of political will; shortage of technical knowledge and capacity; and the complexity of the substantive issues involved, particularly the type of legal instruments to be used. Consequently, the problems of procurement systems in Nigeria were summarized by Wahab (2006) as follows: absence of project cost/benefit analysis to justify the need for the project; lack of transparency and competition in project procurement which lead to high cost of projects; unjustifiable disparity between budget and actual released leading to underfunding, delayed completion, price escalation and project abandonment; and lack of adequate project monitoring to ascertain compliance with specifications. Other problems include frequent government interference and reversal of policies; preference for new projects to the detriment of the completion of the existing ones; and failure to advertise projects or where advertisement was made, the rules are made in such a way to give competitive advantage to predetermined winner.

However, it is believed that if the procurement process is designed properly, it will bring about the needed transparency and innovations in the procurement process thereby improving government's services and enhance users' experience (Odulana et al., 2019). To achieve this, Odulana et al. (2019) further explained that e-procurement has been identified as the potential instrument to mitigate against corruption in the public service processes, by eliminating to a considerable degree face-to-face interaction among stakeholders where most demands for kickbacks often emanate (Pictet and Bollinger, 2008). Neupane (2014) hinted that a lot of scholars and leaders in many countries around the world have come to the realization that the implementation of information and communication technology (ICT) tools such as electronic procurement is an essential way to any sincere attempts to reform the government procurement system.

Various researchers like (Adebiyi et al., 2010; Davila and Gupta, 2003; Nasrun et al., 2016) have highlighted the numerous benefits of adopting e-procurement and processes. These benefits include promotion of efficient and effective procurement process, provision of up to date product information and pricing, promotion of widespread adoption of e-business in the government. In China, e-procurement promoted regulation of financial activities and efficiency of financial expenditure while the Korean online e-procurement system (KONEPS) provides one-stop services which led to faster handling and performance transparency by eliminating inefficiency in administration process, thereby contributing to the savings in the national budget. Overall, implementation of the e-procurement leads to savings of over 40% in purchasing transaction cost (Davila and Gupta, 2003). Despite the perceived benefits however, organizations are yet to realize the full benefits of e-procurement (Adebayo and David Evans, 2016).

Many developed countries have successfully adopted e-procurement technologies and processes (Al-Hudhaif and Alkubeyyer, 2011). However, studies like (Afolabi et al., 2019; Uzoka et al., 2007) have shown that the uptake of e-procurement in Nigeria is low and moving at a very slow rate. This is more evident in the public sector as only 20% of government ministries, Department and Agencies have used e-procurement systems in the building industry as against 60% in the private sector (Afolabi et al., 2019). This means that in spite of efforts made by organizations to use e-procurement technologies and applications to support their procurement activities, challenges still exist that inhibit the success of these efforts (Aduwo et al., 2016). This study is therefore set to investigate the benefits and challenges to the adoption of e-procurement in Nigeria. The knowledge of these challenges will enable organizations to develop ways of mitigating them, while that of the benefits will lead to the speedy adoption of e-procurement.

RESEARCH METHODOLOGY

This article is exploratory in nature. A conceptual review of literature on e-procurement was carried out using a wide range of materials including journal articles, conference papers as well as internet sources. Conceptual analytical approach is applied in addressing a particular problem so as to understand it's nature, scope and function with regards to a given phenomenon (Furner, 2004). Conceptual analysis is used in order to get a better understanding of e-procurement practices in Nigeria. In light of the method discussed, this study examined: (i) The benefits of e-procurement adoption, (ii) The Challenges of e-procurement adoption, and (iii) E-procurement in Nigeria.

BENEFITS OF E-PROCUREMENT ADOPTION

Electronic procurement or e-procurement has been defined by Neupane (2014) as 'the use of any Internet based inter-organizational information systems which automates and integrate any parts of procurement process in order to improve efficiency, transparency, and accountability in the wider public sector" (Vaidya et al., 2006). Conversely, Davila and Gupta, (2003) also defined e-procurement as the use of Information and Communication Technology (ICT) such as the Internet or web-based systems designed to facilitate the acquisition of goods and services by the government or by private institutions. It has played an excellent role in the successful management of public resources and more importantly the enhancement of transparency, integrity and accountability of government procurement (Ahmed and Mahmood, 2010).

The Internet is widely used for providing comprehensive information about bidding at a single web portal that can be accessed by the government and all the registered potential bidders. Recently, countries of Asia and the Pacific have increasingly adopted ICT systems in order to better government services and business transactions (Wescott, 2001). Vaidya and Hyde (2011) opined that e-procurement has been accepted in advanced countries like United States, United Kingdom and Australia and in emerging economies including India, China, South Korea, Brazil and Mexico, which are already implementing e-procurement initiatives. It is seen as an effective way to boost transparency and accountability (Moabit, 2006).

E-procurement is fast becoming the model procurement method in both the public and private sectors. With the advent of the Internet, many businesses now sell only via computer technology. It is an excellent platform for businesses to cut overhead costs and reach a larger customer base (Adebiyi et al., 2010). Currently, the literature is replete with the benefits of implementing e-procurement systems as a solution for poor managerial process. In their study, Davila and Gupta (2003) showed that firms that adopt e-procurement system experience above 42% savings in their transaction costs primarily as a result of the ease in the purchase process and the reduction in the sequence of time required for purchase, which in turn, improves flexibility and offers updated information at the time of placing a purchase order (Odulana et al., 2019). Furthermore, According to Eadie (2007), an organization which uses e-procurement has the advantages of price reduction in tendering since there is no paperwork, postage fee and other costs associated with preparation and sending tender documents, and also the reduction in time to source materials.

Evaluating the benefits of e-procurement platform in the construction industry in Nigeria, Afolabi et al. (2019), showed that it is an innovative tool that can reduce many of the challenges in the Nigerian construction industry notably corruption, lack of efficiency and transparency, internal and external interference and cumbersome procedures, which have resulted in to a significant waste of government resources. In the same vain, Aduwo et al. (2017) argued that e-procurement facilitates easy documentation and ensures exchange of information are done accurately, efficiently and at the lowest transactional cost. According to Lindsley, G. & P (2008), e-procurement systems can address the challenges experienced in the traditional processes of procuring goods and services in the construction sector. Corroborating this position, Oyediran and Akintola (2011) affirmed that e-procurement platforms are capable of increasing productivity in the construction framework while equipping construction stakeholders to adequately monitor the procurement process. In

addition to this, their study also identified the benefits of cost-saving as a result of fewer paper-based transactions and increased efficiency. This is consistent with the findings of Nasrun et al. (2016) who averred that the significant cost saving of e-procurement to the government is in the reduction of cost and effort of processing the purchase order which can be manipulated electronically, as well as the marked reduction in inventory costs and decreased order fulfilment time. Conversely, Weippert et al. (2002) opined that the e-procurement platforms increase competitiveness and opportunities among construction organizations. In developed countries however, Kim (2010) explained that the use of e-procurement is emphasized due to its ability to optimize cost while in South Korea it is the underlying benefits of increasing transparency and minimizing procurement transactional cost that encouraged the use of the platform. The results from Adebayo and David Evans (2016) also showed that e-procurement adoption helps to improve transparency, integrity and reduce corruption in the procurement process. Neupane et al. (2012) summarized some of the numerous benefits of using public e-procurement in the public sector to include: Centralization of data in order to improve audit and analysis, eliminates the direct human interaction on bidding and other works and services, improves better interaction between supplier and vendors. A summary of the benefits is presented in Table 1.

Table 1. Benefits of e-procurement adoption

Benefits	Authors (year)	Location	Sector
Reduction in corruption and inefficiency, increased transparency and procedure simplification.	Afolabi et al. (2019)	Nigeria	Construction industry
Savings up to 42% in transaction costs.	Davila & Gupta (2003)	United States	Mining, technology, manufacturing, food processing, transportation and communication.
Centralization of data to improve audit and analysis, elimination of human interaction on bidding and other services and better interaction between supplier and vendor.	Neupane et al. (2014)	Nepal	Public sector
Price reduction in tendering process.	Eadie (2007)	United Kingdom	Construction industry
Cutting overhead cost and reaching larger customer base.	Adebiyi et al. (2010)	Nigeria	Public sector
Increased productivity in the construction framework and enabling proper monitoring by stakeholders.	Oyediran & Akintola (2011)	Nigeria	Construction industry
Cost saving and increased efficiency in processing purchase order, reduction in inventory costs and decreased order fulfilment time.	Nasrum et al. (2016)	Malaysia	Telecommunication sector
Increased competition and opportunities among construction organizations	Weippert et al. (2002)	Australia	Construction industry
Cost optimization, increasing transparency and minimizing procurement transactional costs.	Kim (2010)		
Improving transparency, integrity and reduce corruption in the procurement process.	Adebayo and Evans (2016)	Nigeria	Public sector
Easy documentation, making exchange of information more accurate, efficient and at the lowest transaction cost.	Aduwo et al. (2017)	Nigeria	Building industry

CHALLENGES OF E-PROCUREMENT ADOPTION

The published literature is filled with findings regarding the organizational and human factors influencing e-procurement adoption in the different business and industrial sectors. Based on previous researchers, there are factors that contribute to challenges in the adoption of e-procurement. In Nigeria, Aduwo et al. (2016) investigated the factors influencing e-Procurement among 213 professional consulting firms, contractors, client organizations, and government establishments in the Nigerian building industry. That results revealed that the two factors with the most significant adverse effect on the uptake of e-Procurement were the high investment cost, and lack of technical expertise required in setting up e-procurement technologies and processes. The study also identified Technical, infrastructure, political, social, and cultural issues; the lack of evidence of the benefits of e-procurement in the building industry; and lack of top management support as the three strongest predictors of low uptake of e-procurement by the organizations they surveyed. A summary of the challenges is presented in Table 2.

Table 2. Challenges of e-procurement adoption

Challenges	Authors (year)	Location	Sector
High investment cost, lack of technical expertise, infrastructure, political, social and cultural issues, lack of evidence of benefits of e-procurement, lack of top management support.	Aduwo et al (2016)	Nigeria	Building industry
Fear of change to a new system, lack of skills and knowledge of e-procurement, lack of interoperability and standards with legacy system and insufficient financial support.	Nasrun et al (2016)	Malaysia	Telecommunication sector
Lack of planning, policy development, change management strategies, human resource management.	Aduwo et al (2017)	Nigeria	Building industry
Lack of budgetary allocation for e-procurement adoption, lack of top management support and employee skills & knowledge of e-procurement technologies and tools.	Gunasekaran & Ngai (2008)	Hong Kong	Private sector
Lack of top management support, firm size, perceived indirect benefits and business partner influence.	Al-Moalla & Li (2010)	United Arab Emirates	Public sector
Inadequate knowledge of e-procurement, infrastructure, culture, security and legal issues.	Laryea & Ibem (2014)	South Africa	

This is consistent with the study by Nasrun et al. (2016). Adebayo and David Evans (2016) also established that fear of change to a new system, lack of skills and knowledge of e-procurement, lack of interoperability and standards with legacy systems and insufficient financial support as the main barriers to the implementation of e-procurement in Nigeria. This result justifies the study by (Abdullahi et al., 2019). In another research, Al-Moalla and Li (2010) investigated the organizational issues associated with e-procurement adoption by public sector organizations in the United Arab Emirates. The authors reported that e-procurement adoption by government institutions in that country was influenced by planning, policy development, change management strategies, human resource management, and staff education and training. Based on the findings of the literature review, Patel et al. (2016) observed that the organizational factors influencing e-procurement adoption in the different business and industrial sectors are basically budgetary allocation for e-procurement adoption, top management support (i.e. organization's policy on ICTs use), and the employees' skills and knowledge of e-procurement technologies and tools. In the construction sector, Teo, Lin,

and Lai (2009) examined the factors that influenced e-procurement adoption among 141 companies, including architecture/engineering/ construction firms in Singapore. The authors found that, among other factors, the firm size, top management support, perceived indirect benefits, and business partner influence were positively and significantly associated with e-procurement adoption by firms in that country. Their result is analogous with the study of (Patel et al., 2016).

The most important factors influencing the adoption of e-procurement in the order of importance were the benefits of e-procurement in ensuring efficient project delivery process, removing geographic impediments, and enhancing effective communication by the participants in the building procurement process. Laryea and Ibem (2014a) identified barriers to the adoption of e-Procurement in South Africa to include Infrastructure, Culture, Security, Inadequate Knowledge of E-Procurement and Legal Issues. These factors can also apply to Nigeria since Laryea and Ibem (2014a) reported Nigeria and South Africa share socio-economic and technological similarities.

E-PROCUREMENT IN NIGERIA

In Nigeria, the procurement system is largely manual based where all the various processes and procedures are conducted manually by the procuring entities in accordance with the guidelines contained in the public procurement act of 2007. In order to modernize and sanitized its public procurement system, Nigeria announce the introduction of e-Government Procurement on August 2016 at a stakeholders' workshop attended by over 500 participants (Osoba, 2016). As a follow up to this, in October 2018, the Director General of Bureau of Public Procurement (BPP), the government agency responsible for overseeing all procurement activities of government attended the Global Public Procurement Conference in the US which saw 13 African nations, including Nigeria, commit to using e-procurement platforms to streamline public procurement. This came at a time when in the same year, Nigeria was ranked 169 out of 189 economies on the ease of doing business. This introduction is supposed to signal the adoption of E-Procurement in the country.

However, the implementation of E-Procurement in Nigeria is still at an elementary stage (Abdullahi et al., 2019). Ibem et al. (2016) submitted that in the Nigerian construction industry, the use of e-procurement has not been given the desired attention both in the usage as well as in terms of research efforts. Firms' participation in e-procurement is very low as few organizations have automated some part of their procurement processes. Procuring entities that automated some aspects of their procurement activities according to Abdullahi et al. (2019), include the BPP and the Nigerian National Petroleum Corporation (NNPC). The BPP uses a web-based portal for the classification and categorization of contractors and consultants. A lot of consultants and contractors have been registered using this medium. The BPP has also developed a web-based e-procurement system known as Public Procurement Review Software (goPRo) to aid in discharging their oversight functions of monitoring public procurement processes like bid solicitations and award of contract by public procuring entities across the country. The system is made up of two different software i.e. goPro express and goPro web. The NNPC has implemented a system called Nigerian Petroleum Exchange Joint Prequalification System for prequalification of companies intending to partake in bidding for oil and gas contracts in the country; and an Electronic Marketplace (e-Marketplace) for processing of contract.

Hence it is clear that Nigeria is facing some challenges with regards to the e-procurement adoption especially in key areas of implementation and training. Organizations have not fully employed the e-procurement adoption initiative of the government due to the identified challenges. The few that implement it have only done that partially. These challenges have therefore hindered the attainment of the benefits of e-procurement as enumerated earlier.

While research has shown that in Nigeria the actual users of e-procurement technology is the private sector, the reverse is the case for developed countries like the United Kingdom. A research by Eadie (2007) showed that government of the United Kingdom plays a crucial role in the high adoption of e-procurement technologies by the public sector when compared to their counterpart in the private sector. This indicate that in Nigeria, the private sector takes the lead in terms of e-procurement adoption. Egidario B. Aduwo et al. (2017) opined that the result seems to be similar to the situation in the South African construction industry, where Laryea and Ibem (2014a) also reported that the private sector was taking the lead in e-procurement use. They explained further that the socio-economic and technological similarities between Nigeria and South Africa could be responsible for the similarity in the results.

FINDINGS AND DISCUSSION

This review has investigated the benefits and challenges of e-procurement adoption in Nigeria. The study identified four major benefits of e-procurement adoption. These are: cost savings, reduced corruption, increased productivity and improved transparency and integrity. Consequently, the study identified the challenges in e-procurement adoption as: high investment cost in IT infrastructure, lack of technical expertise, lack of top management support, poor internet and ICT infrastructure, unreliable power supply, lack of skills and knowledge of e-procurement and insufficient financial support. The benefits of and challenges of e-procurement adoption are discussed below.

The adoption of e-procurement helps to improve productivity and transparency. As procurement involves several activities that are fragmented in nature and requires the input of several stakeholders, this creates problems in processing data using paper-based techniques and processes. E-procurement can be used to enhance the efficiency of the procurement processes. This is consistent with Egidario B. Aduwo et al. (2017) who explained that firms leverage the internet-based technologies and processes of e-procurement to improve the level of efficiency and productivity in the procurement of building works and services and infrastructure. Furthermore, effective implementation of e-procurement will assist in reducing corruption and unethical practices in the procurement process. Through the automation of procurement processes, human interference and favoritism are reduced to a considerable extent. This is consistent with the findings of Odulana et al. (2019) who argued that the best anti-corruption approach is to reduce lithographic works and physical contacts in the procurement processes.

From the results of this study however, the factor that posed the greatest challenge to the adoption of e-procurement in Nigeria is high investment cost in IT infrastructure. This economic factor is related to the financial capability of organizations to acquire, use and maintain e-procurement technologies and tools as provided by the vendors. This result justifies the findings by Robert Eadie et al. (2011) who identified high information investment

cost in UK as a key barrier to the adoption of e-procurement. The result is also consistent with that of Laryea and Ibem (2014b) who fond high cos of internet services as one of the barriers to e-procurement adoption in the South African construction industry. The other challenge is the lack of technical expertise to handle e-procurement technologies and tools in the organizations. This is obvious since e-procurement technologies and processes are relatively new and require trained personnel for their successful implementation in organizations. This result is consistent with the results of (Isikdag and Underwood, 2013; Laryea and Ibem, 2014b). This implied the organizations are yet to develop the expertise required for the successful adoption of e-procurement.

The other challenges to the adoption of e-procurement in Nigeria are poor internet and ICT infrastructure and unreliable power supply. This is consistent with the findings of Oyediran and Akintola (2011), but these are external barriers which are beyond the control of individual organizations. Despite the huge internet users in Nigeria, the quality of internet services in the country is not encouraging. Initially, access to internet was limited to major cities and towns and the cost of internet is quiet high. This situatuation is attributed to the poor state of ICT infrastructure in the country. The current availability of the internet services does not meet the demand of the huge population of the country. Conversely, the current supply of electricity in the country is less than 6,000 megawatts, which is not enough to serve one state alone out of the 36 states of the country and Abuja. Since internet technologies and processes rely on constant power supply, it is difficult for organizations to use these technologies in the absence of constant power supply. Other challenges to the adoption of e-procurement in order of their high impact are technical, infrastructure, political, social, and cultural issues, lack of top management support, lack of awareness on e-procurement use, the lack of evidence of the benefits of e-procurement and lack of financial support as listed in Table 2. These explained why organizations could not participate in e-procurement. The lack of top management support as a barrier to the adoption of e-procurement was also confirmed by other researchers like (Isikdag and Underwood, 2013) and (Eadie et al., 2007) to be a key barrier in the adoption of e-procurement in the construction industry in Turkey and UK respectively. Another important factor with high impact on the challenges of e-procurement adoption in the Nigerian building industry is perceived lack of evidence of the benefits of e-Procurement. This accounts to a large for why most organizations have not participated in e-procurement. The finding validates previous studies of (Laryea and Ibem, 2014a) and (Aranda-Mena et al., 2004) in the South African and Australian construction sectors respectively.

In order to mitigate the challenges to the adoption of e-procurement in Nigeria, Afolabi et al. (2019) evaluated critical success factors for the adoption of e-procurement and submitted that these factors are crucial for the adoption of e-Procurement systems in the Nigerian construction industry. The availability of reliable, affordable, and fast Internet services are considered as having the highest impact for the adoption of e-Procurement technologies in Nigeria. E-procurement technologies and processes are web-based systems that require internet to function. This result has justified previous researches alike (Aduwo et al., 2016) and (Oyediran and Akintola, 2011). For the success of e-procurement adoption, there is a need for adequate investments in the internet infrastructure and electricity supply. In fact, the provision of constant power supply is critical in the adoption of e-procurement technologies. Top management support is crucial for the adoption of e-procurement. It is within the purview of top management to provide the adequate support towards ensuring organizational readiness

for e-procurement adoption. The employment of skilled personnel and the type of in-service training they are exposed to within the organization requires top management support. This is in line with Egidario B Aduwo et al. (2017) who averred that organizations that would mostly adopt e-procurement systems are that whose senior management support the use of e-procurement systems and have the attitude of aligning with the current global trend. This review has established that e-procurement adoption helps to improve transparency, integrity and reduce corruption in the procurement process. The findings of this study are presented in Tables 1 & 2 which represent the benefits and challenges of e-procurement adoption respectively in Nigeria.

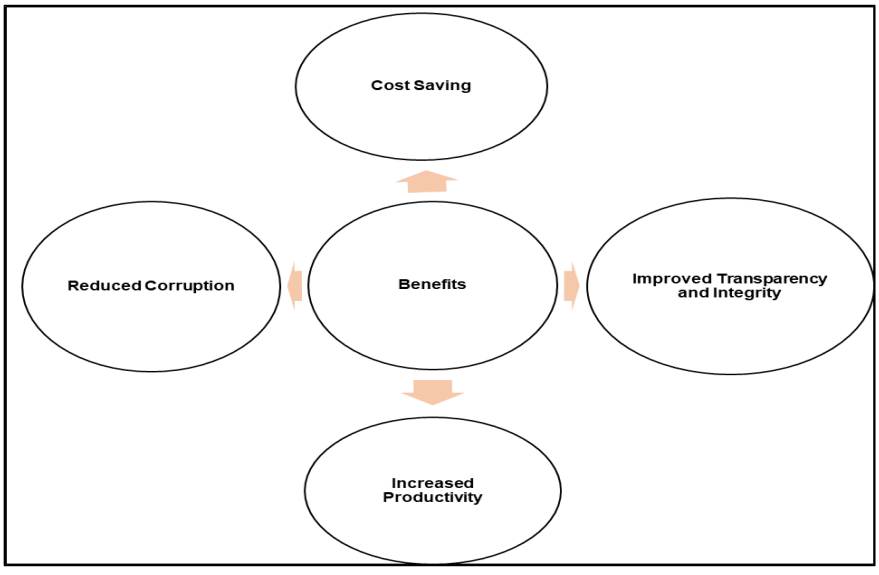

Figure 1. Benefits of e-procurement adoption

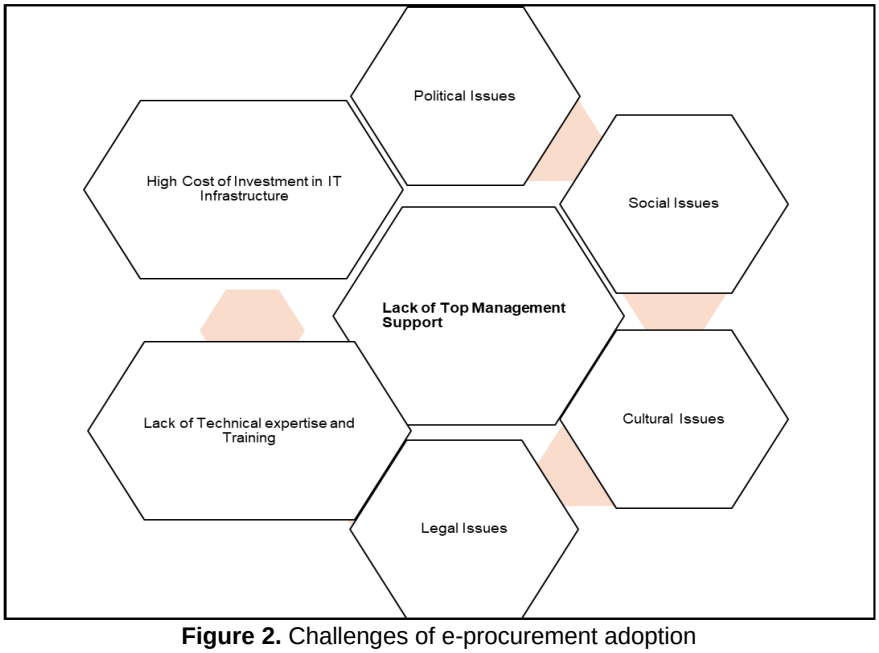

Figure 2. Challenges of e-procurement adoption

CONCLUSIONS AND RECOMMENDATIONS

The study investigated the benefits and challenges of e-procurement adoption in Nigeria by reviewing the existing literature. E-procurement is a veritable tool that will enhance the efficiency of the entire procurement processes. However, the adoption of e-procurement in Nigeria is at the infancy stage, the adoption rate is very slow despite the enormous benefits derived therefrom. The study revealed the low participation of public sector in e-procurement as compared to the private sector. The study revealed that factors with the most negative effect on e-procurement adoption are high investment cost on e-procurement technologies and tools and the lack of technical expertise to handle e-procurement technologies and tools in the Nigerian building industry. The study further revealed that the availability of reliable, affordable and fast internet services, constant power supply and a trained and skilled personnel are the most critical factors for the adoption of e-procurement in Nigeria. The benefits of e-procurement adoption are cost saving, reduced corruption, increased productivity and improved transparency and integrity. The recommendations for the study are as follows:

- Since Nigerian government is in the process of adopting e-Government in the country, it is expected to provide the required leadership and policy framework for the adoption of e-procurement, as well as the necessary ICT infrastructure needed.
- Procurement officials need to be adequately trained on ICT and e-procurement in order to create the necessary awareness of the e-procurement tools and technologies and the benefits to be derived from its use.
- Most of the studies conducted in Nigeria on e-procurement are limited to private sector, therefore future studies should be focused on public sector adoption of e-procurement in the country.

The first impact of the study is that, since Government is preparing to implement its e-Government policy across the nation, it has acquainted the authorities concerned that there is a future possibility for success in the use and maximization of the benefits of e-procurement in Nigeria. This can only be achieved when there is availability of reliable and affordable ICT infrastructure and knowledgeable construction professionals across the country and supportive legal environment. This would encourage the uptake and sustained use of e-procurement in the country.

The second impact is the need for collaborative actions by all stakeholders to eliminate the technical, infrastructure, political, social, and cultural barriers to the adoption of e-Procurement in Nigeria. This calls for the government to take a leading role in the formulation of legislation and establishment of robust regulatory framework for the uptake of e-Commerce in the country.

The third impact of the study is that it contributes to knowledge by providing insight in to the benefits as well as challenges to the adoption of e-procurement in the procurement systems and processes of Nigeria. Findings of this study are therefore expected to add to the growing literature on e-Procurement in construction from the perspective of a developing country.

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MEASUREMENT MODEL OF IBIM IMPLEMENTATION IN AECO INDUSTRY: PLS-PM APPROACH

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Abstract
The Aim of this paper is to determine the measurement constructs of Integrated Building Information Modelling (iBIM) implementation within Architectural, Engineering Construction and Operation (AECO) industry. The literature showed some factors influence iBIM implementation in AECO projects under three dimensions, namely Technology, People and process. A hierarchical model was used to comprise the three dimensions of iBIM implementation and their indicators. Data were collected through a questionnaire survey was used for data collection. The study population were BIM professionals working on AECO firms in Malaysia. A total of 322 valid questionnaires were collected. The study model was identified using Confirmatory Factor Analysis (CFA). Principal component analysis (PCA) was used to identify the components of the hierarchical model of iBIM implementation. Validity, reliability, and quality of the model were measured using partial least squares-path modelling (PLS-PM).The results affirmed three constructs of iBIM implementation. This paper gave a comprehending for professionals and team members of AECO projects about factors that influence iBIM implementation. The paper emphasized the iBIM implementation perspective and contributed to developing a hierarchical measurement model of iBIM implementation in AECO projects. New initiatives can be proposed by industry players in response to the new perspective of iBIM. Finally, the paper provides a development of iBIM implementation hierarchical models as a measurement latent variable.

Keywords: *Integrated Building Information Modelling; AECO industry; lifecycle; PLS-PM.*

INTRODUCTION

Information and Communication Technology (ICT) has developed significantly and adopted in the Architecture, Engineering and Construction and Operation (AECO) industry in decades. In recent years, Building Information Modelling (BIM) arises as an ICT tool that solve problems such as errors, rework etc. BIM is expected to improve the inherent quality of building design information dramatically and the communication methods such as design information that shared among different construction projects teams (Crotty, 2013; Lu et al., 2013). Moreover, BIM is expected to integrate, maintain and update all the relevant information related to a construction project consistently, to facilitate coordination work through its visualization and clash detection analysis functions, to serve as a collaborative platform for professionals from different disciplines, and even to play as the driving-force of Integrated Project Delivery (IPD) (Eastman et al., 2011). Integrated Building Information Modelling (iBIM) can be defined as a combination of cloud computing systems with computer-based building information model BIM, which is enable users for accessing, storing, integrating data and information, as well as visualizing and checking the whole data emerging with the lifecycle of construction project (Taylor et al., 2009). The integration BIM with cloud computing technologies breed a creative working pattern organising communication with the onsite processes. Besides that, cloud computing technology develops

an enhanced accessibility of project information easily by remotely linking mobile devices with a devoted remote server (Abanda et al., 2018). Currently, iBIM process enables major construction teams to collaborate in a single iBIM cloud database. Multi disciplines team members from all over the continents can participate and cooperate effectively on a single project, despite the different time zones and places (Almashjary et al., 2020). However, despite the huge information, data, and models are created by BIM technology, collaboration through the different phases of the construction project have been depended on the traditional exchange of 2D drawings and documents (Gu et al., 2008a; Singh et al., 2011; Systèmes, 2014). Moreover, the BIM adoption level in the AECO industry is very low, whereas lots of construction projects teams have not worked based on the new iBIM technology (Merschbrock & Munkvold, 2015; Papadonikolaki et al., 2015; Smits et al., 2017).

Researchers and practitioners have found a succeeded collaboration that expands organisational limits improves the overall performance of the design and construction effectively. They both argue adopting iBIM should drive to tighter collaboration and closer communication among construction project players working in cross-organisational environments (Homayouni et al., 2010). Besides, there is increasing evidence of the positive impact of BIM on project performance in addition to iBIM's real effect on collaboration (Poirier et al., 2017). The process of establishing the iBIM is actually the process of accumulating, expanding, integrating and applying the construction life data. By integrating each stage or sub-information model created by each application to form a complete BIM. BIM provides a viable way to achieve its corresponding data access and control to the BIM information. Effectively, iBIM solve the storage and distribution of the fragmented information and models, sharing and coordination issues. (Wang, 2017).

The aim of this paper is to determine the measurement constructs of iBIM implementation within AECO industry. The establishment of such factors is critical to understand the concept of iBIM in-depth. This in turn assists management and project team to comprehend how those factors influence iBIM implementation. The purpose of this paper is to develop a measurement model that determines the factors of iBIM implementation and their indicating variables. This model would facilitate testing the relationship between iBIM implementation and other factors. Furthermore, the development of this model will contribute the body of knowledge regarding to the factors of iBIM implementation in the context of AECO. This will provide further development of iBIM implementation theory in AECO field. Based on the literature, a conceptual framework of iBIM implementation developed and presented in the following section. The framework consists of three aspects of iBIM implementation, namely, Technology, people, and process. Data collection, questionnaire survey, and methods for testing the proposed framework are presented in the methodology section. Results section report data analysis and discuss results. Finally, the last section concludes the study.

BIM introduces a virtual n-dimensional (n-D) models that help in achieving many purposes during design, construction or operation of any project (Masood et al., 2014). In other words, BIM does not provide the only 2D, and 3D dimensions to illustrate the architectural drawings to owners. It takes the construction projects to another dimension. Figure 1 illustrates the different dimensions of BIM.

- 2D: the traditional CAD software was used to prepare 2D drawings which do not provide enough information to users(Memon et al., 2012). Moreover, the 2D CAD approaches usually suffer from a clash of information and do not integrate the drawings with cost and schedule (Masood et al., 2014).
- 3D: 3D modelling has been started in the manufacturing industry to simulate products. However, the 3D modelling in the construction industry was delayed due to the computing cost and the widespread use of CAD (Eastman et al., 2011). 3D design modelling introduces more comprehensive view compared with the 2D design. Accordingly, the design quality is greatly improved and many human errors are avoided.
- 4D: BIM 3D model has been enhanced to be 4D through inclusion the construction schedule information in the project's model. 4D models help the various project players such as designers, engineers, MEP consultants, owners, and contractors to realize the total duration of different project phases and also illustrates the completion rate of the project's activities.
- 5D: 5-dimensional (5D) modelling includes adding cost/budget information to BIM model. This feature enables the project players to visualize the cost of different construction activities as well as the total cost over the time.
- 6D: 6-dimensional (6D) modelling means adding facility management (FM) components to BIM model. In other words, BIM model can be used during the building post-construction phase through extending the model with the information related to all aspects of operational performance of building (McArthur, 2015).
- 7D: 7-dimensional (7D) modelling includes adding sustainability information to BIM model such as carbon emission, manufacturers' details, and recycled content and so on. Based on this information, BIM model can simulate and analyze the complex building performance to identify many features that can be used for sustainability assessment such as energy consumptions, thermal analysis, solar analysis, and day lighting (Azhar et al., 2009).

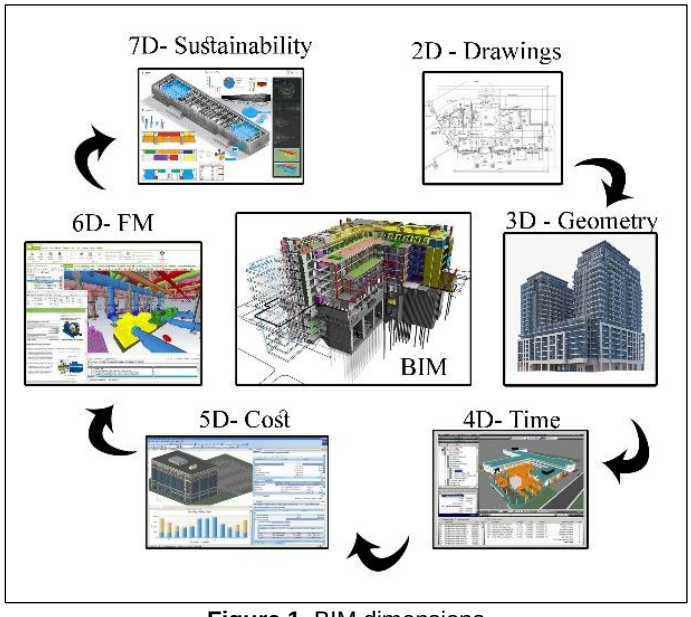

Figure 1. BIM dimensions

FRAMEWORK OF IBIM IMPLEMENTATION

Literature lacks a precise definition of iBIM. According to Häkkinen and Kiviniemi (2008), iBIM is a database of all BIMs containing the information of a building covers not only geometry, spatial relationships, quantities ,and geographic information. Furthermore, it is an advanced state of BIM that can be used to represent the entire lifecycle of the construction project including the processes of construction and facility management. As a source of information, iBIM can conduct analysis for best solutions as well as to store the results of analysis for further purposes (Taylor et al., 2009). BIM implementation is vital to three interrelated factors: people, technology, and process (Enegbuma et al., 2014; Gu et al., 2008a; Megahed, 2015; Shafiq et al., 2012; Succar, 2009). Indeed, BIM is about people and process as much as it is about technology. According to (Enegbuma et al., 2014; Gu et al., 2008a; Shafiq et al., 2012; Succar, 2009) studies, these factors support the structure of the proposed framework. However, these factors do not have fixed boundaries but are merged with each other, and each is integral to the performance of the others. the following subsections introduce and summarize each factor inserted in the framework.The factors that influence iBIM implementation in the AECO industry are classified into three major categories: technology, people and process.

Technology Category

Currently, software vendors firms have developed tools of BIM due to the market demand and to enhance the quality of BIM process. According to (Yaakob et al., 2016), it has been proven that there is a must to integrate BIM software, because no single tool can achieve all the needs of project. The divergence of BIM software led to compatibility problems. Cost of the BIM technology is one of the main challenges in implementation of iBIM. Model management in iBIM also consider a challenge by many BIM users. Cost of software and required hardware upgrades consider top challenges of iBIM implementation (McGraw-Hill construction, 2008; Taylor et al., 2009). Conducting training for employees to utilize new systems and technology is a costly process. Nevertheless, the degree of top-level management support lead to the success of participating organisations in adopting new technologies such as BIM within AECO industry (Merschbrock & Munkvold, 2015). Construction companies usually tend to standardize the version and tools for information exchange. Nevertheless, the teamwork often find problems in access to the different types of information due to the divergent of applications versions. It is hard to identify the changes from previous versions in case of changing versions (Eastman et al., 2011; Gu et al., 2008b; Liu et al., 2017; Shafiq et al., 2012; Shafiq et al., 2013). There is growing need for the shared model in the multidiscipline construction projects. Therefore, for successful collaboration for the models, it is necessary for the different players to access the information and to be shared, viewed, coordinated and managed. Usually, the model management with external teams faced some difficulties (Enegbuma et al., 2015; Gu et al., 2008a; Shafiq et al., 2012).

People Category

Traditional practice in construction project has been dominated most of the organisations in AECO industry. However, there is a limited collaboration among the construction players because of many aspects such as of culture differences and resistance to change. For instance, professionals prefer hardcopy rather than softcopy to review designs of construction project.

Experience and leadership are required to utilize BIM successfully by professionals as well as define their roles and responsibilities which need a certain training programs for them. Moreover, this training program must be in line with global demand (Yaakob et al., 2016). Leadership considering one of the major factors for iBIM implementation within the AECO industry. Generally, the collaborative teams using the iBIM need a leadership to produce an efficient work; it could be difficult due to the separation between the different parties of the construction projects (Eastman et al., 2011; Liu et al., 2017; Taylor et al., 2009). On the other hand, there was a critical apprehension about the models exchange due to the major shift in the responsibilities and roles of the in process of exchanging and sharing models. However, the main barrier is the roles' assignment. iBIM mainly depends on information centralisation that is constant updating, broadly accessible as well liable. As with many factors that related to BIM implementation, the measurement of return on investment increases as the BIM obtains experience regarding to the level of involvement which is consider logical progression. BIM experts are prefer to have a comprehension of the specific factors that related to BIM which play a significant role of in tracking the return of investment (Azhar et al., 2011; Hardin & McCool, 2015). In other words, intermediate and beginner users should have trust on BIM benefits. Moreover, many AECO industry professionals believe that BIM training begins in academic education, particularly in colleges and universities which consider the perfect environment to face AECO industry challenges (Eastman et al., 2011; Merschbrock & Munkvold, 2015; Singh et al., 2011).

Processes Category

Process challenges such as data fragmentation, information security, data input and information exchange are frequently rise in BIM-based projects by AECO industry players. The BIM process challenges could lead to ineffective communication, information sharing, and cause trust issues among project players and sometimes can cause failure of construction project (Yaakob et al., 2016). Data Fragmentation issues obstruct the development of AECO industry (Khosrowshahi & Arayici, 2012). Some types of information need to be fragmented or sub-models generated due to requirements of each different phase of the project. There is an obvious isolation between the different phases through project lifecycle with formal data flow after each phase. Thereupon, the data is usually missed in the next phase delivery (Hoeber & Alsem, 2016; Lucas et al., 2009). According to Soust-Verdaguer et al. (2017), during the BIM process, data input is consider the most time consuming phase. Nevertheless, in the design early stages that are defined via BIM Modelling, the development of the BIM model gives manageable and flexible elements by designers. In this regard, the LOD of the BIM model defines the level of detail that will be developed through the different BIM tools (Soust-Verdaguer et al., 2017). Due to missed data on many projects, the integrated BIM model dose not achieve its potential. As a reason, this could happen because of the incomplete data input into the model BIM team (Smith, 2016).

The information exchange of construction project across the different phases depended on the traditional exchange of 2D blueprints, documents and teams meetings for decades. However, the way of data exchange has been changed by adopting BIM in AECO industry. In general, more professionals head for exchange information via BIM models as well integrate more information. In spite of the 3D environment that each disciplines producing, collaboration in construction projects still depends on the 2D drawings exchange (Gu et al., 2008a; Merschbrock & Munkvold, 2015; Pauwels et al., 2017; Taylor et al., 2009).

Information security and privacy is critical factor on cross- organisational environment. It is required in the collaboration within AECO industry to manage and transfer BIM information and models efficiently with ensuring of data privacy and security. Even so, the privacy and security problems primary focused on security of information, whereas the players not knowing who can access and where is their data (Homayouni et al., 2010; Mahamadu et al., 2013; Redmond et al., 2012; Wong et al., 2014; Zhang et al., 2014).

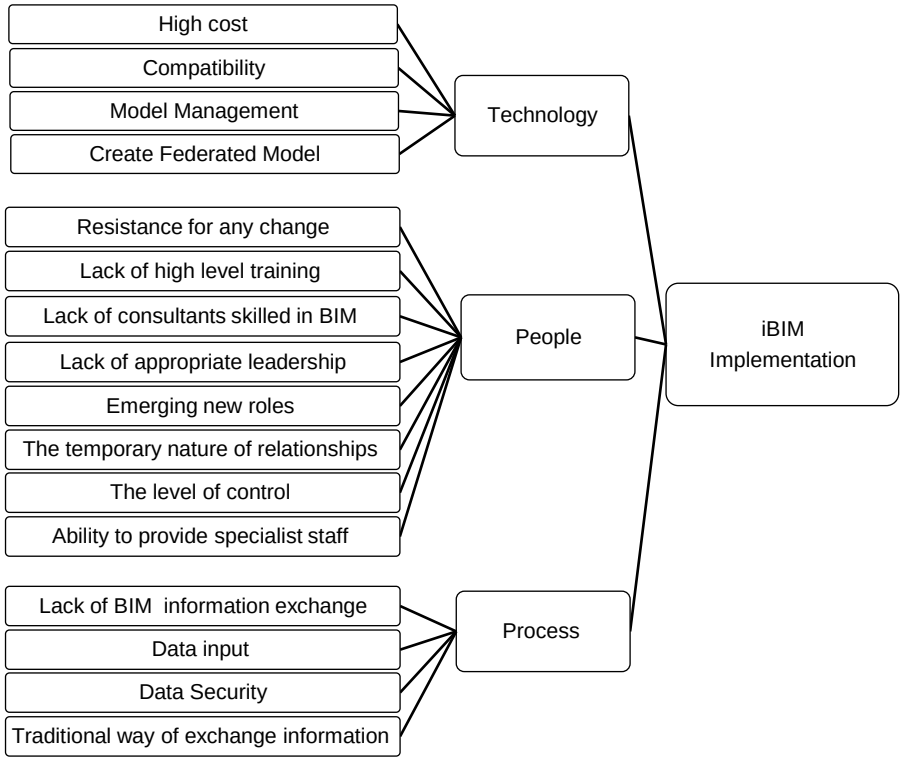

Figure 2. Conceptual model of iBIM implementation (second-order construct)

The construct of iBIM implementation can be measured using these indicators through a hierarchical measurement model as illustrated in Figure 2. Hierarchical models can be represented and conceptualized via layers or dimensions that provide a theoretical meaning to the construct (Diamantopoulos et al., 2008). Hierarchical models can consist two, three, or even four layers of measurement constructs in order to complement the theoretical definition of the variable measurement (Wetzels et al., 2009). However, the second-order construct is the most common type is (Jarvis et al., 2003). The repeated indicators approach was selected to determine hierarchical model mathematically (Tenenhaus et al., 2005). By postulating a latent variable, a higher-order construct is constructed which perform all the indicators of the underlying lower-order constructs. Thus, the indicators of the first-order constructs are repeated in the second-order construct (Wilson & Henseler, 2007). The next section presents the method applied to test proposed model of iBIM implementation in AECO projects.

METHODOLOGY

This paper attempts to demine factors of iBIM implementation in AECO projects. To determine the constructs of iBIM implementation and their indicators, a quantitative approach

using a questionnaire survey was adopted. The model can be generalised to AECO projects by utilizing this approach. Based on the literature review, a measurement instrument was developed. A Pilot study has conducted to test validity and reliability of the questionnaire survey prior to data collection. To examine and validate the model, two main approaches were adopted. The first is the principal component analysis (PCA) to determine the basic components of iBIM implementation. The second is partial least squares-path modelling (PLS-PM) to analyse the hierarchical model. This approach will be used also to confirm the results of PCA and draw a solid conclusion of the contribution of the factors of iBIM implementation. Figure 3 shows the research methodology for this paper.

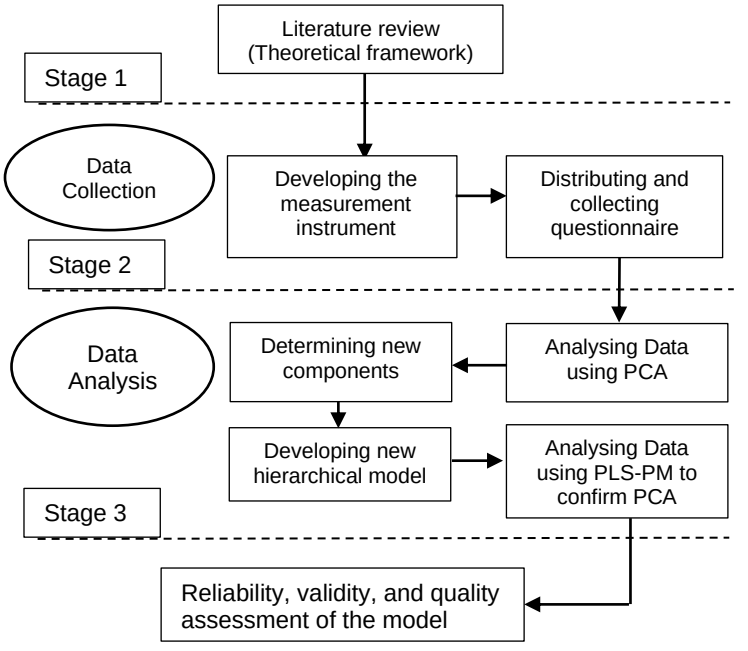

Figure 3. Research methodology

Measurement Instrument Development

The measurement instrument was developed using the indicators of the three aspects (People, Technology, and Process) of iBIM implementation, which identified from the literature in the previous section. As shown in Table 1, these indicators were compiled in the questionnaire survey. To measure the indicators, A five-level Likert scale was used. It ranged from "1 – totally disagree", "2 – disagree", "3 – neutral", "4 – agree", and "5 – totally agree", with each item.

Table 1. Variables/measurement items of iBIM implementation

Construct	Variable	Item
Technology	Technology Cost	High cost of BIM software and hardware updates
	Training cost	High cost of BIM training within AECO industry
	Process compatibility	The collaborative BIM work flow is not compatible with existing processes
	Systems compatibility	iBIM is incompatible with exciting applications and systems within AECO industry
	Model Creation	Creating integrated model for iBIM
	Model Management	Managing the BIM model inside the iBIM (BIM-cloud)

Construct	Variable	Item
People	Leadership	iBIM held back by a lack of appropriate companies leadership
	Level of control	The level of control required to implement iBIM is outside of any single player of construction project
	New roles	Emerging new roles by using iBIM
	Nature of relationships	The temporary nature of relationships within AECO industry
	Change resistance	Resistance by professionals for any change.
	Skills	Lack of consultants skilled in the use of BIM Tools.
	High level training	Lack of high level training on the use of BIM.
	Specialist staff	The ability to provide specialist staff to operate iBIM
Process	Fragmentation	Lack of necessary information for BIM exchange, due to the fragmented nature of the AECO industry
	Data input	The highly fragmented nature of information within AECO industry is a challenge for data input in iBIM
	Data exchange way	Traditional way of exchange information (2D drawing and documents)
	Security	Data security is a challange to implement iBIM within AECO industry

Data Collection

The targeted respondents to the questionnaire are professionals who have experience in BIM within AECO projects in Kuala Lumpur, the capital city of Malaysia. Architects, engineers, project managers, site managers, quantity surveyors, safety advisors, planning managers, and the professionals who are involved in the AECO processes included as potential respondents. These professionals are working for professional firms that affiliated to official boards recognised by the Malaysian government, i.e Board of Quantity Surveyors Malaysia (BQSM), Construction industry Development Board Malaysia (CIDB), Board of Architects Malaysia (LAM) and Board of Engineers Malaysia (BEM). The members of these boards are selected as potential respondents for this survey. The company membership directories that are available on the website of CIDB, LAM and BQSM are chosen. The contact person of these companies is included in the sample database as potential respondent. To increase the number of samples, the researcher also tried to access other resources for potential individual respondents. As an example, LinkedIn platform was applied for this purpose. An advanced search has been executed through this platform by using specific keywords related to BIM roles such as: BIM modeler, BIM coordinator, BIM Manger, etc. A potential respondents profiles were thoroughly chosen by matching their afflation with registered firms that was mentioned above. Eventually, 3305 potential respondents were obtained through the research stated above.

As a result of the previous calculations Based on Cochran (1965) formula for sampling, the study concludes that the minimum number of respondents is 344. The Data collected in about six months and most of the data were collected through electronic survey method. In total, A total number of 346 responses filled and returned back the questionnaires, but 24 responses were excluded because of the invalid answers. Finally, only 322 valid forms were completed with a response rate of 32.2%. According to J. F. Hair, Black, Babin, and Anderson (2013), this rate is considered sufficient to conduct multivariate data analysis, including PCA and PLS.

Respondents' Profile

Table 2 presents the demographic information of 322 respondents including their educational level, professions, nature of the company , years of experience, type of projects

implemented BIM and BIM position. The analysis on the educational qualification of the respondents show that 69.1% of respondents have Bachelor Degree, 28.2 % of them possessed Postgraduate Education while there are only 9.6% respondents who have Diploma. In regard to the respondents' profession, 92 respondents are Civil Engineers (28.6%), 84 respondents are Architects (26%) and 51 respondents are MEP Engineers (15.8%). The rest main forces of the respondents are 29 Project Managers (9%), 25 Quantity Surveyors (7.8%), 15 Contractors (4.7%), 19 Technical Assistant (5.9%) and 7 are from other specialisations (2.1%) including Owners, Surveyors, Environmental Engineers, and GIS Engineers. The analysis on nature of companies show that the construction firms took the largest proportion in the sample (42.9%). On the other hand, the multidisciplinary firms take only 14% of the proportion and it has almost equal distribution with consultant firms (23%), where the value is made up of general consultant firms (17%) and specialist BIM consultant firms (6%). In term of years of experience in construction industry, the results show the respondents' working experience in construction industry, and it is clear that most of them have working experience less than 5 years in the Malaysian construction industry with 54.3%. the remnant of the respondents' experience years are from 5 to less than 10 years 23.6%, from 10 to less than 15 years 9.3%, from 15 to less than 20 years" 5.0% and 20 years and more 7.7%. Analysis on type of projects implemented BIM show that most of the projects are commercial building with (33%), while 28% are residential building. 12% projects implemented BIM are industrial projects and only 7% of the projects are healthcare buildings. In term of BIM position of respondents, the majority of respondents are 151 BIM modeler (46.9%). The rest main forces of the respondents are 85 BIM coordinator (26.4%) and 35 BIM manager (10.9%). 51 from other roles (15.8%) including BIM consultants and BIM trainers.

Table 2. Variables/measurement items of iBIM implementation

Respondents Demography	Categories	Frequency	Percentage
Gender	Male	224	69.6%
	Female	98	30.4%
Educational qualification	Diploma	31	09.6%
	Bachelor	200	62.1%
	Master's	80	24.8%
	Ph.D.	11	03.4%
Profession	Architect	84	26.0%
	Civil Engineer	92	28.6%
	MEP Engineer	51	15.8%
	Project Manager	29	09.0%
	Quantity Surveyor	25	07.8%
	Contractor	15	04.7%
	Technical Assistant	19	05.9%
	Other	7	02.1%
Nature of the company	Construction	138	42.9%
	Consultancy	9	02.8%
	Design	104	32.3%
	Property Development	8	02.5%
	Multidisciplinary	47	14.6%
	Other	16	04.9%
Years of experience	< 5	175	54.3%
	5 to 10	76	23.6%
	10 to 15	30	09.3%
	15 to 20	16	05.0%
	>20	52	07.7%
Type of projects that implemented BIM	Commercial building	106	32.9%
	Residential buildings	91	28.3%
	Industrial buildings	38	11.8%
	Education buildings	12	30.7%

Respondents Demography	Categories	Frequency	Percentage
	Healthcare buildings	22	60.8%
	Infrastructure	34	10.6%
	Other	19	50.9%
BIM position	BIM Modeler	151	46.9%
	BIM Coordinator	85	26.4%
	BIM Manager	35	10.9%
	Other	51	15.8%

Principal Component Analysis

Principal component analysis (PCA) was used to identify the components of the hierarchical model of iBIM implementation as well as group the variables under certain number of meaningful factors (Hair et al., 2013). Unlike the exploratory factor analysis, the PCA is aligned with Partial Least Squares (PLS) (Chin, 1995), which will be used in further analyses. To evaluate the appropriateness of conducting a PCA, Kaiser–Meyer–Olkin (KMO) and Bartlett's test of sphericity was used. As shown in Table 3, of the KMO was 0.943, which is above the threshold of 0.60 (Tabachnick et al., 2007) and Bartlett's test showing a high Chi-square and an appropriate significance level (0.000). These results indicate the suitability of conducting factor analysis for this study.

Table 3. KMO and Bartlett's test of PCA

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		**0.943**
Bartlett's Test of Sphericity	Approx. Chi-Square	3812.582
	df	153
	Sig.	**0.000**

Table 4. Pattern matrix and communalities of iBIM implementation

Variable	Communalities		Components [a]		
	Initial	Extraction	1	2	3
Technology Cost	1.000	.764	.156	-.028	.807
Training cost	1.000	.750	.106	.031	.797
Process compatibility	1.000	.549	-.225	.711	.278
Systems compatibility	1.000	.550	-.255	.735	.265
Model Creation	1.000	.605	-.013	.798	-.029
Model Management	1.000	.669	-.058	.877	-.060
Leadership	1.000	.522	.409	.385	.011
level of control	1.000	.587	.275	.627	-.155
New roles	1.000	.562	.201	.659	-.125
Nature of relationships [b]	1.000	*.367*	.311	.309	.084
Change resistance	1.000	.480	.459	.130	.234
Skills	1.000	.616	.829	-.193	.133
High-level Training	1.000	.663	.897	-.159	.019
Specialist staff	1.000	.671	.839	-.052	.027
Fragmentation	1.000	.619	.643	.175	.043
Data input	1.000	.627	.496	.429	-.100
Data exchange way	1.000	.443	.416	.343	-.045
security	1.000	.500	.400	.358	.044

Notes: **Extraction method – principal component analysis, rotation method – Promax with Kaiser normalization. a Rotation converged in eight iterations; b variables in italic font will be eliminated from further analyses as they scored less than 0.4**

PCA was conducted using the SPSS by defining the following criteria: (a) the rotation method is oblique (Promax − kappa = 4); (b) the data exclude pairwise cases; (c) there are

three components; and (d) the factor loading N .40. The results of the PCA, including factor loadings and communalities, are shown in Table 4.

The results of PCA eliminated one variable from further analysis because its scored less is than 0.4 of the factor loading as they do not contribute significantly to the denoted components. The rest of the variables were interrelated and grouped under the three components or factors. The extracted factors can be named as follows; Component 1: human resource and data management; Component 2: system operation management; and Component 3: cost management. These findings contribute to the measurement of iBIM implementation in AECO industry. In addition, iBIM implementation can be measured more precisely by indicating which factor has a significant influence on iBIM implementation in AECO industry. Next section will analyze the hierarchical model of iBIM implementation in AECO industry.

Hierarchical model analysis using PLS-PM

In spite of PLS-PM advantages, it has rarely been used in the AECO field (Aibinu & Al-Lawati, 2010; Alashwal & Abdul-Rahman, 2014). It is suitable for explorative research, for which there is little theoretical support or new phenomenon, and producing maximum estimations (Tenenhaus et al., 2005; Vinzi et al., 2010). Furthermore, PLS-PM is more practical for estimating hierarchical models than is Covariance-Based SEM (CB-SEM).

It is thus useful for validating the results of PCA using a confirmatory factor analysis (CFA) (Barroso et al., 2010; Tenenhaus & Hanafi, 2010). However, this approach is not without limitations. The estimation of PLS measurement error is typically more biased if compared with CB-SEM (Dijkstra, 1983). In addition, PLS does not impose any restrictions on the data. Therefore, no overall test of model fit is available (Temme et al., 2010). However, the quality of the model can be tested by a global Goodness-of-Fit (GoF) (Tenenhaus et al., 2005).

The SmartPLS package version 3.2.8 was used (Hair et al., 2017) to illustrate the hierarchical model and validate the results of PCA. Repeated Indicators Approach was selected (Tenenhaus et al., 2005) to build the hierarchal model. As mentioned, the indicators of the second-order constructs will be repeated in the first-order construct (Wilson & Henseler, 2007). Of the estimating schemes available with SmartPLS, the Centroid Scheme is the most appropriate for conducting a CFA because it considers the sign of the correlations between a latent variable and its adjacent latent variables (Henseler, 2010). This scheme indicates the existence, rather than the direction, of the relationships among latent variables (Tenenhaus & Hanafi, 2010). The results of the analysis confirmed 17 variables under the three constructs, as shown in Figure 4.

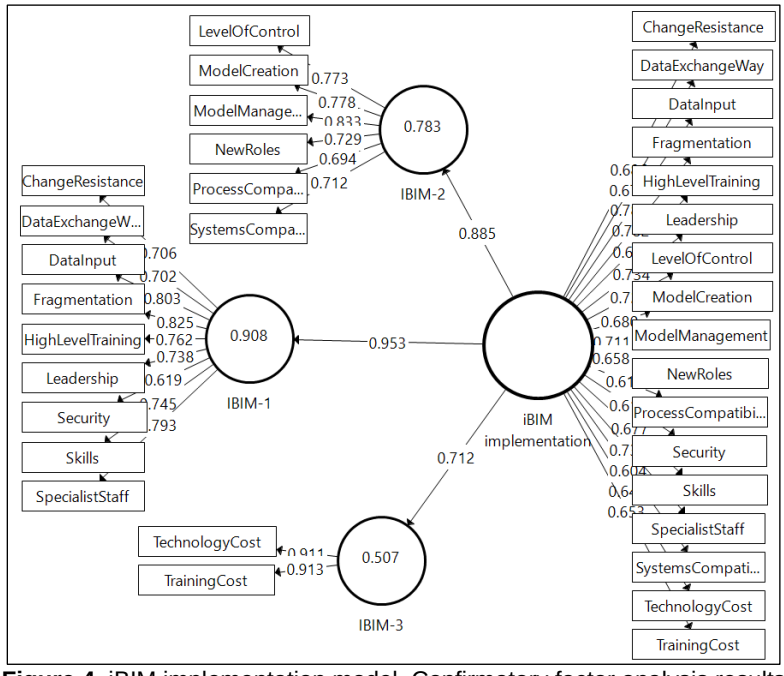

Figure 4. iBIM implementation model, Confirmatory factor analysis results

Quality of the Model

The quality of the iBIM implementation model can be evaluated at two levels: the quality of the measurement model (outer model), measuring the relationship between the manifest variables and the latent constructs, and the quality of the structural model (inner model), measuring the relationship among the constructs. First, the quality of the measurement model can be determined via the item loading, reliability, and validity of the constructs. As shown in Figure 4, the item loading of both IBIM-1 , IBIM-2 and IBIM-3 is above the threshold of 0.55 (Falk & Miller, 1992). As shown in Table 5, the composite reliability and Cronbach's alpha are above 0.7 for all constructs (Fornell & Larcker, 1981). The average variance extracted (AVE) can determine the discriminant validity if above 0.5 (Fornell & Larcker, 1981). The AVE is either borderline or slightly above the threshold in the second-order constructs. However, it is lower in the first-order construct, probably because of the few weak manifest variables that cannot be eliminated as they have high loading in the second-order constructs. Convergent validity can be assessed by observing the cross-loading of variables and the range of the highest and lowest items' loading, where the lower range indicates good convergent validity (Chin & Dibbern, 2010). Second, the quality of the structural model can be determined by the strength and significance of the relationship among constructs, the coefficient of determination (R2) of the endogenous constructs, and the GoF (Chin, 1998). As illustrated in Figure 4, the path coefficient of IBIM-1, IBIM-2 and IBIM-3 is strong at $\beta 1 = 0.949$, $\beta 2 = 0.887$ and $\beta 3 = 0.713$. In addition, the relationship between iBIM implementation and the three constructs is significant at T1= 145.403, T2= 55.892 and T3 = 16.48 as shown in Table 5. The R2 of the endogenous constructs is significantly higher than 0.24 (Vinzi et al., 2010). The GoF can be calculated using the square root of the geometric mean of the average communality multiplied by the average R2 (Tenenhaus et al., 2005). The GoF of study model is 0.69, which is significantly above the good quality model threshold of 0.36 (Wetzels et al., 2009).

Table 5. Quality criteria of iBIM implementation measurement model

	Cronbach's alpha	Composite reliability	AVE	R Square	Communality	T statistics	Correlations			
							IBIM-1	IBIM-2	IBIM-3	iBIM implementation
IBIM-1	0.899	0.918	0.557	0.9	0.557	145.403**	0.746			
IBIM-2	0.848	0.888	0.569	0.786	0.569	55.892**	0.733	0.754		
IBIM-3	0.798	0.908	0.832	0.509	0.832	16.48**	0.611	0.518	0.912	
iBIM implementation	0.928	0.937	0.482				0.949	0.887	0.713	0.695
Average				0.731	0.652					
GoF	√ 0.731*0.652 = 0.69									
**** Significant at p b 0.01 (1-tailed)**										

DISCUSSION

The model proposed earlier in this paper consisted of three iBIM implementation dimensions: Technology, people and process (Enegbuma et al., 2014; Gu et al., 2008a; Shafiq et al., 2012; Succar, 2009). The results of the analyses confirmed three constructs, IBIM-1, IBIM-2 and IBIM-3, which comprise 17 iBIM implementation indicators or factors. IBIM-1 includes items from two dimensions: People and Process. Items in this construct include Leadership, Change resistance, Skills, High-level Training, Specialist staff, Fragmentation, Data input, Data exchange way and Security (refer to Figure 4). Obviously, these items represent the human resource and data management. The second construct IBIM-2 includes of two dimensions: Technology and People. Items in this construct, such as model management and compatibility, represent the system operation aspects of iBIM implementation. Finally, the third construct includes one dimension which is Technology. Items in this construct include cost of technology and cost of training indeed, cost of software and required hardware upgrades consider top challenges of iBIM implementation (McGraw-Hill construction, 2008; Taylor et al., 2009). This items represent cost management. Despite the traditional focus on BIM adoption aspects in construction projects, this study considers cost management; human resource and data management; and system operation aspects as important components of iBIM implementation in BIM-based projects.

The findings of this paper revealed that these aspects make significant contributions to the BIM-based projects milieu. However, the human resource and data management aspect seems to have significant a more influence on iBIM implementation, as indicated by the strength of their relationship, than does the other aspects, as seen in the previous section. This paper seeks to contribute to the measurement model of iBIM implementation by testing the aspects of implementing iBIM in BIM-based projects supported by the empirical findings. Adopting these new aspects of iBIM implementation would promote and aid a systematic way of adopting such a process. BIM management can continuously anticipate and support iBIM implementation in BIM-based projects. Realising these aspects will enable the project manager or sponsor to gain better outcome through the project lifecycle. The implementation of iBIM introduce a powerful solutions for issues of the data storage; distribution of the fragmented information and models; and coordination issues. (Wang, 2017). This, in turn, would lead to the successful management of construction projects.

CONCLUSION

The aim of this paper was to identify the aspects of iBIM implementation in BIM-Based projects. PLS-PM approach utilisation that described in this paper offered some advantages including: easy to specify and analyse hierarchical measurement models, suitable to deal with conceptual models with low theoretical support, and enables testing the model's quality, validity, and reliability. Other researchers can use the same procedure to examine iBIM implementation across projects that belong to other industry such as infrastructure or oil and gas industry. It aslo might be useful to further research for measuring iBIM implementation as hierarchical measurement model in other settings or industries. In addition, researchers can determine the relationship between iBIM implementation and other factors (e.g. collaboration, IPD, etc.). This is important also to measure the factors that enhance sustainability in the AECO industry.

ACKNOWLEDGMENT

The authors would like to express their appreciation to the faculty of the built environment at Malaya University for assistance in this research. The authors would also to express their gratitude to Hadhramout Foundation.

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PRELIMINARY REVIEW OF SUSTAINABILITY INDICATORS TO GREENING EXISTING BUILDING BASED ON LCSA COMPONENTS

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Abstract
While numbers of green projects have been increasing recently, supported with various sustainable efforts implemented globally, still the sustainable impacts is considered as insignificant. Previous research reveals that this happen due to numbers of newly built sustainable building is small compared to existing building stock. Hence, to achieve better sustainability objectives, greening existing building through refurbishment has been introduced. This paper attempts to explore sustainable indicators that are required to assess the performance of existing building. To ensure the indicators incorporate triple pillars of sustainability, the concept of Life Cycle Sustainability Assessment (LCSA) will be adopted. Comparative methodology was used where six (6) prominent green building rating tools were reviewed and compared with literature to gather preliminary list of indicators and sub-indicators. Among selected tools include BREEAM, LEED, Green Mark, GBI, GreenRE, and MyCREST. Experts validation were conducted to further validate the list of indicators gathered. Upon completion, a total of 87 assessment indicators were proposed to greening existing buildings. These sub-indicators were grouped according to the components of LCSA namely environmental (40 indicators), social (43 indicators), and economic (4 indicators).

Keywords: *Sustainability; greening existing building; life cycle sustainability assessment; LCSA; sustainable indicators.*

INTRODUCTION

Although it was first introduced in the past few decades, recently the word 'sustainability' has becoming a catchphrase globally. The world has started drawing attention on various greening efforts to help in reducing many environmental issues such as climate change, pollution, greenhouse gas emission, CO_2 emission, and energy crisis. Specifically, in built environment and construction industry, the construction and operation lifecycles has been significantly recognized as indirectly giving impact to the environment (Raslanas et al., 2013; Wong and Zhou, 2015; Shafeie et al., 2017; Vilches et al., 2017). It was recorded that more than 35% of the total global energy consumption has been contributed by the industry itself (UN Environment & International Energy Agency, 2017). Therefore, over the past few years, excessive research and development has been done on green construction related areas starting from policy to guidelines as well as implementation strategies by both public and private sectors.

Nevertheless, according to Brooke (2011) and Nazri et al. (2013), the sustainability impact recorded is still considered as not really significant. Numbers of existing building stock available currently however exceed the numbers of newly developed green building (Zhou et al., 2016; Zhang et al., 2018) resulting the aforementioned insignificant impacts. Ankrah and Ahadzie (2014) reveal that the existing building stock has been constantly releasing energies throughout its operation phase thus continuously affecting the environment. According to Leung (2018), nearly 30% of the current world total energy use were derived from this phase. To cope with the matters, Zhou et al. (2016) and Vilches et al.

(2017) highlight the needs to convert these existing buildings through refurbishment activities that incorporates sustainable strategies. In this research, the concept was translated as 'greening existing building'. 'Greening' is the term use replacing the often used 'going green' which actually brings the similar idea of incorporating sustainability aspects to decrease environmental impacts. On the other hand, the concept corroborates with the key priorities roadmap developed in Global Alliance for Buildings and Constructions (GABC) as published by UN Environment and International Energy Agency in 2017. Accordingly, one of the targets to reduce energy release is through building refurbishment to improve its performances and energy efficiency.

Apart from that, it has been widely accepted that the concept of sustainability integrates three fundamental dimensions which are 'environmental', 'social', and 'economic' aspects (Hansmann et al., 2012; Hannouf and Assefa, 2017; Tomislav, 2018; Mensah, 2019). These dimensions which have been denoted as the pillars of sustainability were derived from Triple Bottom Line (TBL) concept and considered as critical in delivering a balance and complete sustainable development (Kamali and Hewage, 2015; Tomislav, 2018). In efforts to continuously consider sustainable thinking throughout whole building life cycles, the concept of life cycle sustainability assessment (LCSA) has been introduced by Kloepffer in 2008. LCSA approach evaluates the negative impacts as well as benefits of the development throughout its whole life cycle based on the three aforementioned dimensions (Dong and Ng, 2016; Valdivia et al., 2012). To further elaborate LCSA, Kloepffer (2008) expressed the concept based on the following equation:

LCSA = LCA + LCC + S-LCA

Where,

LCSA = Life Cycle Sustainability Assessment
LCA = Life Cycle Assessment [Environmental Dimension]
LCC = Life Cycle Cost [Economy Dimension]
S-LCA = Social Life Cycle Assessment [Social Dimension]

LCSA principally encircle all aforesaid triple techniques (Kloepffer, 2008; Valdivia et al., 2012; Hannouf and Assefa, 2017), each one representing different pillars of sustainability (Hossaini et al., 2015) throughout the decision-making process. Therefore, in ensuring the sustainability strategies being fully incorporated to existing building, all the triple dimensions need to be addressed sufficiently. As mentioned by Kamali and Hewage (2015), among the first step needed is to identify the indicators that are required to assess the sustainability performances of existing building. These indicators may be qualitative or quantitative, providing information and assisting project stakeholders in making decision to improve existing buildings. To address the issues, the primary goal of this paper is to preliminarily review potential indicators required based on the triple components (environmental, economic, and social) of LCSA to sustainably improve existing buildings.

METHODOLOGY

In this research, comparative methodology as developed by Kamaruzzaman et al. (2018) has been adapted. It has been acknowledged previously that in any research developing new

green assessment tools, it is essential to conduct comparative study of prominent existing assessment tools (Alyami and Rezqui, 2012; Kamaruzzaman et al., 2018). Alyami and Rezgui (2012) further add that the comparison methods enable the researcher to highlight areas of convergence and distinction. Although the primary aim of this research is not to develop new green assessment tools, the method is adapted considering the objective to achieve is related. Hence, this research selected and reviewed six prominent assessment tools (BREEAM, LEED, Green Mark, GBI, GreenRE and MyCREST) for existing non-residential building which will be further elaborates in the following sub-topic.

Each of the tools were comprehensively reviewed following content analysis approach and the list of indicators and sub-indicators has been collected. Content analysis refers to the process of systematically review, evaluate, and collecting information related to research questions through document analysis (Kamali and Hewage, 2015). The indicators list was compared and re-categorised into common assessment indicators as suggested by CIDB (2018) and collected from previous research (Alyami and Rezgui, 2012; Yu et al., 2015; Addy et al., 2017; Kamaruzzaman et al., 2018; Meiboudi et al., 2018). Figure 1 illustrates the overall process of generating list of potential indicators to greening existing building. Additionally, the identified preliminary indicators were then re-classified into three major components of LCSA namely environmental, economic, and social.

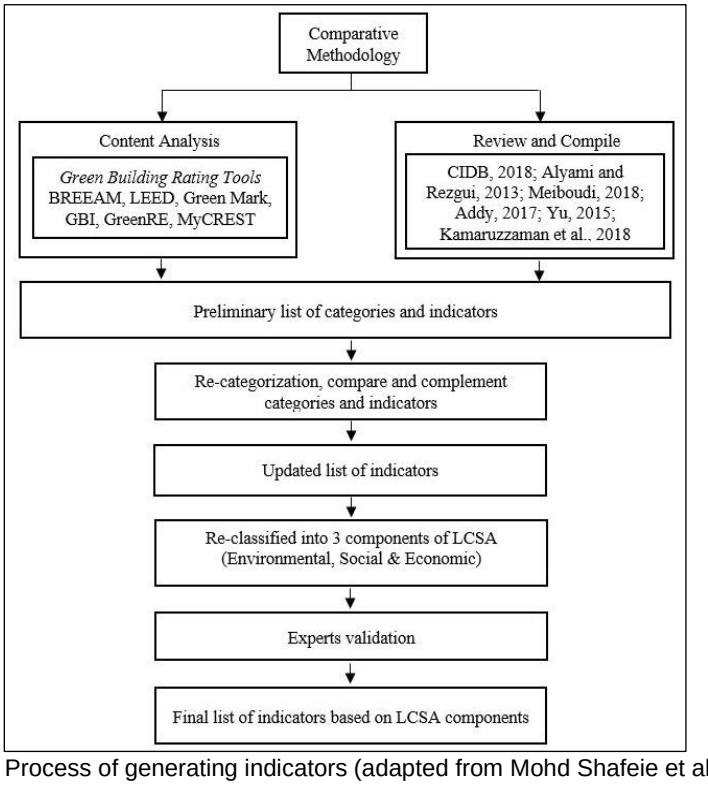

Figure 1. Process of generating indicators (adapted from Mohd Shafeie et al., 2017)

Upon getting the updated list of indicators, validation with experts were conducted. Eight (8) numbers of expert consisting from academician and industry practitioner were selected considering their knowledge and experiences with green building project. Among validation content includes:

(a) suitability of indicators grouping to triple components of LCSA
(b) repetitiveness or possibility of similar indicators
(c) indicators that require further or extra explanation
(d) missing indicators

GREEN BUILDING RATING TOOLS (GBRT)

With increasing attention on sustainability and green buildings for the past two decades, numerous studies have been discussing and establishing new methods, tools, and systems to evaluate green buildings' performance (Shan and Hwang, 2018). The tools are either developed by local authorities, private organization or through research and development based on specific region. These rating tools are essential to evaluate different aspects of sustainability during planning, construction and operation of a building (Vyas and Jha, 2016) as well as serve as a baseline for the stakeholders during decision-making process (Shan and Hwang, 2018). Li et al. (2017) highlight that these assessment tools are a yardstick that set a parameter through certain criteria and indicators to foresee up to which extent evaluated buildings fulfilled the green requirements.

To analyse the potential assessment indicators to greening existing building, several international and local GBRT will be selected for the purpose of comparisons, review and compile. According to Li et al. (2017), based on frequency review, among the most popular tools selected and studied by researchers are Leadership in Energy and Environmental Design (LEED) and Building Research Establishment Environmental Assessment Methodology (BREEAM) (as shown in Table 1). BREEAM was developed in United Kingdom in the 1990s (Li et al., 2017; Kamaruzzaman et al., 2018). BREEAM as a pioneered, was successfully implemented and began to influence many other regions to develop their own GBRT (Syed Yahya et al., 2014). LEED on the other hand was developed by United States of America (USA) in 1998. It grew rapidly and has becoming a famous and almost dominant assessment rating tools (Mattoni et al., 2018) as it was used in 41 countries around the world including Canada, Brazil, Mexico, India and China (Li et al., 2017). The results followed by Comprehensive Assessment System for Building Environmental Efficiency (CASBEE) of Japan, Green Star of Australia, Sustainable Building (SB) Tool of Canada and Building Environmental Assessment Method Plus (BEAM) Plus of Hong Kong respectively. Hence for the purpose of this research, LEED and BREEAM will be selected considering the tools' worldwide influence (Li et al., 2017) and its recognition as among the most reliable tools (Mattoni et al., 2018). Another tool selected is Green Mark of Singapore. Although the tool is not among mostly studied worldwide, the selection takes into consideration the country shares similar characteristics including climatic, cultural and social with Malaysia (CIDB, 2018).

Table 1. Most studied green building rating tools (GBRT)

Rating Tools	Frequency
LEED	54
BREEAM	42
CASBEE	27
Green Star	12
SB Tool	12
BEAM Plus	11

(Source: Li et al., 2017)

Meanwhile in Malaysia, prior to the governments' efforts towards achieving sustainable cities, the country has consequently launched its first rating tool in 2009 known as Green Building Index (GBI). Although BREEAM and LEED were among the most prominent tools available worldwide, GBI was developed benchmarking over Green Mark of Singapore considering several similar factors such as climatic, cultural and social (CIDB, 2018). Since then, a number of rating tools have been developed to measure the sustainability rating of a construction projects. To date, there are 10 green rating tools available in the country covering different types of project from building, township and infrastructure. The tools, aside from GBI, are CASBEE Iskandar, Green PASS, Green Real Estate (GreenRE), Low Carbon Cities Framework and Assessment System (LCCF), Malaysian Carbon Reduction and Environmental Sustainability Tool (MyCREST), My Green Highway Index (MyGHI), Melaka Green Seal, Skim Penilaian Penarafan Hijau JKR (PHJKR) and Sustainability Index (SUSDEX).

Table 2 classified each tool according to property coverage types namely individual building, township and infrastructure. Since this research focus on greening the building, therefore tools that are classified for township and infrastructure will be omitted. Other tools that provide assessment for individual building are GBI, GreenRE, Melaka Green Seal, MyCREST, PHJKR and GreenPASS. Among all aforementioned tools, Melaka Green Seal was developed specifically for the use of building in the state of Melaka. Therefore, it will not be included in the research. Only three (3) prominent and most comprehensive local assessment tools (CIDB, 2018) are selected including GBI, GreenRE and MyCREST.

Table 2. Local GBAT types of property coverage

Types of Property	GBAT	
Individual Building	GBI GreenPASS PHJKR GreenRE Melaka Green Seal MyCREST	
Township	GBI GreenRE SUSDEX LCCF CASBEE	
Infrastructure	MyGHI	

Currently, GBI is the only local tool that has achieved maturity for consistently expanding since it first establishment by releasing series of tools for different types of building (CIDB, 2018). It consists of 19 rating tools including assessment for Residential New Construction (RNC), Non-Residential New and Existing Building (NRNC & NREB), Industrial New and Existing Building (INC & IEB), township, hotels, hospitals and many more. Meanwhile, GreenRE was the second tools available in Malaysia after GBI. According to CIDB (2017), GreenRE was rated as one of the most comprehensive and effective assessment tools available locally (GreenRE, 2017). To date, GreenRE has developed four (4) assessment tools including Residential New Construction, Non-residential New and Existing Building and township (Usman and Abdullah, 2018). MyCREST on the other hand, as mentioned by CIDB (2018) was developed by combining both PHJKR and GreenPASS. Therefore, it is believed that analysis on MyCREST indicators should be sufficient as it will reflect both previously mentioned tools.

In summary, three (3) international and three (3) local green building rating tools are selected to analyse the potential indicators. To ensure comparisons are made on the similar basis and follow the purpose of research, rating tools selected are for existing non-residential building. Accordingly, the following documents are referred:

- BREEAM International Non-Domestic Refurbishment 2015 Technical Manual (Refurbishment and Fit-Out)
- LEED for Building Operations and Maintenance (Version 4.0)
- BCA Green Mark for Existing Non-Residential Buildings (Version 3.0)
- GBI for Non-Residential Existing Building (NREB) (Version 1.01)
- GreenRE for Existing Non-Residential Building (Version 3.1)
- MyCREST for Operations and Maintenance (Version 3.0)

RESULTS AND DISCUSSION

Sustainability Indicators to Greening Existing Building

As shown in Table 3, different assessment tools may have different terms of sustainable categories assessed. BREEAM consists of 10 categories namely 'Management'; 'Health and Wellbeing'; 'Energy'; 'Transport'; 'Water'; 'Materials'; 'Waste'; 'Land Use and Ecology'; 'Pollution'; and 'Innovation'. LEED and other tools may have several categories similar to BREEAM for example 'Energy'; 'Water'; 'Materials'; and 'Innovation'. However, 'Sustainable Sites' categories in LEED is not included in BREEAM. Meanwhile, Green Mark consist of one category named 'Sustainable Operation and Management' which is not mentioned anywhere in BREEAM or LEED but included in GreenRE. Similarly, for local assessment tools. MyCREST has several categories differs from other tools such as 'Lowering Embodied Carbon'; 'Sustainable Facility Management'; and 'Sustainable Carbon Initiatives'.

Therefore, in attempt to identify key similarities and differences among previously discussed six (6) rating tools, re-categorization of each sustainable categories and indicators is done following the primary themes of sustainability as suggested by CIDB (2018). The themes are 'Project Management & Planning'; 'Site Planning & Management'; 'Transportation'; 'Energy Efficiency'; 'Water Efficiency'; 'Materials and Resources'; 'Waste'; 'Indoor Environmental Quality'; and 'Innovation'. In this study, categories were defined following the previously mentioned sustainability themes, meanwhile indicators are interpreted as parameters that are used to assess the performance of existing building. Table 4 summarizes the distribution of each category to the rating tools.

Different rating tools may have different performance assessment categories and indicators used. As example for 'Project Management & Planning', as shown in Appendix B, only BREEAM and MyCREST has a wide coverage over this category. As mentioned by Alyami and Rezgui (2012), management of site activities and construction process serve as core criteria in environmental rating tools (Amasuomo, Atanda and Baird, 2017). Provision of these criteria aims to encourage adoption of sustainable principles and actions during the key stages of design, refurbishment, fit-out, commissioning, handover and aftercare. Additionally, MyCREST emphasize several indicators related to aftercare and maintenance. CIDB (2018) highlighted MyCREST is the only local tool that actually covers overall building phases including design, construction, and operations and maintenance. However,

since the documents reviewed pertaining to operation and maintenance hence indicators extracted mostly related to aftercare services. However, as shown in Table 4, all other categories were mentioned and included in all six rating tools.

Based on the first step of re-categorization and compilation of all nine (9) categories from rating tools and literature review, a total of 90 indicators has been gathered. All of the indicators extracted from the tools were included in the preliminary list. Each of indicators were then analysed where any similar meaning indicators were merged together. The next step was to reclassified all the indicators based on the three components of LCSA namely environment, social, and economic. Upon reclassification, 42 indicators were grouped under environment, 45 indicators under social, and three (3) indicators under economic dimension. To further verified the list of indicators gathered, validation with eight (8) experts were conducted. Amendments were made based on expert reviews and opinions to finally come out with final list of 87 indicators to greening existing building. Several amendments made were as follows:

- Environmental: from 42 indicators, two (2) were removed due to similarities with other indicators.
- Social: from 45 indicators, two (2) were removed due to unsuitability with existing building context and also, repetitiveness with other indicators.
- Economic: from three (3) indicators, one (1) was suggested to remove due to repetitiveness. However, several experts suggested to add two (2) new indicators related to return of investment and cost of material selections.

Table 3 summarised proposed sustainable indicators for greening existing building.

Table 3. Proposed sustainable indicators to greening existing buildings

Environmental Indicators	• Implement environmental management system (EMS) • Develop five years' site improvement plan • Develop building management plan • Develop climate change adaptation strategy appraisal • Protection against existing ecological features • Conservation of existing natural and damaged areas • Flood risk assessment strategy to prevent flooding • Reduction of surface water run-off • Maximize rainwater collection from rooftop or runoff rainwater system • Incentive provision for credits achievement that address specifically on environmental, social equity, and public health priorities • Reduction in nitrogen oxides (NoX) emissions levels through the use of low emission heat sources in the building • Reduction of night light pollution • Reduction of noise pollution • Minimize urban heat island effect (through various greenery efforts) • Minimize water course pollution • Energy efficient internal and external artificial lighting • Energy efficient internal vertical transportation systems (Lift/Escalators) • Energy efficient HVAC system • Building envelope consideration to minimization of heat gain • Implement building energy audit • Energy control system (i.e: energy metering system) • Certified energy efficient equipment/fittings (i.e. EnergyStar certified) • Carbon dioxide (CO2) sensors to prevent CO2 emission and regulate fresh air intake • Develop energy management policy • Strategy for renewable energy (i.e. solar, wind, geothermal, biomass)

	• Reduce consumption of potable water in existing buildings by using water efficient fittings (i.e. dual flush system, certified fittings from WELPS/WELS) • Water metering system to monitor water consumption • Water leak detection system (early detection of water leakage) • Provision for alternative water resources • Water efficient landscape irrigation system (i.e. drip coupled with rain sensor/soil humidity sensor) • Recycling of greywater and/or blackwater for building and irrigation use • Use of reused materials • Use of recycled content materials • Use of regional or local material (i.e. timber) • Use of environmentally friendly products that are certified by local certification body • Establish Sustainable Purchasing Policy • Establish Waste Management Policy • Collection and disposal of recyclable and non-recyclable waste • Segregation and storage of recyclable and non-recyclable waste • Incorporate innovation strategies that provide sustainable related benefits • Establish environmental policy and end-user guide and manual • Implement considerate refurbishment practices and manners • Appoint individual to monitor, record and report overall performance and impacts of refurbishment work • Post-occupancy user satisfaction survey (to assess end-user's comfort) • Functional adaptability (to facilitate future adaptation) • Accessibilities to public transportation (i.e. bus station, train station etc.) • Facilities to support alternative transport measures (i.e. electric vehicle space/charging station, bicycle, carpooling etc.) • Proximity to amenities (i.e. food outlet, cash facilities, recreation or leisure facilities) • Establish travel plan to encourage end-user using sustainable modes of transportation • Provision for pedestrian walkway • Ventilation in carparks area • Ventilation in common areas (i.e. toilets, staircases, corridors, lift lobbies etc.) • Establish Indoor Air Quality Plan • Use of environmentally friendly refrigerants and cleaning materials, effective and low-carbon cleaning equipment and machineries • Dedicated smoking area (outside of building) • Air filtration in ventilation system
Social Indicators	• Natural ventilation to allow fresh air into the building • Use of environmentally friendly materials and finishes (with low volatile organic compound and formaldehyde) • Carbon dioxide (CO2) sensors to measure indoor air quality • Room temperature display to enable controllability of room temperature • Mold occurrence prevention through monitoring of air filters • Glare control strategy to disable glare in all relevant building areas • Daylighting into the interior sides of building • Adequate window or permanent opening for viewing out • Zoning of internal lighting to allow for occupant control • Thermal comfort system control by occupants to promote comfort and well-being • Thermal zoning and control to efficiently heat or cool indoor areas • Appointment of suitably qualified acoustician (SQA) to measure indoor noise level • Maintaining internal noise level at an acceptable and tolerable level • Sound insulation strategy to ensure acoustic performance • Risk assessment strategy for natural hazards • Indoor integrated pest management system • Consultation with all relevant third-party stakeholders (i.e. building owners, end-users, consultants • Appoint sustainability champion to facilitate the sustainability target • Commissioning, decommissioning and testing of all related works • Commissioning, decommissioning and testing of building services system (including specialist appointment, and maintenance strategy) • Testing and inspecting the integrity of building fabric after completion • Complete handover process • Aftercare support for building end-user • Seasonal commissioning once building substantially occupied

	• Establishment of data and area system management to monitor buildings' overall performance during maintenance • Establishment of Operational Plan and Annual Asset Maintenance (POPAT) or Operational Budget and Annual Asset Maintenance (BOPAT) for government building or equivalent for private sector organisation • Appointment of operation and maintenance team to maintain equipment and amenities to ensure better performance and quality
Economic Indicators	• Life cycle cost (LCC) analysis during early refurbishment design stage for design options decision-making • Capital cost for the refurbishment works (including cost of new materials selected and new building components installed) • Maintenance cost for the newly refurbished building • Return on investment (ROI) analysis

CONCLUSION AND FUTURE RESEARCH

This research reviewed six (6) prominent international and local green building rating tools to finally summarized sustainability indicators to greening existing building. Among the tools reviewed include BREEAM, LEED, Green Mark, GBI, GreenRE and MyCREST. To ensure comparison and analysis were made following the purpose of the research, all the tools selected were for existing non-residential building. From the review, 90 indicators were compiled and then reclassified according to three components of LCSA namely environment, social, and economic. Experts validation were conducted to review and validate preliminary list of indicators gathered. Throughout the validation process, several repetitive indicators were merged, some were omitted due to unsuitability and new suggested indicators were added to the list. Upon completion, 87 final indicators were proposed to greening existing building. However, to further validate the importance of the proposed indicators, the current research will be continued by developing an instrument to measure and analyse them. Besides, this research does not look deeper into detail methodology or processes of LCSA. The concept of LCSA was adopted merely to ensure that indicators selected to greening existing building emphasize and integrate the triple components of sustainability (environment, social, and economic). It should be also mentioned that the findings of this paper are part of ongoing research to develop a model to greening existing building using BIM as a tool, based on LCSA approach.

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Appendix A

Main features of selected Green Building Rating Tools (GBRT)

Features	Assessment Tools					
	International			Local		
	BREEAM	**LEED**	**Green Mark**	**GBI**	**GreenRE**	**MyCREST**
Country	UK	USA	Singapore	Malaysia		
Year	2015	1998	2005	2009	2013	2016
Sustainable Categories	Management Health and Wellbeing Energy Transport Water Materials Waste Land Use & Ecology Pollution Innovation	Sustainable Sites Water Efficiency Energy and Atmosphere Materials and Resources Indoor Env. Quality Innovation	Energy Efficiency Water Efficiency Sustainable Operation & Management Indoor Env. Quality Other Green Features	Energy Efficiency Indoor Env. Quality Sustainable Site Planning & Management Materials & Resources Water Efficiency Innovation	Energy Efficiency Water Efficiency Sustainable Operation & Management Indoor Env. Quality Other Green Features Carbon Emission	Infrastructure & Sequestration Energy Perf. Impacts Occupant & Health Lowering Embodied Carbon Water Efficiency Waste Management and Reduction Sustainable Facility Management Sustainable & Carbon Initiatives

Appendix B

Distribution of categories among green building rating tools (GBRT)

Sustainable Categories	Assessment Tools					
	International			Local		
	BREEAM	LEED	Green Mark	GBI	GreenRE	MyCREST
Project Management & Planning	√	-	-	-	-	√
Site Planning & Management	√	√	√	√	√	√
Transportation	√	√	√	√	√	√
Energy Efficiency	√	√	√	√	√	√
Water Efficiency	√	√	√	√	√	√
Materials and Resources	√	√	√	√	√	√
Waste	√	√	√	√	√	√
Indoor Environmental Quality	√	√	√	√	√	√
Innovation	√	√	√	√	√	√

COMPELLING OUTGROWTH OF ENGINEERING, PROCUREMENT AND CONSTRUCTION CONTRACT IN MALAYSIAN OIL AND GAS INDUSTRY

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Abstract
The oil and gas sector involved a plethora of professionals and processing requirements across the lifecycle of its product. In Engineering, Procurement and Construction (EPC) contract, the contractor has to deal with the owner and a large number of sub-entities. Due to that, many issues have arisen among the stakeholders in the EPC project and it leads to a delay in completion and budget overrun. A literature search indicated issues in the EPC contract that happened in other countries. However, there is a limitation of literature that highlights the issues of the EPC contract from the Malaysian context. This somehow hinders the effort to improve the issues of EPC contracting strategies in Malaysia. Hence, this research aims to identify the current critical issues facing by the Malaysian oil and gas industry. The research applies the qualitative paradigm through pilot semi-structured interviews with the actual practitioners. From the pilot interview conducted, the issues highlighted differs from both client and contractor's thoughts. Contractors are concerned about project risk and project management issues while the client emphasized on the technical issues in the Engineering phase and procurement phase. This research offers a rich understanding in an unsaturated area of EPC contract from the Malaysian perspective and is expected to become the basis to support the future strategy in enhancing the effectiveness of EPC contracts in the Malaysian oil and gas industry.

Keywords: *EPC contract; oil and gas industry; project management; pilot study.*

INTRODUCTION

Tailoring to the 11th Malaysian Plan strategies where the government initiate to develop Malaysia as oil and gas hub in Asia Pacific by strengthening the upstream capabilities (Economic Planning Unit, 2016), oil and gas players are looking for a solution to diversify their portfolios. Upstream activities offer the whole range of engineering, procurement, construction, installation and commissioning of the facilities. Hence, it involves a complex engineering effort which include hundreds of engineers from different organisations, working together to design, construct and commission the asset before handling it over to the owner or operator. Oil and gas industry are complex, considering that, projects demand relatively a long period of time and huge initial capital investment (Moreau & Back, 2000). A research by (Ernst & Young, 2014) illustrated that from 365 oil and gas megaprojects in the world, 73% of the projects disclosed delayed in schedule and 64% of project experienced cost overruns. The key factors of delayed in schedule and cost overruns to happen are management, contracting and project delivery strategies (Ernst & Young, 2014). Commonly, to deal with large capital projects including the construction of offshore and onshore facilities, the owner or operator will opt for EPC as their project contracts due to their increasing requirements for reduced project cost and for a shorter schedule (Ishii, Takano, & Muraki, 2014). In EPC projects, contractor has the solitary responsibility for project cost, quality and schedule under a fixed-price, which had been set before the commencement of the project as a lump-sum contract (Ishii et al., 2014).

ENGINEERING, PROCUREMENT AND CONSTRUCTION CONTRACT

EPC consists of two main phases of EPC; Development Phase and Implementation Phase. From Figure 1 below, it shows 4 different phases. Development phase is carried out in Phase 1 of Pre-Front End Engineering Design (FEED) and Phase 2 of FEED; while Implementation Phase is carried out in Phase 3 of Execution and Phase 4 of Operation. Generally, in Development Phase, important planning activities such as investigation, scope definition, work packaging and contract award are carried out (Dissanayake Mudiyanselage Nayana Shamali Dissanayake, 2017). This include the basic design and engineering of the facilities, development of the layout, vendor inputs for major packages, Health and Safety Environment (HSE) impact and clarification of conceptual design estimation in Phase 2; FEED stage.

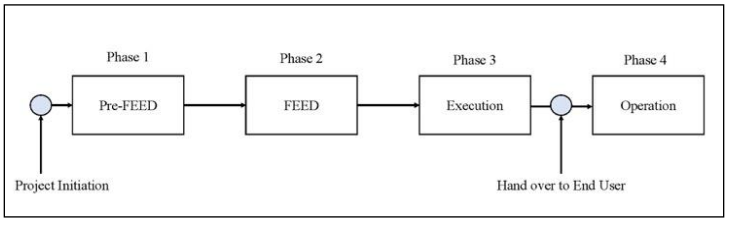


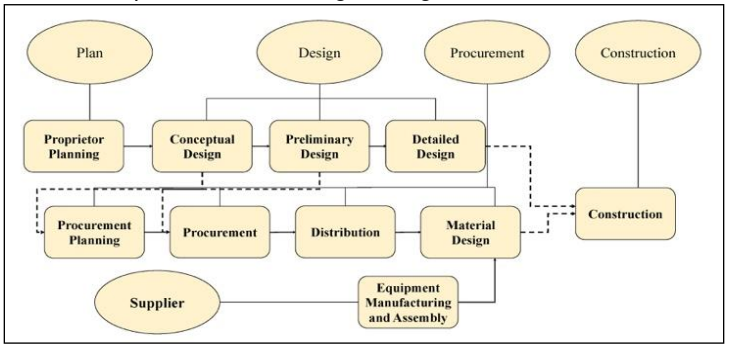
Figure 1. Four different phases in EPC contracting process

As for Implementation Phase, there are three main activities carried out as shown in Figure 2 namely; engineering phase, procurement phase and construction phase. The process of EPC gets off the ground with the owner or operator defining the project scope and specifications (Pre-FEED) and conveyed to either in-house design personnel, external engineering consultants or the EPC contractor to develop FEED to a level of sufficient for inviting tender proposals (Loots & Henchie, 2007). Once the EPC contract is awarded, the Implementation Phase begins and takes a maximum of three years to complete. The design engineering is accomplished through a series of steps include the conceptual design, preliminary design and detailed design. EPC contract has transpired as the preferred choice for oil and gas projects as it provides many technical and commercial benefits for owner/operators (Dissanayake Mudiyanselage Nayana Shamali Dissanayake, 2017). Despite this merit, (Lunde, 2001) raised the concern on the challenges to successfully merge the engineering, procurement, fabrication and construction contracts while offering benefits to owner/operator and contractor alike. It has higher exposure to risk in contractor and to all the design which lead to a higher contract price. Therefore, EPC project implementation has become a major challenge for project owners.

ISSUES IN EPC CONTRACTING ARRANGEMENT

EPC contracting process demand a complete scope of definition during the commencement of the project in engineering phase (Dumont et al., 1997). A combination of collaboration and information in EPC projects lead to the involvement of many professionals with huge amount of work. In reflection to that, a string of issues had been addressed by other researchers on previous studies as shown in Table 1. The complexity of EPC contracting process schedule lead to the overlapping of these three phases, Engineering-Procurement-Construction. Phase overlapping is an issue in EPC contract as it foster lack and incomplete detailed information of EPC contract as well as low involvement of suppliers in planning and design of long-lead equipment (Jianhua & Yeo, 2000; Salama et al., 2008; Yeo et al., 2002).

Figure 2. Activities in Implementation of Engineering, Procurement and Construction phases



EPC contract involved multi-disciplinary that devised a high level of risk and complexity (Dissanayake Mudiyanselage Nayana Shamali Dissanayake, 2017). For example, there are a number of engineering disciplines involved in oil and gas projects including Chemical Engineering, Mechanical Engineering, Piping and Instrument Engineering, Electronic Engineering, Electrical/Power Engineering, Information Technology and Telecommunication, Civil and Infrastructure Engineering, Structural Engineering (both onshore and offshore) and Subsea Engineering. The high level of integration of various disciplines increases the level of risk (Dissanayake Mudiyanselage Nayana Shamali Dissanayake, 2017). If there is no integration between these various disciplines, it might cause project changes and variations that give rise to project delay and failure (Chan & Kumaraswamy, 1997). (Ogunlana et al., 1996) reinforced Chan and Kumaraswamy's by adding that changes and rework are due to inflexibility and unresponsiveness of engineering and construction industry to the needs of its customers.

There are various factors that contribute to the issues in EPC contract includes inadequate planning of engineering design during project initiation and FEED stage (Ernst & Young, 2016), relationship conflicts, financial and supplier market uncertainty and as well as poor portfolio management (Olaniran et al., 2016). Other than that, poor selection of contractors also imposed consequences on quality, project costs and schedule performance later in the project cycle (Ernst & Young, 2016). All issues aroused resulting in delayed completion, budget overrun, poor quality and the subsequent barrage of claims and counter claims (Yeo, K.T., & Ning, 2002).

RESEARCH METHODOLOGY

The objective of this paper is to identify the critical issues of EPC contracting arrangements face by Malaysian oil and gas industry. Several researchers emphasize the importance of conducting an exploratory study as a useful preliminary course of action in any research when a researcher has restricted amount of experience or knowledge about a research issues (Faisol, 2010). The exploratory study can be based on a single investigation or a series of informal studies that offers background information as it may form the foundation of a good research (Babin & Zikmund, 2016; Malhotra et al., 2017). A researcher succinctly emphasized that a pilot study is not a 'pre-test' in that it should not attempt to actually start the process of generating theory, but it helps in developing suitable lines of questions, potentially clarifying the essence of the study to the researchers as well (Yin, 2017). Pilot study would be useful in exploring and searching through a problem or situation to provide

insights, ideas and understanding as it was particularly helpful in breaking broad, vague problem statements into smaller and more precise sub problem (Babin & Zikmund, 2016; Naoum, 1994). This is supported by (Lancaster et al., 2004), where researchers stressed on how pilot study is carry out to ensure the data is comprehensible and appropriate and the questions are well-defined, clearly understood and presented in a consistent manner.

In this study, the interview for pilot study was conducted to obtain an in-depth understanding of the issues that take place in EPC contract of Malaysian oil and gas industry. Therefore, an exploratory study consisting of three interviews was conducted from August 2017 to November 2017. The process of conducting the pilot interview began by identifying a list of oil and gas companies who do business in Malaysia due to geographical accessibility. Researcher underline that convenience, access and geography proximity can be the main criteria for selecting pilot case or cases (Yin, 2017). As a result, six companies were contacted via email and telephone. However, only three companies agreed to be interviewed. The companies interviewed comprised of various categories of stakeholders so that the extent to which importance of EPC contracting issues could be viewed from various range of oil and gas organizations. These companies were selected due to close personal relationships of the researcher with the top management of the companies who were also the informants. Thus, all information was easily accessible. All informants held strategic position in the company and involved directly in the making the decision for the company such as Senior Executive in Contract and Procurement Department, Contract Manager and Head of Lead, Planning & Reporting under Project Control & Services, Engineering & Construction Division. Six open ended questions were used to conduct the semi-structured interviews. The time taken for each interview ranged from 35 minutes to an hour, with an average time taken of 45 minutes.

MAIN RESULT

The interview was conducted with three prominent oil and gas organizations in Malaysia, representing various types of organizations including client and contractor. The informants were asked to comment on application of contractual arrangement in the organization, condition of contract used and critical issues in implementing EPC contract. The interviews were recorded and transcribed for analysis of the data. The cross-case analysis method was used to further strengthen the data that has been analysed. The profiles featuring the three organizations have been presented in Table 1.

Table 1. Characteristics of three Oil and Gas organization

Organization	Company A	Company B	Company C
Interviewee Position in the Organization	Senior Executive in Contract and Procurement Department	Manager of Project Control & Services, Engineering & Construction Division	Contract Manager of Contract Department
Type of Organization	Client	Contractor	Contractor
Type of Contractual Arrangement	EPC, EPCIC, EPCC, PCC	EPC, EPCIC, EPC, PC	Traditional/Open Selective
Type of Condition of Contract	Bespoke	Bespoke	Following client preferences
Critical Issues	Engineering and Procurement Stage	Project Risk, Communication and Change Management	None

From the pilot interviews with three different oil and gas companies in Malaysia, it can be deduced that different project participants have different viewpoints and facing different nature of problems in EPC contract. Each respondent possesses their own thoughts as client and contractor. The main problem identified from the interviews are tabulated as per Table 2 below.

Table 2. Issues facing by client and contractors in EPC contract

Roles	Issues	Descriptions
Client	Technical Issues of Engineering Phase	1. Incomplete detailed information during design Engineering stage 2. Change Order and Variations to arise
	Technical Issues of Procurement Phase	1. Troublesome in processing the extra work payment 2. Face difficulty with the issuance of change order
Contractors	Project Risk	1. Company in Malaysia did not utilize the use of Risk Assessment Tool 2. Improper Risk Analysis and management
	Project Management	1. Lack of communication problem among stakeholders 2. Change management

Briefly, there are three key points highlighted by both stakeholders including technical issues, project risk and project management. As mentioned by Company A, technical aspects inevitably become a major setback. Technical aspect in this study is defined by the process in Engineering, Procurement and Construction itself. In the case of this company, Engineering and Procurement stage are the problems. EPC contract consists of two main phases of planning phase and implementation phase (Dissanayake Mudiyanselage Nayana Shamali Dissanayake, 2017). According to the representative from Company A, EPC projects comprises of 70% of planning and 30% of project execution. Engineering stage falls on planning and plays a crucial role in the contract. If it goes awry and not as planned, the subsequent phases will be facing problems as well. Hence, it is very crucial to have a detailed information in design engineering stage. But in the actual condition of oil and gas industry, the problems still arise though a well-defined information is provided. This is due to the reason that EPC contract is signed based on conceptual design. Due to that reason, it leave client's requirement being not clearly elaborated (Shen et al., 2017). As project proceed, client may give rise to change order that lead to contractor's claims. This portrayed that change order and variations order including error in construction design plans, specifications and unforeseen conditions are not caused by one party only but both stakeholders. Contractor may submit claims that are attributed to client's organizational behaviours such as delay in payment, change orders and inefficient processing, but client may reject the claims for the reasons of inaccurate estimation, insufficient supporting documents and contractor's opportunism behaviour (Chester & Hendrickson, 2005). This conjuncture is supported by a literature from previous researchers where claims in EPC projects are mainly involved with the organizational behaviour of two parties; client and contractor (Shen et al., 2017). Table 3 tabulated the major causes of rework by phase that cause claims to happen in EPC project. It supports the statement by (Shen et al., 2017) where the primary cause of rework is not only by contractors but owner and designer alike.

Table 3. Major causes of rework by EPC phase

Primary Cause	Design Phase	Procurement Phase	Construction Phase	Start-up
Owner change	•	•	•	•
Designer error/omission	•	•	•	•
Designer change	•	•	•	•
Vendor error/omission	•	•	•	•
Vendor change	•	•	•	•
Constructor error/omission			•	
Constructor change			•	
Transporter error		•	•	•

Prolong to that, client will be facing difficulty in procurement phase with the issuance of change order and variation order by contractor. In procurement phase, problems such as uncertainties in procurement of equipment and materials (Du et al., 2016) are common to happen. Financing challenges, (Preiss et al., 2014) that is a consequences from lack of attention in cost management among contractor also contribute to the problems to appear. If the issues occurred, it is troublesome for client's side as the process of approving the payment of extra works are complicated and time consuming. This shows that management of claim is one of the biggest challenges in current changing international oil and gas industry (Shen et al., 2017). Hence, the respondent agreed that claim management should be emphasis in EPC project delivery.

From the contractor's perspective, the respondents are concerned about the project risks. Successful projects depend on how well project stakeholders address project risk. Taking into example, the case of the British Petroleum Deepwater Horizon (DWH) blowout. The root cause of the disaster is not due to mechanical failings but project risk management failures. Risk is an inherent part of oil and gas industry (Badiru & Osisanya, 2013). Respondent from Company B mentioned that in a risk management of a project, the major part of risk has been allocated. This is because risk management must be a core component of a company's project management portfolio in the oil and gas industry. However, Company B has a thought that the oil and gas companies did not seen risk management tool to be fully utilized by Malaysian companies as much as major banks and financial institution deployed. Due to that reason, the improper risk analysis and management in the industry still happened (Mubin & Mannan, 2013). The usage of risk assessment and risk management approaches help to deal with challenges in the industry. The global involvement of parties in EPC contract makes the project become risky. To avoid this situation, government regulators can work with oil and gas producers to monitor data and operations.

From the stance of Respondent from company B, the execution of EPC project will be agitated when the stakeholders are lack in communication and engagement. The oil and gas industry involves collaboration of multiple stakeholders in the flow of information throughout the project life cycle (Deshpande et al., 2012). Hence, the high degree of incredulity circulates through supply chain network in EPC projects, make the engagement of the stakeholders become distracted (Saad et al., 2014). This problem lead to inefficient coordination and communication management process alignment among the EPC project team members (Ahn, 2015). Apart from that, the project management in EPC project is also one of the problems in EPC contract. Project management is a basis of a project and to complete within timeframe and budget, all key players must work together. However, due to the issues of communication and engagement among stakeholders, problems in terms of cost, quality and time will arise during the project execution. EPC projects are plagued with project participants and often resulting in delayed completion, budget overrun, poor quality and subsequent barrage of claim and counter claims. This is aided by statement from previous researchers who are concern on the issues of delayed in project schedule (Pícha et al., 2015);(Al-Hajji & Khan, 2016), cost overruns (Pícha et al., 2015; Olaniran et al., 2016; Al-Hajji & Khan, 2016) as well as quality and safety (Pícha et al., 2015).

CONCLUSION

Oil and gas industry are associated with a high degree of risk because of its nature, process, activities, technological complexity and organization. Engagement with various participants, such as designers, owners, suppliers, contractors and subcontractors contribute to high volume of fundamental risks. In this era of oil and gas downturn, it is vital to have a good contracting arrangement to ensure the process of a project runs smoothly. From the pilot interview conducted, the results signified that there was not much difference of problems exists in oil and gas sector in Malaysia as compared to other countries. Issues identified from the interview with the industrial practitioners formed the ideas of current practice of EPC contract in Malaysia. Thus, it is convinced that the literature developed for this study was relevant and the issues in this study was significant to the area of research. By analysing the problems in EPC contract, it will help the stakeholders to identify on which stage issues frequently aroused. To address the issues, researchers can come out with greater solutions to improve the EPC contract especially via technological means as there is a limitation of technological implementation in EPC contracting arrangement.

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CRITICAL ANALYSIS OF "DOCTRINE OF PRIVITY" IN MALAYSIAN CONSTRUCTION INDUSTRY

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Abstract
Despite the rapid evolution of the norm, experts and law-makers still debate what should be the scope of bodies and rights covered, the scope of permissible exceptions to the right and even the scope of rights holders remain. Sanctity of doctrine of privity means giving recognition to the contractual framework with appropriate legislation. It is a general idea that once parties duly enter into a contract, they must honour their obligations under that contract. However, the issue of interpretation and application of this doctrine has been one of much controversy. The main issue in contention are the liabilities of parties when there is an agreement for direct payment by the employer to the sub-contractor. This paper examines the problems with privity of contract in Malaysian construction industry due to conflicting laws and lack of clarity of the Contracts Act 1950 which inflict additional legislative in various systems. From the review of primary data through legal journals and books, it divulged that there is lack of awareness and understanding among the construction industry key practitioners on the doctrine of privity in order to mitigate third parties claim. It also highlights the effect of contract of privity that will serve a platform for further research, honing and nuance comprehension of contractual management and governance in project.

Keywords: *Construction contracts; construction industry; doctrine of privity.*

INTRODUCTION

In Malaysian construction industry, the contract of privity has been closely intertwined with the law of contract, similar to that of various common law countries. However, the application of the doctrine of privity has been made complicated due to the employers election of the "Shadow Employer" or Agency to minimise his own obligations in the contract. "Shadow Employer" can be defined as appointed agency who acts like the owner, but actually is a proxy of the owner. This can be well-described in the case of *Star'k (M) Sdn. Bhd. v ZLG Sdn. Bhd. & Ors* (2018) 1 CIDB-CLR 179, whereby the third defendant though cited as the "employer", was not the owner of Avenue K; the owner was City Properties Sdn Bhd. This may not in the interest of the construction industry in the long run.

The short-term benefits of shifting liabilities to contractors may create an atmosphere of animosity which necessitates a plethora of contractual disagreements and, even, worse, a reluctance to partake tender for works in future (Fung, 2008). In practice, the doctrine of privity engendered hardship and injustice and proved inadequate to modern fulfilments. This predicament will further exacerbate the adverse repercussion of contract of privity which is far greater than justifying the urgent need to reform. Mitigation of this thorny issues requiring the canvassing of the multitude of laws that related to the issue of privity of contract not only involved prohibitively time-consuming but also difficult for construction players.

The doctrine of privity of contract states that any third party, which is not even distinctly related to the two involved parties, does not have a right to initiate a suit against the said parties to the contract even though he/she is the beneficiary. This is important to protect the interests of the contracting parties and prevent third parties to take undue benefit of the contractual terms. This is the decisive statement from the classic case of *Tweddle v Atkinson*

(1861) 1 B&S 393 which is the established authority on privity of contract. Apart from promisor(s) and promisee(s), all persons constitute the third party. Thus, the third party cannot sue the contracting parties for the enforcement of the beneficiary clause in the contract.

The contractor manages the subcontractor's work and is ultimately responsible to the employer for the subcontractor's work. Therefore, the contractor has recourse against his subcontractor but will need to prove he has suffered losses under the main contract, except if there is a liquidated damages provision in the subcontract. It is rare, however, to find a standard form of sub-contract, which includes provision for the deduction of liquidated damages should the subcontractor complete late. The normal procedure is for the main contractor to levy a claim against the subcontractor in respect of actual loss incurred.

Nevertheless, the contractor is still responsible for time, quality and paying the subcontractor in accordance with the contract between the contractor and subcontractor regardless of any issue that could arise between the contractor and the employer. This will depend upon the terms of the contract between the contractor and a subcontractor. It might also depend on the separate contract between the employer and main contractor.

As to instructions, the employer has no right to direct the subcontractor to carry out any specific work. The main obstacle in this intervention is there is no privity of contract between the employer and the sub-contractor. It is submitted that doctrine of privity contract theory cannot accommodate third party rights.

In the construction environment, most of the exception was created by meeting the needs of the employer to overwhelm the crucial situation due to dispute created by parties in the construction contract.

This doctrine has two distinct general rules. Firstly, the first rule has where at common law a third party cannot be held responsible by a contract in which he is not a party to or unaware of it. However, this first rule is not controversial at all.

The focus of this paper is to examine the problems with the second rule. This paper presents the development of common law doctrine of privity of contract with regards to the second law which provides that a person who is not part of the contract could not sue upon it in order to gain promised performance, even though the contract entered into has benefited him. It is interesting to note that in the United Kingdom, this second rule doctrine of privity of contract has been reformed by the Contracts (Rights of Third Parties) Act 1999.

RESEARCH METHODOLOGY

For the purpose of this study, the methodology adopted is qualitative in conducting in depth review of doctrine of privity. The purpose of having proper document primary data analysis is to identify significant controversial issues and to determine the guideline and scope of its application. In this study, primary data which are used for analysis include the legal cases, legal construction books, legal journals, etc.

There are numerous misconceptions and interpretation in implementation of the doctrine of privity. The lack of research permitted these misconceptions to perpetually persist,

obscuring and complicating what are essentially solvable issues. Thus, it does not possess the genuine and effective link with the parties that entitle them to claim loses suffer. Consequently, this has sparked off contentious hot button issues and questions to be answered and addressed. There were several issues in contention including whether conduct of the other parties had necessitated the employer undertaking liability for paying the sub-contractor. For the purpose of discussion on the liability issue of privity, this paper limits its scope to refer only to PAM 2018 contract form.

From the result obtained from the analysis, it is hopeful that it will provide a better insight and understanding on the doctrine of privity. Any recommendations made will be in view of helping the key construction players in executing their contractual obligations better and more effective administration of the contract.

Malaysia Situation

In Malaysia, the Contracts Act 1950 does not expressly provide for this principle but it is firmly acknowledged that the doctrine has been transplanted into laws of Malaysia. It is a fundamental principle of common law that apart from special circumstances, for example in cases of agency, trust, assignment or statutory exception, a person not a party to a contract has no right to sue on a contract (Sinnadurai, 2011). It was doubtful formerly whether this rule was applicable in Malaysia because of the wide import of Section 2(d) of the Contracts Act 1950. The decision of Privy Council in *Kepong Prospecting Ltd. & Ors v Schmidt* (1968) 1 MLJ 170, (1967) 2 PCC 465, (1968) AC 810, PC affirmed that the rule applies in Malaysia. The Court of Appeal and the High Court also uphold the application of the doctrine throughout all these years. This rule has been criticised particularly in cases where the contract is for the benefit of the third-party. At this time there has been no statute introduced and the rule persists in Malaysian Law to prevent a third-party enforcing contractual provisions made in their favour.

In Kepong's case, the Privy Council held that the doctrine of privity applies in Malaysia and further down at pp 866 to 867:

> …This would of course be in line with the doctrine of privity. The doctrine is clear. A non-party cannot bring an action on the contract. A person not a party to a contract cannot enforce or rely for protection on its provisions. The rule of privity relates to who can enforce the contract.

The following sub-sections are provided to put further insights into what had been decided in Kepong's case:

Two Aspects of the Doctrine

The doctrine has two aspects (Pollock & Mulla, 2017). The first aspect is that no one but the parties to the contract is entitled under it. Contracting parties may confer rights and benefits upon a third party in the form of promise to pay or to perform a service, or a promise not to sue (at all or in circumstances covered by an exclusion or limitation clause). But the third party on whom such right or benefit is conferred by contract can neither sue under it nor can rely on defences based on the contract.

The second aspect of the doctrine is that parties to a contract cannot impose liabilities on a third party. A person cannot be subject to the burden of a contact to which he is not a party. It is the counterpart of the proposition that a third party cannot acquire rights under a contract. This rule, for example, also bars a person from being bound by an exemption clause contained in a contract to which it is not a party, so that a contract between A and B cannot impose a liability on C.

Justification for the Doctrine

The main rationale for keeping the privity principle is twofold. First, contractual rights and obligations are relative or personal to those who voluntarily create them (Wang, 2011). Second, there was a fear among the draftsmen of the Malaysia law that without the privity principle, anyone could potentially enforce a contract, thus opening the floodgate for unnecessary litigation. In a similar vein, without the doctrine of privity could potentially encourage any third party to issue the litigation and to pay damages for which the contracting parties were not liable (Liang, 2001) This would essentially impose and unfettered burden on a third party. To fend off potential abuses of third-party rights and obligations in court proceeding, it is necessary to comply with doctrine of privity (Chen, 2017).

LIMITATION OF THE DOCTRINE OF PRIVITY OF CONTRACT

According to Cheshire et al. (1998) firstly, the doctrine of privity was not accepted as universally true in the earlier common law. Secondly, an exception to this rule, admitted in the first half of the eighteenth century, when the rule itself was obscure, has since maintained its ground. If A has made a contract with B, C may intervene and take A's place if he can show that A was acting throughout as his agent, and it is irrelevant that B entered into the contract in ignorance of this fact. This right of intervention, known usually as the doctrine of the undisclosed principal, has, indeed, been attacked on the very ground that it offends the common law doctrine of privity. But criticism has been fruitless, and the undisclosed principal is a well-established character in the modern law of agency.

Thirdly, the rule is strictly a creature of the common law. Equity, as may well be imagined, tends to take a less rigid view of the boundaries of contract and has sometimes sought to transcend them though approach has been unusually timid. Fourthly, the doctrine of privity, while a natural inference from a strict theory of contract, has clashed with the needs and concepts of the law of property. Fifthly, we should note that the doctrine of privity of contract means only that a non-party cannot bring an action on the contract. This does not exclude the possibility that he may have some other cause of action.

Finally, the substance of the matter must be looked at inasmuch as what may look like an absence of privity in so far as the apparent written record is concerned may actually conceal the fact that a verbal contract has actually been made between the parties concerned - of which the writing concerned is only a partial record as in *Tai Shin v Chung Moi* (1906) 1 FMSLR 1.

This limitation of this doctrine has also been discussed by Meng (2009) whereby the author has examined the common law mechanisms applied by the Malaysian courts to circumvent the doctrine of privity of contract which include several areas among others: agency, trust, tort and estoppel.

SUB-CONTRACT LEGAL POSITION FOR PRIVITY OF CONTRACT

It is a common practice in the construction industry that the employer may make direct payment to the nominated sub-contractor for fear that the main contractor will not pay them after receipt of payment from the employer. This will jeopardize the progress of the works and subsequently the completion will be delayed.

The doctrine of privity of contract is firmly embedded in our jurisdiction and the court will not hesitate to strike down any claim by a stranger to a contract. It does not matter if the employer is making payment directly to the nominated sub-contractor. Paying on behalf of the main contractor does not make the employer a party to the contract between the main contractor and the nominated sub-contractor. In the case of Star'k (M) Sdn. Bhd., there was no contractual relationship between the plaintiff who was a sub-contractor and the defendants. This lack of privity of contract between these parties was an important and significant point which must not be overlooked.

The plaintiff and the defendants were also not the typical "neighbours" in a tortious relationship. In this project, the plaintiff's contract was with Jalex and it was that contract which dealt with all of the plaintiff's rights and obligations. Yet, the plaintiff had not cited Jalex in this action. This non-inclusion of Jalex or even GR Associated unearthed the weakness and fallacy of the plaintiff's allegations.

There is no contractual relationship between an employer and its nominated sub-contractor. This is the norm in the construction industry. In the case of Star'k (M) Sdn. Bhd., the employers in choosing to govern their relationship with their nominated specialist contractors in this manner must recognise the limited remedies available to them vis-a-vis the nominated sub-contractor during the execution of the contract. This is ever more so in situations where the "employer" is not the owner of the works and may not be able to prove losses. In such situations, it is prudent for the "employer" to notify the main contractor of the identity of the owner; and the liquidated damages borne by the "employer" in the event of delay and the information be cascaded to the nominated sub-contractors.

The principle of privity of contract must be adhered to. Only the parties to the contract may sue and be sued contractually. Even if a benefit is conferred on a third party, that third party cannot sue unless it is made a party in a tripartite agreement. This is illustrated in the case of *Bond M & E (KL) Sdn. Bhd. v Isyoda (M) Sdn Bhd; Brampton Holdings Sdn. Bhd. (third party)* (2018) 1 CIDB-CLR 87, whereby even if a benefit is conferred on a non-party, that non-party cannot sue unless made a party in a tripartite agreement where the initial obligation of Isyoda to pay Bond was now taken over by Brampton with the corresponding rights of Brampton to sue Bond for any defective works during the defect liability period.

Main contractors often enter into sub-contracts, and then enter into a separate agreement with the employer for the employer to make direct payment to the sub-contractor. With that, the main contractor considers himself discharged from liability to make payment to the sub-contractor. However, the case of Bond M & E (KL) Sdn. Bhd. can be further elaborated the concept of privity of contract, whereby the supplemental agreement and settlement agreement were between Isyoda and Brampton, while Bond was not a party. Such an agreement confirmed a benefit to Bond, it did not allow Bond to sue for that benefit under the agreements

to which Bond was not a party. Bond would still look to the contractor party Isyoda to demand for payments.

Nevertheless, that ignores the principle of privity of contract. The sub-contractor is not party to the agreement between the main contractor and employer. The sub-contractor only has the sub-contract which he entered into with the main contractor. Therefore, the sub-contractor has to sue the main contractor for any payment due under the sub-contract. The main contractor remains liable to the sub-contractor under the sub-contract.

PRIVITY OF CONTRACT IN RELATIONS TO STANDARD FORMS OF CONTRACT

It is worth highlighting the privity of PAM contract 2018 in relations to standard forms of contract. This can be well-illustrated with the case *Bakti Dinamik Sdn. Bhd. v Bauer (M) Sdn. Bhd.* (2016) MLJU 1878. In this case, Bakti Dinamik Sdn Bhd (employer), Hundred Vision Sdn Bhd (contractor) and Bauer Sdn Bhd (sub-contractor) agree that all payments to be made by the contractor to the sub-contractor in accordance with the sub-contract (PAM sub-contract 2006) shall instead be made directly by the employer to the sub-contractor for and on behalf of the contractor within the period of honouring of certificate of payment. All direct payments made under this provision shall not create a privity of contract between the employer and the sub-contractor.

The rule of privity of contract stated that only parties to a contract can sue or be sued on it. The sub-contractor contracts with the contractor and thus, has no privity of contract with the employer. This is stated clearly under Clause 27.10 of PAM 2018 contract, CIDB 2000 contract C4 (a), PWD 203A contract Clause 62 and 63.1 (Mohamed ,2012), and AIAC 2019 contract Clause 27.12 (Rai, 2012).

It is thus clear that the employer in making payment pursuant to the letter of award to the sub-contractor (Bauer (M) Sdn. Bhd.) is purely performing an act on behalf of the main contractor. Therefore, the more pertinent point is that employer failure to pay on behalf of main contractor is of no legal or contractual consequences due to the absence of a contractual relationship between the employer and sub-contractor. Nothing could be more crystal clear worded than the aforesaid last sentence of clause 7.5 of the letter of award which unmistakably states to such exact effect. The sub-contractor is thus a third party to this interim certificates.

Further, Clause 24.1(c) of the agreement and conditions of PAM sub-contract 2006 which expressly permits the defendant to end his appointment in the event of non-payment by the main contractor clearly supports what is already plain and obvious that the defendant's recourse is only against the main contractor, not the plaintiff. Additionally, this clause 24.1(c) specifically provides that such payment obligation by the main contractor in respect of any certificate is however subject to any set off the main contractor could be entitled to under the same contract with the defendant.

The court cannot countenance a departure from the well-entrenched rule in the law of contract that a third party can neither benefit nor suffer from a contract executed by other parties. In the case of *Fibrosa Spolka Akcyjna v Fairbairn Lawson Combe Barbour Ltd.* (1942) 2 All ER 122, the sub-contractor's argument that a debt may come into existence independently of or in the absence of a contractual basis by relying on the House of Lords

authority, an unwarranted attempt to create an exception to the doctrine of privity of contract. The law thus treats the employer as a stranger to the sub-contract.

PRIVITY OF CONTRACT IN TERMS OF INTENTION

In construction industry, it is not the intention of a sub-contract to amend or supersede the existing main contract. The agreement between the main contractor and the employer is separate contract altogether, and the sub-contractor is not a party to it. Therefore the intention of the main contractor to step out of the payment arrangement and for the employer to take over the liability to pay the sub-contractor will not be reflected by these two separate contracts which contractor has entered into.

The case of Bond M & E (KL) Sdn. Bhd. explored the question of who a sub-contractor should sue for payment due to it under sub-contract with its main contractor when there was a separate agreement between the main contractor and its employer that the employer would pay the sub-contractor directly. The sub-contractor was not a party to that agreement between the main contractor and its employer.

The works under the sub-contract and the main contract were completed, but there were still monies payable to the sub-contractor pursuant to the sub-contract between him and the main contractor. The main contractor entered into a supplemental and settlement agreement with the employer, under which the employer was to make certain payments directly to the sub-contractor. In the Star'k case, there was no contractual relationship between the plaintiff who was a sub-contractor and the defendants. This lack of privity of contract between these parties was an important and significant point which must not be overlooked. In this project, the plaintiff's contractual rights and obligations were with Jalex yet, the plaintiff had not cited Jalex in this action or even called anyone from Jalex to testify. This non-inclusion of Jalex or even GR Association indicated the weakness and fallacy of the plaintiff's allegations.

An intention does not necessarily translate into legal obligations unless the contract documents properly implement that intention, present case, the intention of the main contractor was for the employer to take over his liability to pay the sub-contractor. But the sub-contract between the main contractor and sub-contractor, and the separate agreement between the main contractor and the employer, did not reflect nor implement that intention. Instead, the two separate contracts entered into by the main contractor remained separate and failed to connect the sub-contractor's right to payment to the employer's liability to make such payment. As a result, the main contractor remained to make payment to the sub-contractor.

Clarity of intention must be conveyed and then documented to enable that clear intention to be legally implemented (Weick, 1995). A disconnect between intention and documentation is a common feature of the construction industry. Misunderstanding of the legal position represented by the documents is also a common feature of the construction industry. All too often contractors are surprised by their liability to sub-contractors whom they thought to be the responsibility of the employer (Schrader, Riggs, & Smith, 1993). Contractors need to be aware of the doctrine of privity of contract - the contract as signed is binding between the parties that signed it. There is little room to assume that other provisions can be imported, or

that non-parties to the said contract may be liable under that contract. Each contract will be enforced as between the parties to that contract according to its terms.

Weststar Construction Sdn. Bhd. v Prisma Athira Architect (2018) 1 CIDB-CLR 214 suggest that, do not rely on implied terms or potentially complex legal concepts like estoppel. Remember the "privity of contract" principle - only parties to a contract (and not other third parties) can sue or be sued for breach of contract. Establish in writing everything that has been agreed, including supplemental contracts or collateral contracts and sign the written contract or contracts. If the parties agree on provisions that affect third parties, e.g. direct payment to be made to third parties, then write up a tripartite contract and ensure all three parties sign the contract. As a further measure, to prevent potential legal challenges such as an absence of "consideration" in the secondary contract, ensure at least RM 1 is specified as consideration.

EXCEPTIONS TO THE DOCTRINE OF PRIVITY OF CONTRACT

This principle can be furnished by either by the promisee or any other person, "at the desire of the promisor". The doctrine is however, neither rigid nor absolute. Certain exceptions to the doctrine are (Mohamed, 2012; Rai, 2012):

Collateral warranty / contracts

A collateral warranty is a contract which gives a third-party rights collateral to rights in an existing contract entered into by two separate parties. It is particularly widely used in the construction industry, where many parties like employer, tenants, engineer, contractor, sub-contractors, designer, other consultants etc. are reliant on each other. So, collateral contracts are made to protect parties who may be at risk if one of the parties not in direct contractual relationship fails to perform, to establish a collateral contract.

Trust of a contractual right

A third party can enforce a contract, if it can be established that the promise intended to create a trust. A trust is an obligation, enforceable in equity, by which a person, the trustee holds property on behalf of another, the beneficiary (McKendrick, 2009). The law of trusts gives third party beneficiary the right to action against promisors non-performance. In a practical context, the promisee (trustee) on the insistence by the third party (beneficiary) takes action against the promisor in case of breach. There can be no trust in case there is no promise or property that the trustee holds for the beneficiary. Establishment of intention of trust is very important in the law of trust.

Assignment

As assignment is the transfer of a promisee's rights under an existing contract. An assignment is done after the original contract is comes into existence. Due to this reason, a promisee can only assign rights with consent, either express or implied from the promisor. This is the only type of assignment that is recognized at Common Law. Any assignment without promisor's consent may face the rule phrased as 'a chose inaction is not assignable' (Beatson, Burrows, & Cartwright, 2010).

Agency

An agent can take a legal action and recover damages for the loss endured by his principal. The doctrine of agency gives such rights in a business setting. The contract between the principle and the third party is recognised if an agent enters into an authorised contract with a third party on behalf of his/her principle. If the agent makes a contract with a third party on behalf of his principle, that contract is regarded by law as having been made by the principle himself/herself. Hence s/he can sue on it and be sued on it.

Covenants which run with land

The benefit (and burden) of the landlord's and the tenant's covenants in a lease, as long as they are not personal, will run upon as an assignment of the lease or of their version. In *Steel Authority of India Ltd. v State of Ministry of Production & Ors* (1999) SC 1630, it was held that the central government transferred the land along with rights, liberties, privileges, etc., pertaining to the land given to the company.

Marriage settlements, partition or other family arrangements

In the cases where contract is made regarding the marriage, partition or other family arrangement and a provision is made for the benefit of the person, such person may/can take advantage of the agreement though she is not the party to it. For example, in *Nawab Khwaja Muhammad Khan v Nawab Hussaini Begam* (1910) 12 BOMLR 638, the plaintiff, as per marriage settlement had been given 500 Indian Rupee monthly as betel leaf expenses in perpetuity out of the income of certain properties, was held entitled to sue although she was not a party to the contract.

Acknowledgement or Estoppel

Where by the terms of a contract is required to make a payment to a third person and he acknowledges it to that third person, a binding obligation is thereby incurred towards him. Acknowledgement may be express or implied (Singh, 2008). In *Deb Narain Dutt v Ram Sadhan Mandal & Ors* LNIND 1911 Cal 111 transferee of debtor's liability had acknowledged his obligation to the creditor for the debt and the same was communicated to the creditor. When a suit was initiated by the creditor for the recovery of debt, the transferee had undertaken the obligation for the benefit of the creditor and thus the doctrine of privity of contract is not applicable here.

RECOMMENDATIONS

Construction practitioners and stakeholders need to focus or breakthrough innovation. Breakthrough comes from jettisoning old ideas and habits, practicing and evolving and adapting as circumstances change. It also requires a culture that nurtures innovation. A company's culture alters only when the people who work in it alter how they think, talk, decide and act - and that happens only when top management shows the way. This suggests that uncertainty and stakeholders correlations also depending on discarding old ideas and breakthrough innovation.

It is expected that this paper offers a significant contribution to the industry players, construction organizations, researchers and also academicians in helping to identify problems for further improvements. "Lessons learned'' associated with past project reviews where learning has significant potential to reduce uncertainty. However, these reviews have been undermined due to cultural issues. On this issue, it is suggested that there is a need for reflection and reviews, unless those lessons change working practices, no organizational learning has taken place (Senge, 1992).

CONCLUSION

There are plenty of disputes of a variant nature in the construction industry. Most of the disputes centre upon the relationship of the parties privy to the construction contract. There are others, which though not necessarily dependent on privity of contract, nevertheless affect some part of the construction industry and how contractors and employers are expected to conduct themselves.

It is not advisable to rely entirely on a restrictive or limited reading of the term(s) of a contract. The court will take into consideration the true intention of the parties and whether parties had at all times acted in good faith. The court made an observation that it was the duty of the court to construe the words used in the contract to give business efficacy to the bargain between parties.

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SAFETY PERFORMANCE OF SUBCONTRACTORS IN MALAYSIAN CONSTRUCTION INDUSTRY

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Abstract
In Malaysia, construction sector contributes in a great proportion to the economy aspect, however, construction sector also has the highest accident death rate as compared to other sectors. As most of the construction work is sublet to subcontractors nowadays, safety issue is closely related to subcontractors. Thus, the aim of this research is to investigate the impacts on the safety performance of subcontractors towards the safety level of Malaysian construction industry. The objectives are to determine the factors that impact the safety performance of subcontractors and compare the perception of main contractors and subcontractors on factors enhancing safety performance of subcontractors in Malaysian construction industry. Quantitative research method was adopted by distributing questionnaire surveys to Grade 7 main contractors and subcontractors that in Klang Valley, Malaysia. A total number of 70 questionnaires were received from the respondents including main contractor and subcontractor. It was discovered that the top 3 factors that impact safety performance of subcontractors in construction industry are failure to use personal protective equipment, lack of worker training and lack of management commitment whereas the least important factor is lack of job experience. Besides that, the top 3 factors to enhance safety performance of subcontractors identified are to provide personal protective equipment, health and safety plan preparation and provide safety and health training whereas the least important factor is improving working environment. Furthermore, it was found that there are differences in perception on factors enhancing safety performance of subcontractors between main contractors and subcontractors which are provide personal protective equipment and improvement of communication. This research helps the subcontractors and other construction personnel to have a better understanding on what should be aware and improve of in a construction project so that construction accidents rate in construction site can be reduced and construction workers safety is guaranteed.

Keywords: *Subcontractor; accident; safety.*

INTRODUCTION

Construction industry is a vital industry that contributes greatly to Malaysia's economic development. However, it is also a high-risk industry compared to other industries. Construction accidents or failures may occur in the construction site at any time whether it is before the construction commence, during construction stage, or after the construction is completed (Ulang et al., 1998). Construction accidents or failure not only threaten the safety of the workers that work on the site, but also the people that passed by the construction site. Construction accidents will bring a negative impact to the victims, organizations, companies and societies. Apart from that, accidents can also create a huge amount of economic losses to the involved organizations, companies or societies (Nawi et al., 2017). As a developing country, Malaysian's construction industry is still in an active and booming status, therefore, safety performance of the construction professionals has to be practiced well in Malaysian's construction industry so that the injury and death rate in a construction site can be reduced.

According to Social Security Organisation (2018), number of accidents and deaths in construction industry increased dramatically in year 2018 compared to 2017. From January

to November in year 2018, 8,191 accidents and 143 deaths had occurred in construction industry. It shows an increase from 2017, which have 120 deaths from January to November and 7,870 accidents for the whole year. This statistic of accidents and deaths reported by SOCSO shows that Malaysian construction industry is facing the challenges to improve its site safety practices so that the occurrence of accidents and deaths rate can be decreased (Nawi et al., 2017). Safety of a project should always be the first concern for contractors and subcontractors instead of time, cost and quality of a project.

Concurrently, a huge construction project usually consists of a large number of subcontractors that are working under the general contractors (Yong and Mustaffa, 2012). Subcontractors are the one who often directly manage a major portion of the construction activities in a project, thus, they are an important party in a construction project (Abbasianjahromi et al., 2013). This means that the performance of the subcontractors can impact the completion time, total cost, quality and also the safety of a construction project. Due to the importance of the subcontractors in construction sector, they are responsible to ensure the safety of the site, warn of hazards inherent to the site and work, hire qualified workers, coordinate job safety and inspect compliance with safety specifications (Abderrahim et al., 2005). Due to the increasing importance of the subcontractors in this construction sector, safety performance of the subcontractors will be the focus in this research. This research is initiated to determine the factors that impact the safety performance of subcontractors and compare the perception of main contractors and subcontractors on factors impacting safety performance of subcontractors in Malaysian construction industry.

LITERATURE REVIEW

Safety of Construction Industry

Construction industry is defined as one of the most dangerous industry out of all industries due to its higher risk for accident compared to other industries. The occupational safety statistics in most of the countries revealed that construction industry in the countries has the highest accidents rate compared to other industries (Melzner et al., 2013). Construction industry has become a hazardous industry due to the risk nature of construction works, lack of knowledge and risk awareness of construction personnel, large amount of unskilled and temporary workers and complicated contractor system with huge amounts of subcontractors (Kozlovská and Struková, 2013). According to Nawi et al. (2017), construction workers that work at construction site are always the main victim in any accident because they are the one who faced and exposed to those potential risks such as falling from height, electrical shocks, trench collapse and others throughout the whole construction process. Construction accident and site injury does not only have negative impacts to the workers, it also results in the cost and time overruns due to decreasing of output, interrupted schedule, and accident investigation and reporting (Senouci et al., 2013). Apart from that, construction accident not only threaten the human life but also cause substantial economic losses as this is due to the effect of accidents and damage to the construction plant, and machines (Charehzehi, and Ahankoob, 2012). When accident occurs at the construction site, local authorities have to do investigation and inspection. During the days of investigation, construction site is not allowed to work, therefore, it causes the project delays.

Subcontractors in Malaysian Construction Industry

A company that performs specific tasks in a construction project can be defined as a subcontractor (Damci and Polat, 2014). Subcontractors are playing a vital role in most of the construction projects as they are often hired by clients or main contractors to perform specific tasks on construction projects (Lew et al., 2012). Besides that, subcontractors may contribute to the economics of a country and also provide technical expertise to the construction industry (Enshassi et al., 2008). General contractor's performance is strongly depending on the performance of the subcontractors (Albino and Garavelli, 1998). This means that the performance of the subcontractors can impact the completion time, total cost, quality and also the safety of a construction project. Due to the importance of the subcontractors in construction sector, they are responsible to ensure the safety of the site, warn of hazards inherent to the site and work, hire qualified workers, coordinate job safety and inspect compliance with safety specifications (Abderrahim et al., 2005).

According to Choudhry and Fang (2008), main contractor is always the one who bear the responsibility of the construction accidents when the construction accident occurs. However, main contractor is the one who manage and control the construction process while the subcontractor is the one who execute and construct the whole building. Therefore, subcontractors should be selected carefully and wisely as it will easily influence the safety and success of a construction project. The past safety performance of subcontractors is important as it is always revealed as a criterion for the main contractors to select them for a new work or project (Ismail et al., 2009). This means that clients or general contractors will select the subcontractors that have a better safety performance or record rather than just select the subcontractors with lowest bid. Subcontractor that has a poor record of safety performance in their past project is eliminated and subcontractors who implemented safety program are chosen (Bertagnoli, 2002). It is undoubtedly that subcontractor is a party that contribute a lot to the success and safety of a project.

According to DOSH (2018), among the types of accidents that had occurred in Malaysian construction industry from year 2013 until 2018, the death cases involved machine operator and general workers on site. Most of the cases involved falling objects that hit the worker during work. Since most of the works were subcontracted out, it is believed that these workers could be employed by the subcontractors.

RESEARCH METHODOLOGY

Online self-administered questionnaires was adopted in this research as the respondents can answer the questionnaires in any place and time whenever they feel free as long as they have the link to enter the online survey website. Online survey questionnaire can save the cost for the researchers as the researchers do not need to print out the questionnaire and distribute to the respondents. Besides that, online survey questionnaire is able to ensure that all the questions have been answered by the respondents because if the respondents did not fill in all the questions, they cannot submit the questionnaire forms. This is to ensure that the researchers will not receive any incomplete feedback from the respondents.

The questionnaire was divided into 3 section. The first section asked about the role of the respondent's company (main contractors or subcontractors) and the working experience of

the respondents in this construction industry. Respondents were given 5 options to choose where 1 = "≤ 5 years", 2 = "> 5 years but ≤ 10 years", 3 = "> 10 years but ≤ 15 years, 4 = "> 15 years but ≤ 20 years and 5 = "> 20 years. Working experience was asked in this research to determine the reliability of the data as the respondent has a higher working experience means they have exposed themselves in this construction industry longer, thus, they will have a better knowledge and understanding on the safety performance of the subcontractors.

The second and third section was asked the main contractors and subcontractors to rate on the factors that impact and enhance the safety performance of subcontractors in Malaysian construction industry. Each of the section consist of eight factors that the respondents were asked to rate based on their opinion. 5-point Likert scale will be used in this research where 1 = "strongly disagree", 2 = "disagree", 3 = "neutral", 4 = "agree" and 5 = "strongly agree". Likert scale is widely used in the questionnaires survey to measure the opinions or perceptions with a greater degree of nuance. Likert scale is virtually a multiple-indicator or multiple-item measure of a set of attitudes relating to a particular area. Other than that, Likert scale is good in exploring deep into one particular topic to find out what people think about it. Each respondent was asked to respond and answer their level of agreement with the particular statement.

The targeted respondents were randomly selected from the list of registered G7 contractor in Klang Valley obtained from Construction Industry Development Board (2016). The list of registered G7 contractors were obtained online and random numbers were generated using Microsoft Excel to select the contractors randomly from the list downloaded. The reason that this research has selected the main contractor and subcontractor firms that are located in Klang Valley area because this area contains majority of the main contractor and subcontractor firms as compared to other area or state. They are the most suitable source for safety of workers since they work daily at construction site. Form a total of 150 questionnaires distributed, 70 completed questionnaire were received and used in this research.

RESULTS AND DISCUSSIONS

Total of 70 sets of questionnaires were used for analyses in this research. Table 1 below shows the demographic of the respondents.

Table 1. Demographic of Respondents

Parameters	Frequency	Percentage (%)
Types of Company		
Main contractor	37	52.86%
Subcontractor	33	47.14%
Years of Working Experience		
≤ 5 years	34	48.57%
> 5 years but ≤ 10 years	21	30.00%
> 10 years but ≤ 15 years	9	12.85%
> 15 years but ≤ 20 years	3	4.29%
> 20 years	3	4.29%

Factors Impacting Safety Performance by Subcontractors

Table 2 tabulated the detailed breakdown of mean rankings from two different types respondents which are main contractors and subcontractors. It also shows the overall ranking

of eight factors by all respondents. The ranking of all the factors was based on the data that have collected from the respondents.

The highest rank by all the respondents was failure to use personal protective equipment (mean value = 4.19) which considered as an important influential factor that impacts safety performance of subcontractors. Lack of worker training (mean value = 4.09) was ranked as the second influential factor while the third ranked factor was lack of safety inspection (mean value = 3.97). Amongst these eight factors impact the safety performance of subcontractor, lack of job experience (mean value = 3.57) was rated as the least important factor.

Moreover, factor that has the highest ranking for the main contractors (mean value = 4.30) was failure to use personal protective equipment but it was ranked second by the subcontractors (mean value = 4.06). Both main contractors and subcontractors have a same perception that failure to use personal protective equipment is one of the important factors that impact the safety performance of subcontractors. In Malaysia, most of the construction accidents was due to the victims fell from height, thus, if the construction workers have worn or used the personal protective equipment while doing works, it can help to decrease the possibility of occurring construction accidents in a construction project. Several studies show that factor that significantly impact the safety performance of subcontractor is failure to use personal protective equipment (Ulang et al., 1998; Teo et al., 2005, Choudhry and Fang, 2008, Hamid et al., 2008). Wearing or using personal protective equipment should not just because of the law required, it must be used or worn by the workers themselves whenever they feel that it is necessary to conduct particular works or the works might have threatened their life.

Table 2. Factors Impacting Safety Performance by Subcontractors

Factors	Main contractors		Sub-contractor		Overall	
	Mean	Rank	Mean	Rank	Mean	Rank
Lack of management commitment	3.95	3	3.85	3	3.90	4
Lack of worker training	4.00	2	4.18	1	4.09	2
Lack of communication	3.84	5	3.36	6	3.61	7
Lack of safety inspection	3.89	4	4.06	2	3.97	3
No stringent legal enforcement	3.78	6	3.55	4	3.67	5
Lack of job experience	3.65	7	3.48	5	3.57	8
Failure to use personal protective equipment	4.30	1	4.06	2	4.19	1
Failure to employ full-time safety officer	3.49	8	3.85	3	3.66	6

Apart from that, both main contractors and subcontractors have ranked lack of management commitment (mean value = 3.95 and 3.85) as their third most influential factor that impacts the safety performance of subcontractors. This is consistent with Ng et al. (2005) who discovered that top management commitment has a crucial symbolic function as their action or the policies that have implemented by them will demonstrate how they are concerning on this project. Besides that, the safety commitment of the top management and construction workers towards the safety campaign helps to cultivate safety culture in an organization (Teo et al., 2005). Top management that have engaged themselves in regular safety talks with the operatives on site can expect a better safety performance of a project because the management will have a better understanding on the safety issues or problem that faced by the construction site through communicate with the operatives (Langford et al., 2000). Aksorn and Hadikusumo's (2008) revealed that management's active role will show a genuine interest in the safety of construction workers which help to establish a positive attitude amongst the workers. Management must actively support and promote all the safety program such as organizing health and safety training for the workers and implement certain

policies or programs that may help to improve the safety performance of the project as the safety program cannot be run smoothly without management support.

The highest ranking by the subcontractors was lack of worker training (mean value = 4.18) whereas it was ranked second for the main contractors (mean value = 4.00). The hazardous tasks that may occur on site can be eliminated if subcontractors have provided a proper health and safety training to the construction workers (Ng et al., 2005). Workers who have been gone through a proper training are able to make an appropriate decision when dealing with accidents occur on the construction site (Charehzehi and Ahankoob, 2012). Subcontractors should provide their workers safety training routinely instead of just provide one training for each worker because a regular safety training may help to reduce the chances of occurring fatal accidents by increasing the awareness of construction workers in discovering near-miss accidents at construction site.

Moreover, both main contractors and subcontractors have ranked lack of safety inspection (mean value = 3.89 and 4.06) as their fourth and second most influential factor that impacts the safety performance of subcontractors. According to Hinze and Gambatese (2003), safety inspection is one of the methods which project manager and site supervisors can be acquainted with the safety performance of the construction site. Safety performance on site can be improved if the safety inspection is being conducted routinely since the function of the safety inspection is to monitor the safety performance of the workers and to prevent accidents and near miss accident from occurring on the construction site (Nawi et al., 2017). Construction accident is always unpredictable and uncontrollable, therefore, the safety of the construction site should have been monitored by conducting a proper safety inspection routinely so that the project manager and safety officer can inform the construction workers immediately once hazardous is discovered at the construction site.

Factors Enhancing Safety Performance by Subcontractors

Table 3 tabulated the detail breakdown of mean rankings from two different types of respondents which are main contractors and subcontractors. The ranking for the eight factors were presented by depending on the mean value of these factors where the higher the mean value of the factors, the higher the ranking it is.

As shown in Table 3, the most influential factor to enhance the safety performance of subcontractors that ranked by the respondents is to provide personal protective equipment (mean value = 4.21) for the construction workers. Then, the second highest ranked factor is health and safety plan preparation (mean value = 4.20) whereas the factors of provide safety and health training (mean value = 4.19) is ranked third most influential factor enhance safety performance of subcontractors.

Both main contractors and subcontractors have agreed that factor of providing personal protective equipment the most influential factor to enhance safety performance of subcontractors. Even though there are several policies and acts have enforced that the construction workers have to wear or use personal protective equipment at construction site, however, a lot of construction workers still not using or wearing personal protective equipment while doing works (Ghazali et al., 2014). Falling from height is always occur in construction site due to workers do not equipped body harness while conducting works, thus,

provide personal protective equipment to the workers and forcing every worker to wear it are necessary to ensure worker's safety (Huang and Hinze, 2003).

According to Enshassi et al. (2008), the employer or main contractor should stipulate in the contract with their subcontractor with a clause stating that the subcontractor should have provide personal protective equipment to their workers. Since most of the construction works are done by subcontractors, thus, subcontractors should provide their workers a complete set of personal protective equipment before construction commence and give them advice regarding to the importance of wearing personal protective equipment so that workers safety is guaranteed.

Table 3. Factors Enhancing Safety Performance By Subcontractors

Factors	Main contractors		Sub-contractor		Overall	
	Mean	Rank	Mean	Rank	Mean	Rank
Provide safety and health training	4.32	3	4.03	1	4.19	3
Improve working environment	3.76	8	3.58	6	3.67	8
Improvement of communication	3.97	4	3.39	7	3.70	7
Health and safety plan preparation	4.38	2	4.00	2	4.20	2
Responsible to report near-miss accident	3.81	7	3.79	4	3.80	5
Comply with safety rules and regulations	3.89	5	3.82	3	3.86	4
Employ full-time safety officer	3.84	6	3.73	5	3.79	6
Provide personal protective equipment	4.41	1	4.00	2	4.21	1

Furthermore, factor of health and safety plan preparation has been ranked as the second most influential factors to enhance safety performance of subcontractors by main contractors (mean value = 4.38) and subcontractors (mean value = 4.00). Safety and health planning are often established to define whether is the particular project safe enough to construct through formalizing a preliminary hazard analysis (Saurin et al., 2005). Safety and health planning normally involve the identification of all the potential hazards that may occur during the construction stage and determining the safety solution accordingly before the construction commence even though safety and health planning may not determine all the risks accurately but it may help to reduce some uncertainty in a project Bansal (2011). Besides that, it is recommended that the health and safety planner should coordinate with the designer because designer often design the project without considering safety factors (Melzner et al., 2013). A proper safety and health planning preparation may help a project in eliminating those uncertainties especially those hazardous works that may threaten the life of the construction workers before a project commence.

Subcontractors have ranked factors of providing safety and health training for the construction workers as the most influential factors with a mean value of 4.03. Meanwhile, this factor has ranked as the third most influential factors to enhance the safety performance by main contractors with a mean value of 4.32. According to Goldenhar et al. (2001), safety and health training should have been organised by the employer before the time of hiring the workers and also during the construction stage of the project. This result is also aligned with Demirkesen and Arditi's (2015) research that stated that employer should not only just organising safety training for the workers, but also have to monitor the effectiveness of the learning of the workers during the training session. In other words, the employer should ensure that the construction workers have learned some safety knowledge from the training session but not just only went for the training as required by the employer. The more the workers learned in the health and safety training, the lower the chance of construction accidents occur at the construction site.

Last but not least, factor of improving working environment of the construction site has ranked as the least important factor to enhance safety performance of subcontractors by main contractors and subcontractors with a mean value of 3.67. According to Hassan et al. (2007), the working environment may refer to the storage of equipment and tools, physical layout of construction site, temperature of construction site and others. Every subcontractor should have cleaned the construction site routinely and also after they finished their works because a messy worksite may increase the risk of an accident. It is the subcontractor's moral and legal duties and responsibilities to provide their workers a safe working environment (Cheah, 2007). A clean and tidy construction site is an important factor to enhance the safety performance of construction workers when they conducting their works (Sawacha et al., 1999). Even though this factor is ranked the most uninfluential factors among the main contractors and subcontractors, but both of them should also provide a safe working environment for their workers since a safe working environment can help to minimize the chances of happening construction accidents on construction site.

Subcontractors Comparison of Perception on Factors Enhance Safety Performance of Subcontractors between Main Contractors and Subcontractors

Mann-Whitney U Test statistical results were used to compare the perception of factors enhance safety performance of subcontractors between main contractors and subcontractors, the results were shown in Table 3. The significance level (p) which is given as Asymp. Sig. (2-tailed) in Table 3 that more than or equal to 0.05 means that the result has no significant difference between the two groups (Pallant, 2013).

The result shows that 6 factors that enhance safety performance of subcontractors have no statistically difference between the main contractors and subcontractors since the significance level (p) which equal to the Asymp. Sig. (2-tailed) in Table 4 has more than 0.05. However, the significance level of factor of improvement of communication and provide personal protective equipment does not equal or more than 0.05, thus, there is statistically significant difference in the result of main contractors and subcontractors.

Table 4. Mann-Whitney U test statistical results

Factors	Types of Company*	Mean Rank	Z Value	Asymp. Sig. (2-tailed)
Provide safety and health training	MC	38.95	-1.635	0.102
	SC	31.64		
Improve working environment	MC	37.09	-0.732	0.464
	SC	33.71		
Improvement of communication	MC	40.58	-2.308	0.021
	SC	29.80		
Health and safety plan preparation	MC	39.46	-1.853	0.064
	SC	31.06		
Responsible to report near-miss accident	MC	35.78	-0.130	0.897
	SC	35.18		
Comply with safety rules and regulations	MC	36.28	-0.365	0.715
	SC	34.62		
Employ full-time safety officer	MC	36.62	-0.517	0.605
	SC	34.24		
Provide personal protective equipment	MC	39.95	-2.095	0.036
	SC	30.52		

Table 4 indicates that mean rank for factor of improvement of communication to enhance the safety performance of subcontractor by main contractors and subcontractors are 40.58 and

29.80 with a difference of 10.78. This factor is ranked the fourth most influential factor by main contractor but it is ranked as the second least important factor by subcontractors in Table 3. Apparently, main contractors think that improving in communication between each party can help to enhance the safety performance of subcontractors but subcontractors do not think so.

According to Baxendale and Jones (2000), it has an advantage by merging the role of the main contractors and subcontractors when making decision on the safety issues in a construction project as this will create fewer lines of communication and should lessen the potential for contractual disputes over the content of health and safety plan. Safety issues should always be resolved once it is discovered because a construction accident will cause a lot of consequences to a project such as project overruns, cost overruns and the worst situation is death of construction workers life. Thus, the less communication line in a project the fast the problems can be resolved as the communication process takes time to inform other parties especially when there is a lot of parties need to be informed.

The more effective the organizational communication dealing with safety issues, the more positive the safety climate (Mohamed, 2002). Communication within an organization shall not be a one-way communication (top management to employee), it shall be a two-way communication where the employee can also communicate with the top management by giving their advice or opinion that they have seen in the construction site. Construction workers are the one who execute the construction works at the construction site, thus, they know more about the matters that related to construction site as compared to top management that spend most of their time in the office.

Table 4 indicates that the mean rank for factor of providing personal protective equipment to employees to enhance safety performance of subcontractor by the main contractors and subcontractors are 39.95 and 30.52 with a difference of 9.43. This factor is ranked as the most and second influential factor to enhance safety performance of subcontractors by main contractors and subcontractors in Table 2 even though this test revealed that there is significant difference among main contractors and subcontractors.

Although there is significant difference among main contractors and subcontractors on factor of providing personal protective equipment to the workers, but it is still ranked as most influential factors to enhance the safety performance of subcontractor by main contractors and subcontractors. Personal protective equipment has to be worn and used by construction workers all time while they are working on the construction site. It is essential that subcontractors should have monitored and taught construction workers on the proper use of personal protective equipment (Ghazali et al., 2014). By providing personal protective equipment to the workers, they shall also teach them the proper way to use it otherwise the personal protective equipment does not provide any function if it is wrongly equipped or used.

Even though factors of improvement of communication and providing personal protective equipment have statistically difference between the main contractors and subcontractors, however, both of them are vital factors that can help to enhance the safety performance of subcontractors. It is common to have different perspective on various aspect within a project between main contractors and subcontractors but they have to learn to tolerate and accept other party's opinion by putting worker safety as the first consideration.

CONCLUSION

Total of 70 sets of questionnaires were used for analyses in this research. Table 1 below shows the demographic Construction industry plays an important role among other industries as construction industry contributes greatly in the economic growth of a nation. Majority of construction works are executed by subcontractors, therefore, study on safety performance of subcontractors is essential. Hence, the impacts on safety performance of subcontractors in Malaysian construction industry is this research's aim.

The first objective of this research is to determine factors that impact the safety performance by subcontractors in construction industry. It was discovered that the top 3 most influential factors ranked by main contractors and subcontractors are failure to use personal protective equipment, lack of worker training and lack of safety inspection. The least important factor that ranked by all respondents is lack of job experience.

The second objective of this research is to identify factors that enhance the safety performance by subcontractors in the construction industry. It was discovered that the most influential factor to enhance safety performance of subcontractor is provide personal protective equipment to construction workers while health and safety plan preparation is ranked as the second influential factor by the respondents. Then, provide safety and health training to construction workers is ranked as the third influential factor to enhance the safety performance of subcontractors. Meanwhile, improvement of working environment of the construction site is ranked as the least important factor to enhance the safety performance of subcontractors in construction industry.

The third objective of this research is to compare the perception of main contractors and subcontractors on factors impact and enhance the safety performance of subcontractors in construction industry. Mann-Whitney U test's result revealed that there is no significant difference on the factors impact safety performance of subcontractors by the main contractors and subcontractor. However, it was found that two factors that enhance safety performance of subcontractors have significance difference which are improvement of communication and provide personal protective equipment to the workers.

This research focused on the perspectives of the main contractors and subcontractors that have involved themselves in the Malaysian construction sector on the safety performances of subcontractors. These professionals were selected to participate in this questionnaire because they have a strong construction background and knowledge in this construction field, therefore, they have a better understanding compared to other field's professionals. Moreover, the respondents that were selected to take part in this research are from Klang Valley area as there has much more contractor and subcontractor firms compared to other states. Furthermore, this research selected contractors that have registered with Construction Industry Department Board (CIDB) with Grade 7 (G7) and subcontractors as the respondents. Apart from that, the time frame given to conduct this research was limited, therefore, in-depth information was relatively less compared to other research.

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TEACHING STRATEGIES IN INTEGRATING BIM EDUCATION FOR THE QUANTITY SURVEYING COURSES IN MALAYSIAN HIGHER EDUCATION INSTITUTION

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Abstract
The introduction of BIM has created a revolution in the construction industry, where sophisticated technology was used in all the construction life cycle. Recent government requests for inclusive BIM application have led to a strong interest in BIM implementation and, creating a huge demand for BIM's skilled workforce. In addressing the current demand of the industry, it is crucial for the higher education institution to integrated BIM modules into their Quantity Surveying degree programme. However, there is a significant challenge for the higher education institution in educating future professionals due to the lack of information on the right strategies to embed BIM in their curricula. Thus, this research was carried out to identify the suitable teaching strategies for incorporating BIM into the curricula. Case study research method was adopted, involving 5 Malaysian higher education institutions that offer a degree in Quantity Surveying programme. Findings revealed that lecture, workshop, collaboration, open learning platform and project-based learning can be used incorporating BIM into the curricula. It is anticipated that findings from this research will serve as a guide for other courses mainly in the Architecture, Engineering and Construction field that seeks to integrate BIM into their curricula in transforming the Malaysia construction industry into a higher level.

Keywords: *Building Information Modelling (BIM) Education; quantity surveying; Malaysia Higher Education Institution.*

INTRODUCTION

For the past few years, BIM has made a wave in the construction industry as its application has been proven to enhance productivity and efficiency throughout the construction process. BIM is a method used for developing an intelligent virtual model that integrates design, construction, the operation which includes documentation and estimation. Countries such as the United Kingdom, United States, Singapore, and Hong Kong had been adopting BIM to enhance their construction process (Building Research Levy, 2016). Following their footstep, Malaysia government have strongly recommended the use of BIM to transform Malaysian construction industry to a higher level with the launch of the Construction Industry Transformation Program (CITP) 2016-2020 and the BIM Roadmap (2014-2020) (Construction Industry Development Board (CIDB) Malaysia, 2015).

According to the BIM Roadmap (2014-2020), 300 to 600 graduates who were well equipped with BIM skills from Engineering and Built Environment courses need to be produced to meet the industry demand (Construction Industry Development Board (CIDB) Malaysia, 2017). According to Khosrowshahi and Ariyaci, 2012), higher education institution plays an important role in equipping the graduates with the necessary BIM skills and knowledge to meet the industry's demand. To equip students with the BIM skills, the Engineering and Built Environment courses need to incorporated BIM content into their curricula. Several teaching methods and course structure were used in a different programme to incorporate BIM Eadie, et al., 2013; Wan Mohammad et al., 2018).

Among the strategies to incorporate BIM includes embedding BIM in some of the existing subjects, introducing BIM labs in project courses, conducting cross-discipline BIM courses as well as BIM as a standalone course. According to Kevin, R (2018), there is an increasing demand for workers with digital skills as more organisations are moving towards transformation to the digital environment. Sadly, the limited supply of workforce with these skills and knowledge have hindered the further implementation of BIM due to the inadequate of competent employees to operate the software and to conduct BIM training (Aftab et al., 2014). Hence, the graduate needs to acquire the BIM knowledge and skills in orders to meet the demand in the market.

The Ministry of Higher Education of Malaysia (MOHE) stressed upon the desire and ambition of the higher education system in our country to compatible internationally in the term of knowledge and employability (Kementerian Pengajian Tinggi, 2011). To meet the Government initiatives, Malaysia higher education sector has promoted the teaching and learning together with the aspect of BIM.

In Malaysia, various studies related to BIM have been carried out which includes the readiness of the construction industry to implement BIM. Yusof, Embi & Ali (2017) has studied on the readiness of Higher Education to adopt BIM, while Latiffi, A. A., Suzila, M., & Umol, R (2015) has studied on the perceptions of construction players in implementing BIM. On the other hand, Wallace, Godwin, & Ali (2016) has study on the challenges in adopting BIM. However, to date, studies on the BIM education in Malaysia Higher Education System has been minimal.

As BIM ease the work for quantity surveyor in the process of taking off, measurement, costing and reduce the variability in cost estimation (Ali et al., 2015). Hence, the BIM knowledge for Quantity Surveying graduates in essential to achieve the CITP target in 2020. The BIM education is not only about the skills to operate the BIM tools but also involve the collaboration of multidisciplinary in a project which include the engineer, architecture, quantity surveyor and parties that take part in it (Zhao et al., 2015). In 2016, the Royal Institution of Surveyors Malaysia (RISM) had established an education framework in BIM implementation for the QS graduates to prepare and equip the students with BIM skills in project delivery in the construction industry (Ali et al., 2015). However, the actual learning outcomes and the level of Quantity Surveying students from both private and public universities are still unknown. Thus, this created the need to figure out the gaps within the actual learning outcome and the proposed framework and subsequently looked into the teaching strategies that have been practiced.

TEACHING STRATEGIES FOR BIM EDUCATION

BIM education is defined as the process to acquire the required knowledge and skills to adopt BIM and generate the BIM deliverables (Succar et al., 2012). BIM education includes the basic understanding of the concept of BIM and the practical techniques to adopt BIM. The BIM education is needed in orders to increase productivity, efficiency and reduce waste in the construction industry.

As discussed in several reports on the benefits of adopting BIM in the construction industry, the industry players start to implement BIM in the construction project. However,

one of the challenges that have hindered the further implementation of BIM is the lack of professionals with well equip BIM knowledge and skills. The industry is looking for graduates that acquired with BIM knowledge so that less time and money are needed to train their employees in adopting BIM. Hence, BIM education is essential to produce graduates that will equip with BIM knowledge and skills to meet the industry need.

In recent months and years, the issue of BIM education has raise within the AEC educators to integrate BIM in their existing curriculum to prepare their graduates to the current industry needs (Becerik-Gerber, B., Gerber, D., & Ku, K. (2011). The current BIM Education level throughout the AEC courses in the country all around the world was reported in the International BIM Education Report (Kevin, R., 2018). Although the rate of adoption of BIM education increases gradually every year, however, the level of implementation is different in every country.

The BIM education starts with spreading the awareness on BIM benefits to the concept of BIM and mastering the BIM tools. A study conducted by Wu and Issa (2014) shows that most of the industry professionals have ranked the skills to operate the BIM software as the most important and should be master by the graduates in their studies. However, the study also reviews on the deficiencies of the BIM education which include the lack of focus on the collaboration concept within multi-discipline when implementing BIM. The knowledge of BIM concepts and the collaboration within multidiscipline is more important in understanding the work-sharing and the BIM-based communication as the BIM technology will continue evolving in the future (Dossick, C., Leicht, R., & Neff, G., 2012; Ku, K., & Taiebat M.Sc, M., 2011; Sacks, R., & Pikas, E.,2013). The concept of BIM which requires the collaboration within the multidiscipline need to be a practice among the students to prepare themselves toward the future working environment Gu, N., & London, K. (2010).

To enhance the integration of BIM in curricula, several actions have been carried out in worldwide to overcome the challenges such as the draft of BIM education framework Barison, M. B., & Santos, E. T., 2010; Sacks, R., & Pikas, E., 2013), collaboration with the industry (Thomas, K., Chisholm, G., Dempsey, B., Graham, B., & Stubbs, R., 2016) as well as implementing the project-based learning method and others.

From the literature, there are four main teaching strategies can be used incorporating BIM into the curricula; standalone courses, cross-discipline courses, project courses and integration into existing courses Huang, Y., 2018; Meng-Han Tsai, Kuan-Lin Chen and Yu-Lien Chang, 2019).

According to Huang (2018), the effective approach to introduce BIM into the curricula is by having BIM as a standalone course. Using this approach, students will be exposed to BIM technical and managerial skills efficiently. In developing the students' skills, this type of course usually will expose the students with a lower level of software application and then focus on the specific skills of modelling and basic analysis Lee, N., and Hollar, D. A., 2013; Joannides, M. M., Olbina, S., and Issa, R. R. A., 2012; Sacks, R., and Barak, R., 2010; Sacks, R., and Pikas, E., 2013).

Another teaching strategy is offering cross-discipline courses that allow students from a different discipline to take other programs offered such as civil engineering workshops and

architecture studios. This approach is easier to be implemented as it is maximising the existing resources. Furthermore, this approach will also give exposure to the students as it is based on the context of the cross-discipline environment which is the same as the construction industry.

Besides that, BIM can also be introduced in project courses, which allow students to learn about BIM process in various subjects throughout the programme. However, this approach will only limit the application of BIM within a few weeks due to the time constraints and also the needs to fulfil the other syllabus content. In this case, students may only be able to obtain a basic understanding of the BIM process with limited BIM skills.

According to Lee, and Dossick (2012) and Sacks, R. and Pikas, E., (2013), integrating BIM into existing courses is considered the most practical way to offer BIM. In this approach, BIM contents were divided into smaller and manageable topics which will students with a rich and rigorous learning environment and consequently better quality of education. Furthermore, BIM integration should be distributed throughout the programme and not only focused on upper-level courses (Sacks, R. and Pikas, E., 2013).

Sacks and Pikas (2013) suggests that in introducing BIM education to the students, it should begin with the BIM fundamental knowledge such as its concepts, modelling skills, followed by the implementation of specific BIM functionalities in different subjects, such as estimating, scheduling, visualization, coordination and system analysis. In the last few semesters of the programme, BIM should be incorporated into the broader picture of construction projects to create a holistic understanding of the use of BIM process in professional practice (Sacks, R., and Barak, R., 2010).

RESEARCH METHODOLOGY

This study was carried out using the case studies method as it allows the exploration of data in the real situation. This method enables the researcher to obtain a holistic and meaningful characteristic of events (Yin, R. K., 2003). The research process starts with a comprehensive literature review which focuses on BIM education through several journals, articles, books, reports, and academic dissertations. Databases such as science direct, EBSCOhost, emerald insight were used to gather the relevant literature.

Multiple case study approach is adopted to investigate a particular phenomenon at several different sites (Stake, R.,2006). By using this approach, it allows comparisons to be made which is important is in finding the suitable teaching approach when integrating BIM into the curricula. Furthermore, the using of multiple case study approach enables the researcher to understand the differences and the similarities between the cases (Yin, R. K., 2003).

Several criteria were considered in choosing the case study for this research. This includes the higher education institution that has to integrate BIM into their curricula, the commitment of the higher education institution, and the degree of willingness to participate in this research. Based on the above criteria, five higher education institutions were selected.

The semi-structured interview was used to explore the teaching strategies that have been practised in integrating BIM into the curricula. The usage of semi-structured interview allows the probing process for any particular issue relating to this topic. The semi-structured

interview was conducted in the interviewee's offices and was digitally recorded to allow verification and further analysis. The case study data were reviewed and analysed using the transcript, recorded the interview and supported documents. This is necessary for ensuring the data collected is accurate, consistent and reliable.

FINDINGS AND DISCUSSION

Due to confidentiality and to protect anonymity, the selected case study will be referred to as Alpha, Beta, Gamma, Delta and Epsilon. All of the case studies selected were based in Klang Valley and their backgrounds were tabulated in Table 1 below:

Table 1. Background of the Selected Case Studies

Case studies	Type of Institution	Years Accredited by BQSM	Duration of the QS Degree Programme
Alpha	Public	2015	3½ years
Beta	Public	2014	2 years (with Diploma in QS) or 3 years (STPM/ Matric)
Gamma	Private	2017	4 years
Delta	Private	2015	3-3 ½ years
Epsilon	Private	2017	4 years

Based on the semi-structured interview and document review conducted, BIM was integrated into the curricula not only in term of software but also in others aspect which include visualization, legal aspect and integrated project. The subjects that have embedded with BIM in these 5 case studies are tabulated in Table 2 below:

Table 2. BIM Related Subject

Case Studies	BIM Related Subjects
Alpha	Information Computer Technology (ICT), Measurement, Professional Practice & Integrated project
Beta	Measurement, Cost Estimating & Applied Studies
Gamma	Technical Drawing and CADD, Computer-Aided Quantity Surveying, Current Construction Issues, Integrated Project & Digital Construction
Delta	Building Construction, Building Services, Basic drawing and AutoCAD, Measurement of Building Works, Quantity Surveying Practice, Information Computer Technology (ICT) & Integrated Project
Epsilon	Construction Modelling, Design for Construction, e-Construction, Innovation in Construction Practice & Design Project

Each of the case studies has adopted and practised a different kind of teaching strategies to integrate BIM into the existing curricula in preparing their students to meet the industry demand. Among the teaching strategies used includes lecture, workshop, collaboration, open-learning platform and project-based learning. Table 3 describes each of the teaching strategies adopted.

Table 3. Description of Teaching Strategies

Teaching Strategies	Descriptions
Lecture	Infused BIM element into the syllabus Invite a guest speaker to share knowledge and experience
Workshop	Conduct BIM software training workshop for students Lecturers attending BIM certified training to incorporate BIM fully into the curriculum
Collaboration	Collaboration with BIM software supplier for training Collaboration with BIM consultant company of industry players for teaching material and current industry trends
Open-learning Platform	An open learning online platform that allows students and practitioner to learn at their own pace and share knowledge and problems within one another
Project-based Learning	Allow collaborative work environment within inter-disciplinary and coordinated construction data in managing BIM Project

The using of lectures as the teaching strategies will be exposed the students with 3D models of the structure and able to interchange between one another. As BIM is a technology that may evolve from time to time, creative and innovative teaching strategy should be adopted to be on the path with the emergent digital world.

For example, to give a picture of how the 3D BIM models can enhance the visualisation; the lecturer can demonstrate the concept using VR or AR tools/apps. Furthermore, a guest speaker who has vast experienced in BIM were invited to share their BIM knowledge and experience in the real construction industry.

The other teaching strategy is the BIM workshop, which was conducted by engaging certified BIM trainer. The duration of the workshop conducted is between 2 to 4 days. The workshop is not only beneficial for the students but also the lecturers, as they can always learn new things from time to time.

Furthermore, the higher education institution can collaborate with the industry player such as BIM consulting company or BIM software supplier. Gamma has collaborated with a BIM consultant company to facilitate the collaboration with a multidiscipline programme such as architecture and engineering students. This collaboration provides a platform to expose the students to the real project situation where students from different disciplines can share their perspective in a project.

Besides that, an effective learning process can be achieved when the students are active in creating, reflecting and discussing their work. Hence, the Massive Open Online Courses (MOOC) which is an open learning platform allows the educator to create a learning community and engage with the students. This platform has been proven to be 18 times more efficient than other platforms. Epsilon has created a MOOC BIM 101 and 202 to provide an enjoyable learning platform for the students. The MOOC BIM 101 and 202 has been created to allow students to learn in their free time and it is free of charge.

All 5 case studies have been adopting project-based learning strategies. In the Integrated Project or Applies Studies subject, the students are required to apply the BIM knowledge and skills throughout the whole lifecycle of a project based on the scenario given. The students will be assessed based on the 3D models that they developed using BIM software, construction scheduling (4D BIM), cost estimating (5D BIM) and the coordination with one another. Besides that, the students also have the chance to explore on the BIM Execution Plan when embedding BIM in a project and BIM Standard that proposed by a different organisation. Unlike the traditional teaching method, project-based learning focus on self-directed learning where the students need to explore the issue on their own by interpreting, analysing and resolving the problem.

CONCLUSION

Higher education institution has always been a place to learn and acquire necessary skills for the students' future employment. Choosing the right teaching strategy is not an easy task especially in this new digital world. Teaching strategies used need to be chosen carefully for an effective learning process. This research reveals the teaching strategies used by several higher education institutions in integrating BIM into their curricula. Five teaching strategies

had been identified; lecture, workshop, collaboration, open learning platform and problem-based learning. Findings on the teaching strategies used in the 5 case studies will serve as a guide for the other higher education institutions who intents to integrated BIM in their curricula.

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QUANTITY SURVEYING STUDENTS' LEARNING STYLES IN BLENDED LEARNING ENVIRONMENT

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Abstract
Adoption of blended learning is becoming important in higher education, with the aim to accomplish better course learning objectives, meeting students' changing need and promoting effective learning. According to Graham & Dziuban (2003), blended learning environment allows student to access learning materials outside the class while attending face to face education. The incorporation of ICT is the critical factor that drives blended learning to a success. However, a blended learning environment that fits every student with different learning styles is crucial to ensure effective learning. This study analyzed bachelor's degree level of quantity surveying students' learning styles, as well as the factors affecting students' adoption of blended learning in relation to the types of learning styles. The students' perspective towards current learning approach was also examined. A total of 172 survey questionnaires were collected in this study. The identification of students' learning styles was analyzed through VARK model analysis whereas the factors affecting students' adoption of blended learning were identified according to the mean value. The results revealed that majority of the students are kinesthetic learners where they are inclined towards hands on activities and interactive classes. It was also found that both learner's and lecturer's dimensions are the significant factors that affect the adoption of ICT usage in the learning process. Additionally, the results revealed that students favor more face-to-face sessions in a blended learning environment rather than online learning. Hence, educators should strive to achieve a balance between face-to-face and online learning to accommodate students with different needs.

Keywords: *Quantity surveying; blended learning; learning style; VARK theory; higher education.*

INTRODUCTION

Rapid development of information and communication technologies (ICT) has become one of the indispensable elements in the 21st century, affecting every area of life including the teaching style in education. Currently, universities are integrating the use of technology into teaching to make learning more efficient and interesting. As a result, the conventional teaching methods are no longer suitable to provide a better-quality education for students especially in the higher education. Therefore, blended learning is an innovative way to make the learning process more effective that suits the needs of students of the 21st century and matches the various preferences of learning style.

Blended learning is a learning environment that combines technology and traditional face-to-face learning (Akkoyunlu & Soylu, 2006). It is a formal education program where student learns between 30 to 70 percent through online learning and the remaining over face-to-face session. It combines several delivery methods such as collaborative software, web-based course and knowledge management practices.

Learning is perceived as a linkage between instructor, learner, classroom and technology. The integration of all the elements promotes an efficient and effective learning. The delivery of teaching and learning through classroom-based activities has been used for centuries where knowledge is being transferred from the educators to students in one-to-one or one-to-many

arrangements. Today, the utilization of new technology has shifted the practices in education, which led to the transformation of teaching and the way of learning. The transformation from conventional teaching environment to the blended learning environment requires the institution, educators and learners to take a huge step to change and learn the technologies available. By implementing blended learning in education it bridges the traditional face-to-face learning and e-learning, which helps to enrich students' experience in knowledge acquisition.

A good blended learning program should reflect the dynamic educational needs of students and use the right teaching and learning approaches to develop the right skills and knowledge for students in the education process. However, the development of blended learning environment often neglects the issues such as:

The suitability of blended learning contents especially for modules or subjects that cover a wide range of technical and theoretical subjects, for example in the area of construction such as quantity surveying.

1) The students' readiness in terms of commitment, disciplines and module content (e.g. some students find it difficult to adjust themselves to online module structure while managing their time and maintaining self-motivation (Fong et al., 2005).
2) The support of appropriate technologies to ensure the success of the blended learning program.
3) The competency of lecturers in integrating the online components with face-to-face lectures was considered as a critical factor in the implementation of blended learning (Adams, 2013).

Indeed, blended learning is undeniably popular among the higher education institutions in Malaysia and being embraced by various innovative pedagogical approaches. It is crucial to establish an equilibrium between face-to-face and e-learning to achieve an effective learning. The adoption of blended learning environment requires careful planning of modules to suit the needs of the students. Hence, this study seeks: (1) to investigate the bachelor's degree of quantity surveying students' learning styles, (2) to identify the factors affecting the adoption of blended learning environment based on students' learning styles, and (3) to identify the students' perspective towards blended learning environment in a bachelor's degree of quantity surveying programme.

LITERATURE REVIEW

Definition of Blended Learning

Blended learning is the integration of face-to-face and online learning to help enhance the classroom experience and extend learning through the innovative use of information and communication technology (Watson, 2008). In other words, it is an amalgamation of traditional physical classes with the virtual education. There have been many definitions of blended learning being described in the literature. Singh & Reed, (2001) defined blended learning as a learning program where more than one delivery mode is being used with the objective of optimizing the learning outcome and the cost of program delivery. This is further supported by Bersin (2004) who specified blended learning as a more balanced approach with

the combination of different media and methodologies to accomplish success through teaching.

According to Baldwin-Evans (2006), blended learning is a combination of two different learning methods, which can be as simple as watching a documentary film (informal learning) after attending a history class (formal learning). However, Thorne (2003) described blended learning as a way of meeting the challenges of tailoring learning and development to the needs of individuals by integrating the innovative and technological advances offered by online learning with the interaction and participation offered in the best of traditional learning. This definition provides a clearer insight to the public that blended learning is a combination of conventional and online methods to develop an innovative learning environment for students.

Definition of Blended Learning

Blended learning activities are highly dependent on the pedagogy, learning experience, resources and models that are utilized in the implementation of learning process (Bailey et al., 2015). Table 1 summarizes the blended learning activities that can be implemented based on the pedagogy of learning.

Table 1. Blended Learning Activities (Bath & Bourke, 2010)

	Face to Face Learning	Learning With ICT
Learning Resources	• Text book • Work book • Lecture notes • Table learning	• Reading is online • Online learning guide • Website links • Self-paced online learning
Collaborative	• Small group work • Discussion • Debate • Project work	• Discussions, forums, debates and role-play online (virtual classroom) • Small group work in virtual • Build and share online learning resources
Learning	• Lecture • Tutorial • Workshop/seminars • Practical/Internship working group	• Video footage of teaching • Webcast • Virtual classroom (online)
Communication	• Talk face to face • Notice on the notice board • Official letter • Announcement role in classroom	• Email • Notice is online • Space forum • Online chat rooms
Student Activity	• Drill on paper • Self-learning • Reading • Reading reflection	• Drill through online • Online testing • Reading reflection is online • E-portfolio

Learning Styles

Learning style refers to individuals, which differ in regard to the most effective mode of instruction or study (Buşan, 2014). According to Felder & Silverman (1988), learning style is defined as an individual's preferred way of acquiring, retaining and processing information. In addition, learning style is also defined as the unique behaviours of learners in adapting to their learning environment (Moayyeri, 2015).

The combination of teaching methods and stimulating an interactive classroom environment is an important factor to achieve effective learning. However, students learn in

many different ways (Pourhosein, 2011). Some students are visual learners, some may be auditory or kinaesthetic learners and some students may have more than one learning style. Due to these different learning styles, it is crucial for educators to incorporate different activities related to each learning styles so that all students are able to succeed (Pourhosein, 2011).

The Importance of Determining Students Learning Style

Awareness of ones' learning style helps students to understand themselves better. In order to understand and determine the learning styles, students should complete a learning style instrument at the beginning of the course or module. Educators should be mindful that every student learns differently and therefore they should have different teaching approaches to suit the different learning styles. Nelson et al. (1993) concluded that students who completed learning style instrument at the beginning of the course achieved better grades at the end. In addition, the percentage of students participated in learning style workshops who enrolled in universities is larger than those who did not participate in the workshops. Once students' learning styles are determined, educators will have a clear picture in planning the course content by providing a variety of materials to which students can relate it in terms of their personal experiences (Almasa, Parilah, & Fauziah, 2009).

Almasa et al. (2009) stated that many educators have been neglecting the underlying reason of students' failure or refusal to learn. The investigation into what works the best for each student is crucial and consequently will lead to students' success.

Determining Learning Styles (VARK Model)

Learning is a complex process where an individual achieves knowledge or skills, which involves the learner's biological senses (Idrizi & Filiposka, 2018). Neil Fleming, the creator of VARK explained that students' preferred learning modes have a significant influence on their learning behavior and the information accessed through students' use of their modality preferences increase their levels of comprehension, motivation and metacognition (Macdonald, Germine, Anderson, Christodoulou, & McGrath, 2017). The VARK model is based on learners' ability in receiving information by vision, hearing and touch. Miller (2001) defines VARK as a perceptual, instructional preference model, which classifies learners by sensory preferences. Moayyeri (2015) reported that this model has been proven to be a popular and simple way to identify the learning styles of learners. Therefore, it is a common and preferred assessment tool among educators to investigate their students' learning styles. The VARK model recognizes the concept that every learners process information differently, which is referred to as "preferred learning modes" (Macdonald et al., 2017).

Generally, the acronym VARK derives from the physiological dimension of the learning styles, which consists of visual, aural, read/write, and kinaesthetic (Idrizi & Filiposka, 2018). Visual learners like to view demonstrations and can learn through descriptions. They are easily distracted by movements or actions but not by noise. Aural learners prefer to learn with auditory instructions and appreciate aural discussions. However, they can simply be distracted by noise. On the other hand, reading learners often draw out mind maps to remember what they have learned and they do well in hands-on projects or tasks. Finally, kinaesthetic learners learn best by participating or doing and prefer hands-on experiences and do not favor classes

where they need to sit down to watch and listen. Generally, kinaesthetic learners do not perform well in the classroom.

Factors Affecting the Adoption of Blended Learning

Looking into the work of other researchers, the factors affecting blended learning in higher education can be summarized as follows:

- Factors associated with students
- Factors associated with educators
- Factors associated with technology

Factors associated with students

Some students may not be able to cope with the new responsibility of taking own initiative in their learning process (Vaughan, 2007). In addition, there are students who may experience difficulty in adjusting to the online course structure in addition to managing their time and maintaining self-motivation (Fong, Ong, Atan, Idrus, & Ng, 2005). These issues will result in student disenchantment with the online environment. Mackeogh (2003) studied the students' attitude towards the usage of technology in learning and reported that about 20 percent of the students preferred the traditional form of learning, which involves no technology. In contrast, about 12 percent opted for e-learning. The results indicated that quite a number of students were unwilling to forgo the face-to-face learning experience, even though they were the technology enthusiast. In another study, Howard (2009) reported that more than half of the online students surveyed missed the face-to-face interaction with other students and their lecturers.

Factors associated with educators

The establishment of educator presence in online courses is a concern as several studies have shown that a strong educator presence, along with quality course content are essential in facilitating a successful online student engagement activities (Moore, 2014). Another study indicated that instructors' characteristics such as attitude, teaching style, control and responsiveness are also important (Al-Busaidi, 2012). Moreover, instructor's teaching quality are affecting student's social presence as well as learning satisfaction (Kim, Kwon, & Cho, 2011). As suggested by Gray and Diloreto (2016), regular communication with students, consistent feedback and critical discourse modeled by the educator can be the ways to establish their presence in online courses. It is crucial to make students feel confident with the educator and other students in the course to achieve high degree of engagement in the course activities. Students are able to build their knowledge if they have a feeling of connectedness in the online learning communities (Cho & Tobias, 2016).

In addition, there are a number of studies showed that the educator roles in guiding students to successfully participate in asynchronous online discussion is relatively important (Beth, Jordan, Schallert, Reed, & Kim, 2015). They further explained that educator shall provide a clear guideline on ways to participate and initiate the online discussion. Beth et al. (2015) concluded that a successful planning of online discussions can provide an impact in terms of both quantity (e.g. online discussion were scheduled at regular intervals and students

were required to place a number of posts) and quality (e.g., students were instructed to use a conversationally inviting tone, to provide contextual information and to address academic questions and comments to their peers).

Additionally, other study found that the involvement of few face-to-face classes, synchronous online classroom session which involve interaction and discussion can positively affect students' feelings of connectedness to their educators and other students (Sidebotham, Jomeen, & Gamble, 2014). Yet, it is understood that such engagement does not occur without anyone putting in initiative as developing a learning community takes time and can only be accomplished with conscientious effort (Beth et al., 2015).

Factors associated with technology

There are a large number of studies focusing on the technological aspects of blended learning. Technology is undoubtedly an important aspect that cannot be neglected as it is the basic ingredient used to blend with the traditional face-to-face learning in the implementation of blended learning environment (Chen & Yao, 2016). According to Garner and Rouse (2016), learning management system (LMS) or a virtual learning environment (VLE) are used to structure content and to facilitate interaction. The technological aspect, which comprised of system functionality and content feature is a concern in adopting blended learning. In this study, system functionality is defined as the flexibility of access to learning and assessment function in blended learning while content feature is the traits or presentation of the learning contents. So and Brush (2008) in their study found that participants with the lowest expectations on the investigated course had encountered technical problems in their blended learning experiences. Thus, as identified by Raphael & Mtebe (2015), providing technical support for the educators and instructors is essential.

RESEARCH METHODOLOGY

Research Design

In this study, quantitative research method was used as the research approach as quantitative information is able to deliver a greater level of confidence and certainty by using the mean method to average a set of data (Marsland et al., 2014). This method is a formal, objective and systematic process where the results are transformed into numerical data to obtain information (Aliaga & Gunderson, 2003). Online questionnaire method was selected as a large amount of data from a large group of students is required in this study. The questionnaires were structured to be close-ended questions where specific responses are required and answers involved ranking and scales or categories. The identification of students' learning styles was analysed through VARK model analysis whereas the factors affecting students' adoption of blended learning were identified according to the mean value. Figure 1 illustrates a simplified research framework for this study.

Target Population and Research Sample

The population of this study were students of the Bachelor of Quantity Surveying (Honours) or BQS programme in Taylor's University. There were a total of 310 students which consists of 58 semester 1 students, 38 semester 2 students, 65 semester 3 students, 27

semester 4 students, 67 semester 5 students, 43 semester 6 students, 11 semester 7 students and 1 semester 8 student.

Limitations and Restrictions

One of the limitations of this study was the relatively small sample size compared to all the quantity surveying degree students in Malaysia. This was due to the time constraints, which only allowed the study to be focused on a smaller scale.

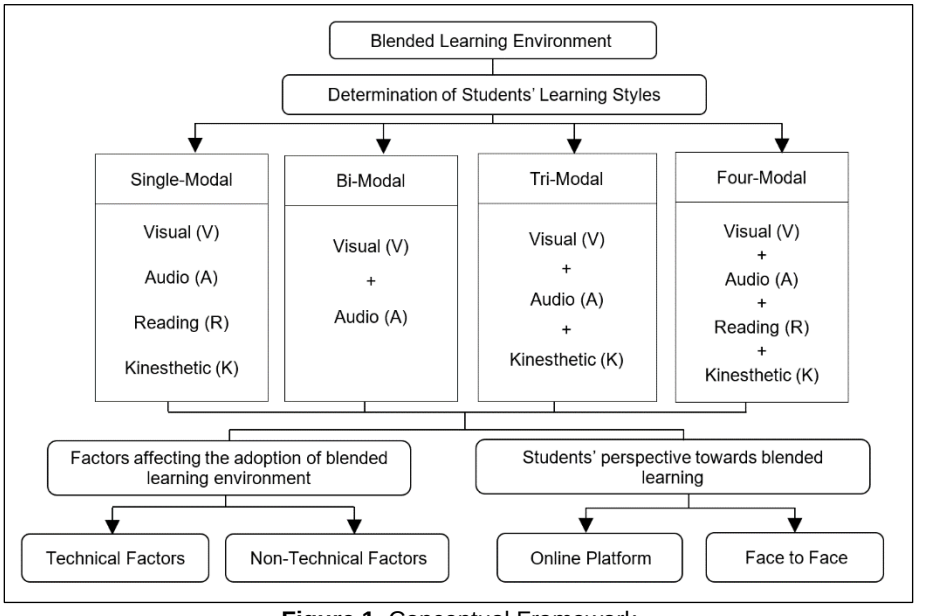


Figure 1. Conceptual Framework

DATA ANALYSIS

Frequency analysis and VARK interpretation analysis were used to analyze the data collected from the questionnaire survey. The five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree) were adopted in this study. The relative Importance Index (RII), Mode, Median and Mean were analyzed to transform the feedback from respondents.

Interpretation of VARK Learning Style

The interpretation of VARK learning style questionnaire is done by collecting answers from every individual learner and interpreted into points, as cited by Khongpit, Sintanakul, & Nomphonkrang (2018). The examples of data interpretation below were attained from the above study. Firstly, the total scores of V+A+R+K are calculated to find the stepping distance from the table below:

Table 2. Use Of Scores Of Stepping Distance To Calculate The Score Level Of Learning Style

The total of four VARK score is	Your stepping distance is
14-21	1
22-27	2
28-32	3
32+	4

Steps of learning style calculation:

1) Calculate the total scores of VARK to find the stepping distance. S is used for stepping distance.
2) Use n1, n2, n3 and n4 respectively and sort the VARK points in the order from the maximum to minimum.
3) Hence, if n1 - n2 > S, it indicates the learner has a single preference of learning style. If the result is less then follow step 4.
4) If n2 - n3 > S, it means the learner has a bi-modal preference. If the result is less then follow step 5.
5) If n3 - n4 > S, it signifies the learner has a tri-modal preference. If the result is less, it means the learner has a four-modal preference.

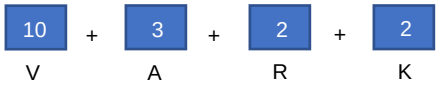
Single Modal Preference Learning Style

The following table is used to compare the total scores of VARK to find out the strength of learners' preference.

Table 3. The Strength of Single Preference

Total Scores	The Strength of Single Preference			
	Very Strong Preference	Strong Preference	Mild Preference	Multimodal No Single Preference
16-21	6+	4-5	2-3	0-1
22-27	7+	5-6	3-4	<3
28-32	8+	6-7	4-5	<4
32+	9+	7-8	5-6	<5

The example below shows how the data is interpreted. Example: Mr. A's score for VARK = 17

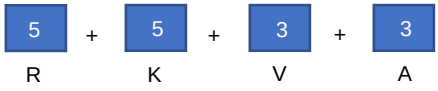


Where: n1 = V, n2 = A, n3 = R, n4 = K

- Calculate the stepping distance, S = 1
- Calculate the learning style: V(10) – A(3) = 7 where, 7 > S
- Mr. A has V learning style with a very strong visual preference.

Bi-Modal Modal Preference Learning Style

The following example shows the data interpretation for bi-modal preference. Example: Mr. B's score for VARK = 16

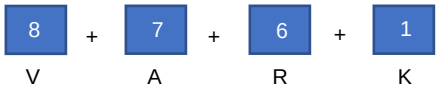


Where: n1 = R, n2 = K, n3 = V, n4 = A

- Calculate the stepping distance, S= 1
- Calculate the learning style: R(5) – 5(K) = 0 where, 0 < S
- Proceed to n2 - n3, K(5) – V(3) = 2, where 2 > S
- Mr. B has bi-modal preference of learning style: R and K.

Tri-Modal Preference Learning Style

Example: Mr. C's score for VARK = 22



Where: n1 = V, n2 = A, n3 = R, n4 = K

- Calculate the stepping distance, S = 2
- Calculate the learning style: A(8) – A(7) = 1 where, 1 < S
- Proceed to n2 - n3, A(7) – R(6) = 1, where 1 < S
- Proceed to n3 - n4, R(6) – K(1) = 5, where 5 > S
- Mr. C has tri-modal preference of learning style: V, A and K.

Four-Modal Preference Learning Style

The learner has four styles of learning (V, A, R and K) if the result of n3 - n4 < S.

Frequency Analysis (Relative Importance Index)

Relative Importance Index (RII) is used to calculate each option and rank each of them accordingly. Data collected in section C of the questionnaire for each factor were computed with the formula of RII to determine the relative importance of the factors affecting the adoption of blended learning.

Relative Importance Index (RII):

$$\frac{\sum W}{AN} = \frac{5(n_5)+4(n_4)+3(n_3)+2(n_2)+1(n_1)}{5N}$$

Where:

W – the weight given to each factor by the respondent, range from 1 to 5;
n1 is the number of respondents for strongly disagree;
n2 is the number of respondents for disagree;
n3 is the number of respondents for slightly disagree;
n4 is the number of respondents for agree;
n5 is the number of respondents for strongly agree
A – the highest weight (5 is the highest in this study)
N – the total numbers of respondents
The ranges of the relative importance index are from 0 to 1

DATA PRESENTATION, ANALYSIS AND DISCUSSION

Key Findings for Objective 1

The first objective of this study is to investigate the bachelor's degree of quantity surveying students' learning styles. Fig. 2 below shows the results revealed that the majority of respondents were susceptible to single modal learning style with 75 students (44%), followed by four-modal with 52 students (30%) then tri-modal with 25 students (12%) and finally bi-modal with 20 students (12%). It can be observed that the students were widely spread among the learning modals with about 57% having more than one modal of learning style, which means they can learn best in over one dimension between visual, audio, reading and kinaesthetic.

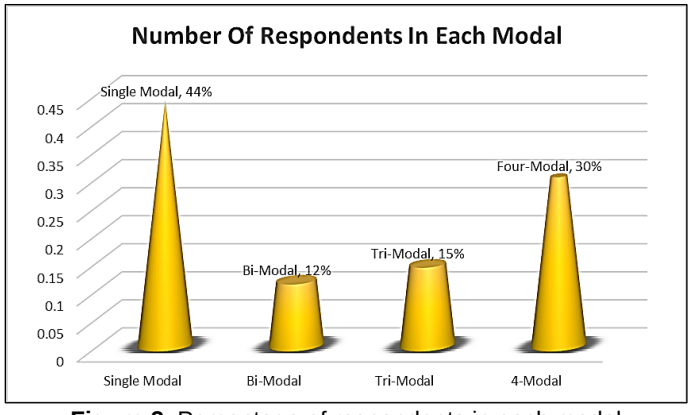


Figure 2. Percentage of respondents in each modal

Figure 3 below illustrates the breakdown of respondents' learning preferences for each modal category. According to Harris, Connolly and Freeney (2009), every learner has different preferences in learning. Bi-modal, tri-modal, and four-modal are made up of single learning styles comprises of visual, audio, reading, and kinesthetic. From the diagram it can be observed that most of the respondents were kinesthetic learners where they are more inclined towards, for example hands-on learning activities.

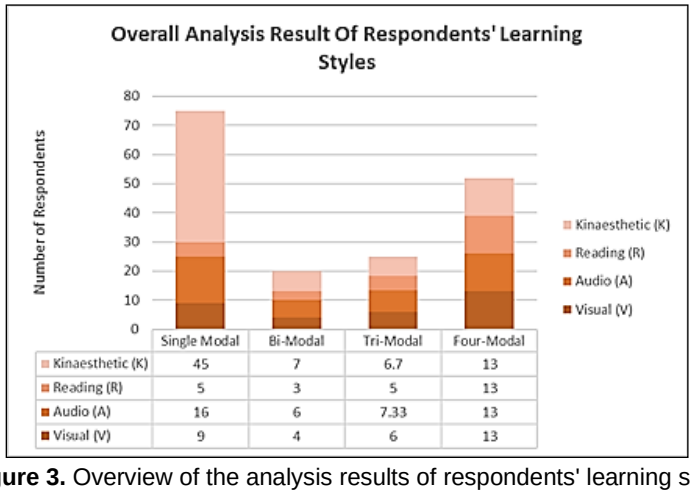


Figure 3. Overview of the analysis results of respondents' learning style

Key Findings for Objective 2

The second objective is to identify the factors affecting the adoption of blended learning environment based on students' learning styles. Referring to TABLE IV, it can be identified that generally students from different learning modals (Bi-modal, Tri-modal and Four-modal learners) ranked the factors affecting them in the adoption of blended learning similarly, with a slight difference for single modal learners. Factors related to lecturers' dimension were ranked the highest by the bi-modal, tri-modal and four-modal learners whereby single modal learners perceived themselves to be affected the most by factors related to learners' dimension, thus making both factors the most significant in affecting all the learning modals. By looking at the top two highest ranking, it can be understood that learning style and teaching process are relatively important and entwined in the students' learning process.

Table 4. Summary of Ranking Based On Each Modal

Non-Technical Factors		
Factors Related To Learners' Dimension		
Single Modal	**Ranking**	**1**
Bi-Modal		**2**
Tri-Modal		**2**
Four-Modal		**2**
Factors Related To Lecturers' Dimension		
Single Modal	**Ranking**	**2**
Bi-Modal		**1**
Tri-Modal		**1**
Four-Modal		**1**
Factors Related Course Design Dimension		
Single Modal	**Ranking**	**4**
Bi-Modal		**4**
Tri-Modal		**4**
Four-Modal		**4**
Technical Factors		
Factors Related To Technical Dimension		
Single Modal	**Ranking**	**3**
Bi-Modal		**3**
Tri-Modal		**3**
Four-Modal		**3**

According to Kazu (2009), education should be provided by taking into consideration the individual differences in the teaching process. The students have diverse learning styles, therefore the inclusion of various techniques in an educator's repertoire should be sufficient to meet the needs of most, if not all the students in the class (Richard, 2008). Hence, the incorporation of ICT in a blended learning environment is relatively interlinked between the lecturers' innovation and the students' readiness to accept this new learning approach.

This is supported by Qasem and Viswanathappa (2016) where they stated that lecturers' perception is the major predictor of the use of new technologies in instructional settings. It was proven in the research by Weaver (2005) that some of the main motivators for learners' participation in online activities are the ability to learn from others by gaining opinions, advice or responses from others, and giving or receiving help from moderators. In addition, Felder and Silverman (1988) described the level of learning that students achieve in class, is governed not only by the student's natural ability, but also by the compatibility of their learning style and the lecturers' teaching style. Hence, the students' perspective and

willingness in adopting to technological advancement is among the main determinants in achieving a better and effective learning process.

Additionally, the results revealed that factors related to course design dimension has the least effect on students' adoption of blended learning. The process of quantity surveying measurement involves a student in reading the construction drawings, quantifying the works and documenting the quantity of works (Lee, 2009). Hence, hands-on activities and real-life examples are essential for the students in achieving a better insight and understanding of the module.

Key Findings for Objective 3

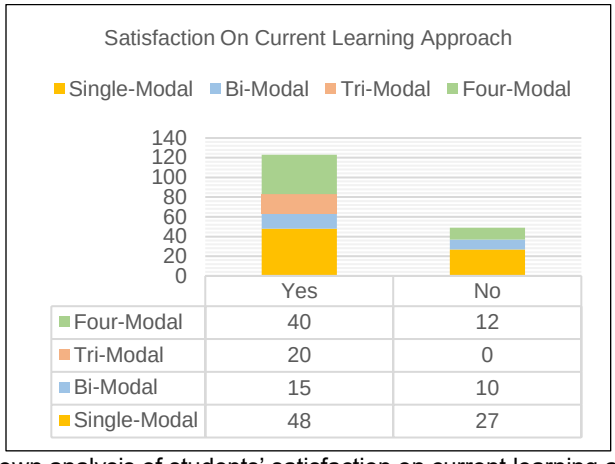


Figure 4. Breakdown analysis of students' satisfaction on current learning approach based on learning styles.

The third objective is to identify the students' perspective towards blended learning environment in a bachelor's degree of quantity surveying programme. Figure 4 provides the breakdown analysis of the respondents' satisfaction on the current learning approach according to the different learning styles, where 72% of the respondents were satisfied while the remaining 28% were not satisfied. The results gave a brief insight that more than half of the students were satisfied with the approaches currently being adopted in their learning environment.

Table 5 shows the students' perspective towards online platform and face-to-face session. Face-to-face was ranked the first with the average mean of 4 while online platform was ranked the second with the average mean of 3.152, which implied that students have higher preference towards face-to-face session than online platform. This is aligned with the statement made by Hiltz (1993) where he mentioned that many researchers claimed that learners tend to be more satisfied with face-to-face interactions when comparing the satisfaction level between online and face-to-face courses. Students often struggle to adapt to the change from traditional classrooms to virtual classrooms in the higher education institutions (Panyajamorn et al., 2018).

Some students may not be ready to accept the extensive use of technology in studies. It was found that students feel more disconnected from their peers and lecturers and more

obliged to be self-directed in their study while completing their online activities (Otter et al., 2013). In addition, students without sufficient technical knowledge or support would feel intimidated by the technological expectations of the online study (Holley & Oliver, 2010). Hence, it can be concluded that the findings of this research is aligned with the findings of other researchers mentioned above.

Table 5. Breakdown Analysis On The Satisfaction Towards The Current Approach

Perspective Towards Blended Learning Environment in BQS										
		SA 5	A 4	N 3	D 2	SD 1	TR	MR	RII	Rank
A	***Online Platform***									
1	Online exercises and practices motivate	6%	24%	42%	12%	16%	172	2.907	0.975	**5**
2	Time saving.	28%	37%	17%	7%	11%	172	3.634	1.218	**1**
3	It is enjoyable to have learning experience with the incorporation of ICT usage.	16%	32%	28%	12%	13%	172	3.262	1.094	**2**
4	Online exercises help your to follow courses easily.	13%	28%	30%	15%	14%	172	3.128	1.049	**3**
5	BQS modules in the online platform meet your needs.	6%	32%	31%	14%	16%	172	2.983	0.994	**4**
6	Online studies complete face-to-face sessions and satisfy your needs considerably in terms of extra practices.	10%	27%	34%	10%	19%	172	3.000	0.159	**6**
B	***Face To Face***									
1	Generally, you prefer to find the answers of tutorial questions in a face to face classes.	48%	34%	16%	2%	1%	172	4.262	1.038	**3**
2	Face to face sessions help you to understand about the contents more detail.	51%	35%	12%	2%	1%	172	4.343	1.058	**2**
3	You are more favourable to sharing and discussion environment in face	27%	19%	31%	17%	6%	172	3.430	0.836	**4**
4	You prefer to have interaction studies such as face to face sessions compared to online	41%	36%	16%	5%	2%	172	4.105	1.063	**1**
5	Physical attend quizzes and mid term exams reflect your progress better.	34%	34%	22%	6%	5%	172	3.860	0.193	**5**

CONCLUSIONS

Summary of Key Findings

Objective 1: to investigate the bachelor's degree of quantity surveying students' learning styles.

The identification of each respondent's learning style was successful and substantial to exemplify the learning preference of students in the BQS programme. From the analysis in the previous section, it was found that majority of students from different learning modals have a similar characteristic in their learning preference.

Analysis of the learning modals showed that the highest learning preference among the different modals is kinaesthetic (K) as shown in Fig. 3. Kinaesthetic type of learners are more favourable towards a learning environment where they get to involve in hands-on experience in their learning process. In addition, kinaesthetic learners process information best when they are physically engaged during the learning process.

Objective 2: To identify the factors affecting the adoption of blended learning environment based on students' learning styles.

It is perceived that students from different learning modal adopt to the blended learning environment in a different way. From the analysis, it was found that the critical factors that affect the students' adoption of blended learning were generally similar for each modal (Single modal, Bi-modal, Tri-modal and Four-modal). The top two highest ranked factors were the factors related to the learners' dimension and the factors related to the lecturers' dimension. On the other hand, the factor that ranked the third was the factors related to technical dimension while the lowest in the rank was the factors related to course design dimension.

To conclude, the detail breakdown of the analysis could help both the public and private higher education institutions in determining the ways to improve students' adoption of the blended learning environment by looking into the needs of students from each learning modal. The various methods of instruction such as lectures, group work, experiments, projects and practical exercises can be carried out through face-to-face sessions or online learning, yet the optimal balance is advised to be identified in order to create an effective blended learning environment that suits all types of learners.

Objective 3: To identify the students' perspective towards blended learning environment in a bachelor's degree of quantity surveying programme.

The results revealed that students were generally satisfied with the current learning approach. However, it was found that majority of the students were more supportive of the face-to-face session rather than the online platform. This findings provide a clear and noteworthy fact that most students in the BQS programme are more inclined towards attending physical classroom sessions with the lecturers. The provision of face-to-face sessions and online activities shall be adjusted in accordance to students' needs to assure they learn effectively in the blended learning environment. A blended learning environment does

not require the learning session to be 50% face-to-face and 50% online learning. The percentage of online session in blended learning shall be proportionate in accordance with the students' need in order to achieve an equilibrium in the learning process.

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ASSESSING THE MALAYSIAN STANDARD FORM OF CONTRACT IN RELATION TO THE CURRENT CONSTRUCTION DISPUTE AND DISPUTE RESOLUTION

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Abstract
Construction dispute in the construction industry is a common issue and keep on increasing not only in Malaysia but in other countries. In Malaysia, many initiatives done by the government, stakeholders and standard form of contract committee advisor to overcome the problem of construction disputes. Thus, the objective of this paper is to identify the most frequent construction dispute occurred in relation to the Malaysian standard form of contract and to investigate the most effective dispute resolution expressed in the Malaysian standard form of contract preferred by the industry players. An observation of Malaysian court cases from 2015 to 2016 and semi-structured interview of 18 experts have been conducted and analyzed using content analysis to achieve the objectives of this paper. From an observation of 85 court cases (2015 to 2016), it can be concluded that 41.18% (35 cases) of payment disputes and 36.47% (31 cases) of contract disputes were marked as the most frequent disputes occurred in the construction industry. The results were supported by a semi-structured interview of 18 experts, where payment of work done (33%) and extension of time (60%) were marked as the most frequent construction disputes occurred in the construction industry. Based on the findings of the most preferred dispute resolution, 56% of the respondents opted for arbitration because it was clearly written in the Malaysian standard form of contract. Adjudication (33%) also referred to as the most effective dispute resolution in-term of cost and time as CIPAA act allows claimant to claim at any time of the dispute occurred compared to arbitration.

Keywords: *Construction dispute; Malaysian standard form of contract; construction dispute; dispute resolution; content analysis.*

INTRODUCTION

Construction dispute is a common issue that happened in developed and developing countries. The dispute arises when a claim that had been submitted by one party get rejected by the other parties. It can happen between contractor and client, client and an architect and many other contractual parties' arrangements (Judi et al., 2017). However, according to Jaffar et al. (2010), a construction dispute also synonym with a conflict, whereby in a situation when objectives were contradicted with the goals of another (Muigua, 2011).

Generally, in Malaysia, there are four (4) institutions using the standard forms of construction contracts (SFC); The Institution of Engineers Malaysia (IEM), Pertubuhan Akitek Malaysia (PAM), Construction Industry Development Board (CIDB) and Jabatan Kerja Raya (JKR) (Nadkarni & Sigh, 2018; Ting et al., 2013; Oon, 2002). In April 2018, AIAC also came out with a standard form of contract AIAC 2018 for the construction industry (Rajoo, 2018).

Overview of Construction Disputes

Most of the construction disputes in Malaysia arising from claims under the contract such as payment, time, variation, and a perceived failure in the administration of the contract (Hussey Fraser referenced in Cunningham, 2015). Fenn and Speek (1997) however identified the factors for construction dispute are due to the client fail to respond in timely manner, poor communication among members of the team, supervision and coordination efforts on the part of the project.

The SFC is usually in a pre-printed and pre-drawn (Zulkifli et al., 2011) and projects governed by the standard forms consists a basic legal framework identifying the rights, obligations, and duties of the parties; establish the ambit of the powers and duties of the contract administrative procedures necessary for operation of the contract (Rodriguez, 2018; Hayagam & Pathmavathy, 2005).

In the construction industry, the contractors encounter difficulties in understanding the contract documents due to their non-legal background and the characteristic of legal wording (Chong & Balamuralithara, 2012). A poor understanding of the construction contract also has been highlighted by a number of previous researches as factors of construction contract dispute (Chong & Zin, 2010; Mohamad & Zulkifli, 2006; Broome & Hayes, 1997; Thomas et al., 1994; Semple et al., 1994).

Table 1 shows the Malaysian construction dispute cases that were recorded from 2014 to 2018 under adjudication. From April 2014 to April 2015, the registered construction disputes were only 84 cases. However, from April 2015 to April 2016, the number of cases has increased from 84 to 207 and from April 2016 to April 2017, the construction disputes had continued to increase from 207 to 547 cases, and finally in 2018, the cases have increased from 547 to 932 (Rajoo, 2018; KLRCA, 2017).

Table 1. Construction dispute under adjudication proceeding

Type of Construction dispute claim under CIPAA 2012	2014-2015	2015-2016	2016-2017
Final account value	27	36	100
Interim payment	38	116	131
Extension of time	1	1	6
Variations	4	3	56
Defective work	0	3	56
Payment of professional fee	0	3	5
Withholding monies	2	15	91
Contract term	3	3	20
Other/NA	0	6	14
Total	84	207	547

The continuous increase in the number of cases clearly shows that most of the construction disputes were mainly derived from clauses under the Malaysian standard from of contract. Hence, this paper intends to identify the most frequent construction dispute occurred in relation to the Malaysian standard form of contract.

Dispute Resolution in Malaysian Construction Industry

Fryer et al. (2004) argued that construction disputes rarely result in a satisfactory outcome. In general, the mechanisms under dispute resolution procedure can be classified

under three (3) main mechanism, i.e., litigation, arbitration and alternative dispute resolution (ADR). El-Adaway and Ezeldin (2007) have labeled both litigation and arbitration as traditional dispute resolution procedures, particularly owing to its availability in the construction industry before the existence of any other dispute resolution procedures. However, it has been always the contractual requirements that both contracting parties achieve settlement of dispute by referring to a multi-tier dispute resolution mechanism either voluntarily or involuntarily.

According to Jelodar et al. (2014), selecting the best conflict and dispute resolution method is not easy and can be very problematic especially when the decision involves multiple objectives or attributes. Conventionally, construction parties consider cost, time and the amount of control they have in selecting their dispute resolution method (Jelodar et al., 2014). On the other hand, one of the most important issues is the intended relationship of quality and future retention status of working relationships. Based on the range of potential relationship contingencies, the conflicting parties can decide on their potential strategy, style and method of conflicting management (Jelodar et al., 2014). Tanielian (2013) endorses arbitration as a superior dispute resolution method for construction disputes. Alternative dispute resolution methods such as mediation, negotiation, and adjudication are also considered as options for pre-dispute phases, whereas arbitration is the best all-around binding (Tanielian, 2013).

In the Malaysian construction industry, dispute resolution that available is such as litigation and arbitration (JKR 203A 2010, Sarawak SFC, PAM 2006, IEM 2017, CIDB 2000 & AIAC 2018). In addition, mediation and adjudication also available in SFC as an alternative dispute resolution (ADR) (PAM 2006, IEM 2017, CIDB 2000 & AIAC 2018). ADR, however, is an alternative to litigation in resolving contractual disputes as it is perceived to be a cost saving, more private and able to avoid ill-will or animosity as it sometimes does, in litigation (Zuhairah et al., 2009; Cheung, 2006).

According to Baskaran (2014), arbitration is most often used since the domestic standard forms of building contract, such as those published by the Public Works Department (PWD) and the Malaysian Institute of Architects (PAM), which expressly provide for arbitration in resolving the construction dispute.

Alternative Dispute Resolution ADR such as mediation and adjudication are increasingly gaining its popularity in resolving construction dispute which is cheaper, less time consuming and flexible than arbitration and litigation proceeding (Abraham, 2018). Rajoo (2008) argued that the latest version of the standard forms shows an improvement of the Standard Form of Contract, where clauses 65 of PWD 203A (Rev. 2007), clause 34 of PAM 2006 and clause 47 of CIDB Building Works 2000 edition shows that the arbitration has been adopted as the final form of settling disputes.

Table 2 indicates the summary of comparison of dispute resolution from the various Malaysian standard form of contact. One of the major differences between the latest PWD 203A 2010 in clause 66 and Sarawak SFC in clause 43.3 is where the dispute resolution process is more straight forward as compared to Sarawak SFC.

Table 2. Comparison of dispute resolution from the various Malaysian Standard Form of Contact

Type of standard form	PWD (203A) 2010	JKR SARAWAK SFC	CIDB 2000	IEM 2016 (IEM.CE2012)	PAM 2006	AIAC 2018
Type of dispute resolution	1. Parties named in Appendix of contract 2. Arbitration	1. S.O 2. Employer 3. litigation or arbitration	1. S.O 2. Mediation 3. Arbitration named in Appendix	1. Engineer 2. Arbitration	1. Adjudication or mediation 2. Arbitration	1. CIPAA 2012 2. Arbitration 3. Mediation
Clause no.	66 pg. 43 of contract	43.3 (aa) pg. 50 of contract	47 pg. 89 of contract	55 pg. 24	34 & 35 pg. 40 of contract	Clause 34 & 35 pg. 85-87
Process	1. Parties shall refer to name in the appendix (clause 66.1) and he or she will make a decision within 45days subject related to clause 66.5 which excluding clause 51 of contract. 2. If parties disagree with the decision shall refer to arbitration clause 66.3 using AIAC arbitration rule	1. Contractor shall submit in writing on the disputed matter to S.O within 14days by post 2. S.O shall make a decision as soon as practically time. 3. If disagreed with the decision, the contractor shall within 14 days after the decision to employer and employer decide within as soon as practically time. 4. If dissatisfied with employer decision shall with 28days after a decision from employer submit the case to litigation or arbitration	1. Contractor shall submit his dispute to S.O to make a decision with 30days after receiving all supporting document and evidence. 2. If disagreed with the decision shall refer to 47.2 mediation After receiving notice/30days. 3. Within 90days after expiring of 30days so decision employer or contractor shall refer to mediator for decision making under CIDB mediation rule. 4. If fail or disagreed then can refer to arbitration after 14days of termination of mediation with the condition must give notice to S.O before referred to arbitrator named in Appendix	1. If any disagreement or dispute shall refer to an engineer. The engineer shall make a decision with 84 days. 2. If the engineer fails to make a decision or disagreed with the decision, the contractor or employer may refer to arbitration within 84days after the expiring date of 84 days decision by the engineer.	1. Parties are free to refer the case to adjudication by serving a notice 21days to appoint adjudicator if fail after 21days. PAM shall appoint on party's behalf. Once a decision has been made by the adjudicator and parties disagreed with the decision can then refer to arbitration under clause 34.5 of the contract clause. 2. Parties also can refer to mediation under clause 35 with the same procedure as adjudicator appointment. If the decision by mediator challenged by the parties. parties can then refer to arbitration clause 34.5	1. Any dispute shall refer to arbitration using the AIAC arbitration rule. Arbitration subject to 34.3(a). 2. Parties also can refer to mediator under clause 35 subject to 35.1 to 35.3 limitations.

Different form of contract has different stages of dispute resolution. By referring to IEM 2016, PAM 2006 and AIAC 2018 form of contract; the dispute resolution is more directive compare to PWD 203A, JKR Sarawak 203a and CIDB 2000 whereby these type of standard forms requires several stages in resolving the dispute.

However, different layers of the dispute resolution under the contract provision had lengthened the time of dispute decision. Furthermore, performance and consistency on the progress of construction works will also be affected by the longer duration of time in resolving the construction disputes. Thus, the second objective of the paper intends to investigate the most effective dispute resolution expressed in the Malaysian standard form of contract preferred by the industry players.

METHODLOGY

Observation of Court Case

According to Zainal (2007) and Yin (1984), an observation case study helps to provide more realistic responses than a purely statistical survey. Observation of Malaysian court cases from CIDB Construction law report 2015 and 2016 were conducted to achieve the first objective of this paper. The court cases used in this investigation have been made public and are available online. Therefore, there is no breach of privacy or confidentiality towards any company or organization. Nevertheless, the cases were only used to identify the source of the dispute, rather than the outcome of the case.

Semi-Structured Interview

A semi-structured interview was adopted as a method of conducting a qualitative research methodology to achieve the first and second objective of this paper. Out of 50 set of semi-structured interview questions emailed to respondents from public and private sector client, consultant, contractor and standard form of contract committee advisor prior to the interview session, only 18 responded to be interviewed. Five (5) respondents are from the client, four (4) respondents are from standard form committee advisor, four (4) respondents are from consultant (quantity surveyors and engineers) and five (5) respondents are from contractor. Denzin and Lincoln (2005) argued that semi-structured interview involves an interpretation, naturalistic approach emphasized on the significant information that is not experimentally examined or measured compared to quantitative research. Qualitative research also emphasizes the improved understanding of human behavior and experience (Denzin & Lincoln, 2005).

ANALYSIS AND DISCUSSION

Construction Dispute in the Malaysian Standard Form of Contract

Both data collection from the observation and semi-structured interview were analyzed using content analysis. Based on result of an observation through Malaysian court cases from year 2015 to year 2016, there were 85 cases in total and the construction disputes were divided into four categories and sub-categories based on the issues reported. They were 10 sub-

categories under payment dispute, 11 sub-categories under contract dispute, seven sub-categories under technical and others by five sub-categories.

Table 3. Construction dispute based on court cases observation

Item	Category of construction dispute	Description	No. of cases 2015	No of cases 2016	Rank
1	Payment dispute	Non payment	7	6	
		Under payment	1	1	
		Late payment	0	2	
		Balance sum/outstanding	6	0	
		LAD	1	0	
		Interim claim	2	1	
		Performance bond	2	0	
		Final account	1	1	
		Variation order	3	0	
		Provisional sum	1	0	
		Total payment dispute cases	24	11	
		Total	35 cases (41.18%)		1
2	Contract dispute	Pay when paid clauses	1	1	
		Validity of contract agreement	0	1	
		Letter of acceptance	0	1	
		Term of contract	3	5	
		Clarity of claim process	0	1	
		Clarity of claim documentation	0	1	
		Clarity of contract agreement	7	1	
		Termination of contract	5	1	
		Limitation time of claim	1	0	
		Government regulation	1	0	
		Completeness of contract document	1	0	
		Total contract dispute cases	19	12	
		Total	31 Cases (36.47%)		2
3	Technical dispute	Workmanship	0	1	
		Soil investigation	3	0	
		Specification requirement	1	0	
		Design failure	2	0	
		Underground services	1	0	
		Duty of care	1	0	
		Competency	1	0	
		Total technical dispute cases	9	1	
		Total	10 cases (11.76%)		3
4	Other dispute	Site possession	2	1	
		Dispute resolution	3	0	
		Third party	1	0	
		Resignation of competent person	1	0	
		Contract of indemnity	0	1	
		Total other dispute cases	7	2	
		Total	9 cases (10.59%)		4

Based on the content analysis on observation of court cases, it can be found that payment dispute and contract dispute were the most frequent disputes in Malaysian construction industry. From 85 constructions dispute cases, 35 (41.18%) cases were from payment dispute,

followed by contract dispute, 31 (36.47%) cases, technical dispute 10 (11.76%) cases, and others were 9 (10.59%) cases. Table 3 shows the frequency of construction disputes from the year 2015-2016.

Based on Table 3, the most frequent construction payment disputes were reported from 2015 and 2016. The highest disputes were non-payment (13) followed by balance sum or outstanding (6), interim payment (3) variation order (3), late payment (2), performance bond (2), final account (2) dispute in underpayment (1), LAD (1) and provisional sum (1). The most frequent construction disputes in this paper were in line with Hussey Freser (2007) where the most of the construction disputes in Malaysia are arising from claims under the contract such as payment. Payment disputes were mainly contributed from poor contract management, incomplete contract and unsubstantiated claims (Global Construction Dispute Report, 2018).

Furthermore, findings based on semi-structured interview with 18 experts in Table 4 shows that the results are in line with the observation of the 85 Malaysian court cases in year 2015-2016 whereby the payment in work done (33.33%) and extension of time (60%) are the most frequent disputes happen in the construction industry.

Table 4. Construction Dispute Based on Semi-Structured Interview

No.	Type of Dispute	Subcategory of Dispute	Frequency	Percentage (%)	Rank
1	Payment dispute	Payment in work done	5	33.33	1
		Late payment	4	26.67	2
		Non-payment	4	26.67	2
		Underpayment	2	13.33	3
2	Contract provision	Variation order	7	31.82	1
		Loss and expenses	5	22.73	2
		Misinterpretation of contractual requirement, Specification and document	4	18.18	3
		Delay by a nominated subcontractor	1	4.55	4
		Issuance of a certification of payment or work done	1	4.55	4
		Breach of contract	1	4.55	4
		Liquidated and damages	1	4.55	4
		Contract price	1	4.55	4
		Termination of contract	1	4.55	4
3	Time dispute	Extension of time	6	60	1
		Delay in progress	3	30	2
		Contract time	1	10	3
4	Technical requirement	Design	1	25	1
		Quality and workmanship	1	25	1
		Site condition	1	25	1
		Scope of work	1	25	1

The results indicate that payment on work done marked as the highest dispute under the payment dispute followed by variation order under the contract dispute, extension of time under the time dispute, design, quality and workmanship, site condition and scope of work were under the technical requirement dispute.

In construction project, construction dispute in terms of payment including progress or interim, preliminaries payment, contingency sum, payment from variation, prolongation cots work, loss and/or expense, final payment, insurance costs, prime cost sum, provisional sum,

retention sum, and pay-when paid are the type of dispute that often being reported in a construction dispute cases (BK Entrusty, 2014). Disputes arise where the parties disagree with the decision namely the contractor's claim is rejected and this rejection is in turn also rejected by the contractor (Nael Bunni referenced in Hussey and Fraser, 2007). Based on the Table 3 and Table 4, the results were consistent with AIAC adjudication records in Table 1 whereby dispute on payment was the highest record from 2014 to 2017 and technical dispute was the lowest.

Malaysian Construction Dispute Resolution

The result from semi-structured interviews shows that out of 18 respondents, 56% opted for arbitration as dispute resolution while 31% for adjudication and 6% opted for litigation mainly as to stay on the dispute decision. Table 5 shows percentage and ranking of Malaysian dispute resolution in the construction industry.

Table 5. Percentage on dispute resolution preference/selection

No	Malaysian dispute resolution mechanism for construction dispute	Percentage (%)	Rank
1	Arbitration	56	1
2	CIPAA/adjudication	31	2
3	Third party intervention such as mediation	6	3
4	Litigation to stay on the decision	6	3

Arbitration marked as the highest percentage followed by adjudication due to the form of the contract expressly stated that arbitration is the mode of dispute resolution if construction dispute occurred during or after a construction project compared to other method of dispute resolution (Baskaran, 2014).

However, due to the implementation of the CIPAA in 2014, the industry players now understand and aware with the better dispute resolution apart from arbitration. They perceived adjudication under CIPAA is cheaper and faster in terms of time and cost compared to other method of dispute resolution namely, arbitration and litigation (Abraham, 2018; Zuhairah et al., 2009; Cheung, 2006). Subsequently, Table 6 indicates three (3) reasons of selection of dispute resolution mechanism.

Table 6. Reason for selection of dispute resolution mechanism

No	Reason for selection on type of dispute resolution	Percentage (%)	Rank
1	CIPAA because it is generally faster and cheaper	45	1
2	Arbitration because there is generally an arbitration clause in the construction contract	45	1
3	Mediation where panel evaluate fairly on solutions	10	2

Most of the respondents preferred both adjudication (45%) and arbitration (45%) as mechanism for dispute resolution because arbitration has been stated as mode of dispute resolution in the contract while adjudication is due to faster in terms of dispute decision and cheaper in terms of fees. Results in Table 7 shows that respondent selected adjudication as the most effective dispute resolution in terms of cost and time followed by mediation and litigation. The results are in line with Barough et al. (2013) and Mnookin (1998) research findings as adjudication is faster and cheaper than other means of dispute resolution.

Table 7. Selection on the most effective dispute resolution in term of cost and time

No.	The most effective dispute resolution in term of cost and time	Percentage (%)	Rank
1	Adjudication	33.33	1
2	Mediation	20	2
3	Litigation	13.33	3
4	Arbitration	13.33	3
5	Not sure	13.33	3
6	Depend on the complexity of the dispute case	6.68	4

CONCLUSION

Construction dispute such as payment dispute and contract dispute are common in Malaysian construction industry. In 2015 and 2016 payment and contract dispute were the highest cases which have been brought to justice. The results conclude that payment disputes (41.18%) and contract disputes (36.47%) marked as the most frequent disputes occurred in the construction industry. Payment disputes were mainly contributed from poor contract management, incomplete contract and unsubstantiated claims. Findings concluded that adjudication (33%) has been referred as the most effective dispute resolution method in terms of cost and time as CIPAA act allows claimant to claim at any time of the dispute occurred compared to arbitration. Arbitration (56%) however yet often to be referred due to the method were clearly written in the standard form as method of dispute resolution.

ACKNOWLEDGEMENT

This project is supported by Postgraduate Student Research Grant (Grant no. F10/PGRS/1796/2019).

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A FRAMEWORK ON PUBLIC PARTICIPATION PRACTICE FOR ENVIRONMENTAL IMPACT ASSESSMENT (EIA) IN MALAYSIA: A CONCEPTUAL PAPER

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Abstract
Elements of public participation are embedded in the Malaysian EIA process. Nonetheless, the evidences of effective public participation for EIA in Malaysia have remained scant. The inadequacies in the requirement and legislations on public participation for EIA have resulted to barriers that hinder quality public participation. Thus, recommendations to further improve the application of public participation for EIA in Malaysia are required. Therefore, this research aims to develop a framework on public participation practice for EIA in Malaysia utilizing four research objectives. The four research objectives are to identify the requirements and legislation on public participation practice for EIA, to analyze the barriers on public participation practice for EIA, to analyze the recommendations to improve public participation practice for EIA and to propose a framework on public participation practice for EIA. A mixture of quantitative and qualitative methods were adapted for this research utilizing questionnaire surveys and semi-structured interviews as the research instruments. Data were collected from three groups of respondents consisted of EIA consultants, environmental NGOs and DOE officers. The data collected were contextualized and validated to establish the framework on public participation practice for Environmental Impact Assessment (EIA) in Malaysia.

Keywords: *Environmental Impact Assessment (EIA); Malaysian EIA Process; public participation; quantitative research.*

INTRODUCTION

Environmental Impact Assessment (EIA) is a planning tool that identifies, evaluates and predicts the potential environmental impacts and provides mitigation measures to minimise the impacts of a proposed development (Broderick and Durning, 2006; Makmor and Ismail, 2014; Peche and Rodríguez, 2009). Environmental Impact Assessment (EIA) has been formally introduced in Malaysia in 1975 after the enactment of the Environmental Quality Act (EQA) in 1974 (Makmor and Ismail, 2014a; Rahman, 2011; Memon, 2000). A provision which refers to the section 34A under the Environmental Quality Act (EQA) 1974 was gazetted as the Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order or known as the EIA Order in 1987 (Emang, 2006; Ismail et al., 2012; Makmor and Ismail, 2014b; Makmor and Ismail, 2016a; Mustafa, 2011). Pursuant to section 34A under the Environmental Quality Act (EQA) 1974, activities that falls under the listed activities are considered as prescribed activities. Consequently, prescribed activities are required to prepare an EIA report (DOE,2007; Makmor and Ismail, 2014a; Marzuki, 2011). In accordance to the EIA Order 1987, there are 21 prescribed activities listed for the First Schedule and 17 prescribed activities listed for the Second Schedule (DOE, 2015).

Even though EIA has been implemented in Malaysia for almost three decades, the evidences of effective application of EIA in the Malaysian environment has remained scant (Makmor and Ismail, 2016b; Withanage, 2006; Wood, 2003). Robust application of public participation has become one of the prime aspects of effective application in EIA as seen in few developed countries (Li, 2008). In accordance to a comparison study conducted by

Makmor and Ismail (2014a), public participation element has been adapted in the formal provision of the Malaysian EIA system as it is adapted in Western Australia, New Zealand and Canada's EIA system. Nonetheless, the effectiveness of the public participation practices in Malaysia is highly debatable (Makmor and Ismail, 2016a; Li et al., 2012; Maidin, 2011).

Public participation has been recognised as one of the key themes in environmental protection and sustainable development as highlighted in the United Nations Conference on Environment and Development in Rio de Janeiro (Agenda 21) and the World Summit on Sustainable Development in Johannesburg 2002 (Rahman, 2011; Bastidas, 2004; Ismail and Rahman, 2012). Furthermore, public participation has also been propagated through multiple international conventions and declarations such as Stockholm Declaration 1972 and Aarhus Convention 1998 (Gugushvili, 2008; Hartley and Wood, 2005; Maidin, 2011). In Malaysia, the Government has acknowledged the importance of public participation as one of the pillars to achieve sustainable development (Ismail and Rahman, 2012; Anuar and Saruwono, 2013). In reference to the Handbook of EIA guidelines, public participation element is required to be embedded into the EIA report for Second Schedule activities whereby the report will be published for public reviews and comments (DOE, 2007; Ahmad et al., 2013). Additionally, it is required to conduct a public hearing about the proposed project for EIA report for Second Schedule activities (DOE, 2007; DOE, 2015; Ahmad et al., 2013).

'Public participation' can be defined as a vital and constructive process of information trading that consist of public concerns, needs, opinions and values that are integrated into decision making process (Ahmad et al., 2013; Omar and Leh, 2009). Omar & Leh (2009) also added that the public participation should open to not only affected individuals and community but also to any organisation or associations who are interested in the proposed development. Multiple authors have emphasized on the importance of public participation as an essential part of EIA to support the growth of sustainable development (Hartley and Wood, 2005; Nadeem and Fischer, 2011; Pölönen et al., 2011; Wang and Chen, 2006). Embedding public participation in EIA not only improves transparency of the decision-making process but also empowers the communities, allowing apposite solutions and requirements from the communities to form the decisions in regards to the proposed development (Pölönen et al., 2011; Jiayu, 2011). Apart from that, public participation offers various objectives such as to inform the communities on information regarding the proposed development, to educate and increase awareness of the communities on the potential environmental impacts and environmental protection policies, to provide relevant data on the physical and social environment of the proposed site from the local communities, to establish trust in project proponents and government institutions thus reduce conflicts among participants in proposed development (Nadeem and Fischer, 2011; Silas, 2013).

According to Aiyeola et al. (2014), public participation holds a pivotal role in ensuring effective stakeholders' involvement in environmental management. Therefore, effective public participation is essential in the application of public participation in EIA. Effective public participation allows communication between the entities, instil responsibilities and accountability especially in governing bodies towards community and also empowers the community in decision making process by decision makers (Dian and Abdullah, 2013). Alam (2014) stated that effective public participation can result to heightened compliance to standards by highlighting the negative social economic impacts of policies towards the

environment. Moreover, effective public participation leads to better decisions that fulfil people's needs which are valid and will last for a longer period of time (Alam, 2014).

Public participation practice promotes the establishment of integration and involvement between stakeholders and the community, thus provide opportunities for constructive debates on environmental issues (Aiyeola et al., 2014). Additionally, some authors have agreed that effective public participation will foster fair and democratic decisions which values the opinion and views of the related community (Alam, 2014; Kanniah, 2000; Maidin, 2011). Kanniah (2000) and Maidin (2011) also added that public participation is essential in ensuring transparent decision-making process that is resistant towards corrupted influences. Effective public participation not only renders positive impacts towards the EIA process, it coincidentally helps in reducing or avoiding public controversy, confrontation and delay (Ahmad et al., 2013). Conclusively, effective public participation in EIA will generate positive impacts which will boost the quality of environment this ameliorate the quality of life (Alam, 2014).

PROBLEM STATEMENT

Even though the public participation is being integrated in EIA reports, Yaakob (2008) has raised concerns regarding the Handbook of EIA guidelines where the handbook does not define the accepted procedures to be administered for the public to participate in the engagement component of an EIA process. Furthermore, there is no proper guideline on public engagement for EIA has been produced by the Department of Environment Malaysia (DOE). Thus, this causes uncertainties behind the requirements on the implementation of public participation held for EIA in Malaysia. Therefore, the first objective of research is to identify the requirements and legislation on public participation practice for EIA in Malaysia.

Inadequacies in the requirement and legislation regarding public participation in EIA have led to various environmental issues around the nation. Makmor and Ismail (2014a) has reported that the public participation held for EIA reports for activities under the First Schedule are often shallow and insignificant. Evidences has shown that most of the EIA reports for the First Schedule activities that were submitted and approved by the DOE do not comprise the element of public participation (Makmor and Ismail, 2016a; 2016b; Marzuki, 2009; Briffet et al., 2004; Harun and Mazlan, 2008). Even though public participation is mandatory for activities under the Second Schedule, the application of public participation is yet to be verified as effective in the Malaysian context (Maidin, 2011; Omar and Leh, 2009; Li et al., 2012). Evidences of ineffective application of public participation can be seen in the series of cases that resulted to environmental issues due to the lack of public participation practice for activities under both First and Second Schedule. Therefore, this research conducts the second objective that will analyse the barriers on public participation practice for EIA in Malaysia.

Authors have highlighted that the public participation are frequently applied late through the EIA process where most of the decisions have already been decided (Makmor and Ismail, 2016b; Komatsu, 1998; Orellana (2010). From a study carried out by Makmor and Ismail (2014a), it has been found that ineffective public participation is also contributed by the attitude of each stakeholders in the process of EIA namely the consultants, the project proponents and also the public. These issues have resulted to an ineffective application of

public participation for EIA administered in Malaysia. Ergo, the third and fourth objectives of this research will be to analyse the recommendations to alleviate the barriers on public participation practice for EIA in Malaysia and to propose a framework on public participation practice for EIA in Malaysia.

LITERATURE REVIEW

The Environmental Quality Act 1974 (EQA) was amended to incorporate EIA (Environmental Impact Assessment) in 1985 and the EIA Order was gazetted in 1987 (Emang, 2006; Makmor and Ismail, 2016b; Maidin, 2011). Consequently, developments that are classified as prescribed activities are required to prepare an EIA report that are inclusive of public participation element. The Handbook of EIA guidelines clearly states that public participation is required only for the preparation of EIA report for activities that falls under the Second Schedule where it will be made available for public views and comments (Rahman, 2011; DOE, 2007; 2015; Makmor and Ismail, 2016b; Marzuki, 2009; Ahmad et al., 2013; Alam, 2014). Nevertheless, Emang (2006) and Maidin (2011) have regarded that public participation element is being integrated EIA reports for activities under both First and Second Schedule. In addition, Makmor and Ismail (2014a) elaborated that the only difference of both EIA reports have on the element of public participation is the depth of the application in each EIA reports. The public participation conducted in EIA report for the First Schedule activities is normally administered via social economic surveys and brief consultations with the affected communities (Makmor and Ismail, 2014a; 2016b; Marzuki, 2009; Briffet et al., 2004; Lee and George, 2000).

In a comparison study carried out by Makmor and Ismail (2014a), the study exhibits extensive application of public participation as the core component in evaluating EIA in West Australia, New Zealand and Canada. Meanwhile, Malaysia has yet to integrate the public participation as the main component in the decision making process for EIA in Malaysia. According to the Environmental Quality Act 1974, public participation is considered as an 'environmental procedural rights' in Malaysia (Anuar and Saruwono, 2013). Nonetheless, there is an immense absence of the statutory rights positioning public participation as the integral medium in developing Malaysian planning system (Maidin, 2011). This absence of 'environmental substantive rights' provision under the Malaysian Federal Constitution has caused public participation to remain only as an 'environmental rights' under the Malaysian legislation (Anuar, 2012). Alam (2014) further explained that the inadequacies arise in the requirements and legislation of EIA increases the risk of the environment being affected by negative impacts imposed by proposed developments.

Few authors have highlighted that the public have limited access to the copy of the EIA report and are not granted the rights to provide comments or feedback regarding projects under the First Schedule (Maidin, 2011; Yaakob, 2008). On the other hand, public participation for Second Schedule activities are mandatory to be administered by the project proponent before submission of each EIA report to the DOE (Maidin, 2011). Public participation is conducted via multiple approaches such as public forums, stakeholders' consultation, public hearings, publishing EIA reports for public viewing and accepting written comments on the EIA reports published (Maidin, 2011; Marzuki, 2009; Rahman, 2011; Omar and Leh, 2009; Briffet et al., 2004). Poor public participation for EIA can result to public protests of future developments as seen in past cases. The two most infamous cases in relation

to ineffective public participation practice for EIA in Malaysia are the Penang Hill and Bakun Dam cases. The protests made by public in these two cases have made substantive results for both cases respectively. In the case of Penang Hill, the project was shut down due to the protests made by the public (Maidin, 2011; Briffet et al., 2004; Komatsu, 1998). On the contrary, the Bakun Dam project was not shut down but it was highly criticised for the absence of public participation in the preparation of the EIA reports (Maidin, 2011; Harding, 2007; Swain and Chee, 2004).

The level of public participation practice for EIA in Malaysia is regarded as ineffective in consequence to the issues that arose from the public participation practice for EIA. In ensuring effective public participation, an active participation from the public is crucial. According to Omar and Leh (2009), 'public' in public participation is not only restricted to individual citizens, but it includes associations or organisations that have equal interests in the proposed development. Substantial participation from various stakeholders in manufacturing effective public participation is crucial. Nonetheless, the importance of having public participation has not been emphasized in the decision-making process (Ahmad et al., 2013). Anuar and Saruwono (2013) also suggested that the non-requirement of public participation to be an integral part of EIA has resulted to an ill application of public participation in Malaysia. Harun and Mazlan (2008) elaborated that the practice of public participation in Malaysia has been strongly rebuked for disregarding public participation as the principal means in finalising decisions for EIA process in Malaysia. Moreover, the practice of public participation for EIA studies in Malaysia are mostly administered to fulfil the requirements and remains as a formality (Makmor and Ismail, 2016b).

The overall environmental management in Malaysia has been jeopardized mainly due to the ineffective public participation held under the EIA application in Malaysia. This is evident with the rising cases of environmental hazards such as the recent flash floods happening in two states which are Selangor and Penang due to the excessive development in the said states. These natural disasters has been occurring since the 1990s and has been more frequent recently due to the environmental damage that were accumulated throughout the years. Thus, this research aims to develop a framework on public participation practice for EIA in Malaysia in order to curb thus minimize the environmental damages by strengthening and promoting effective application of public participation through EIA in Malaysia.

There are four research questions designed to fulfil the research objectives towards achieving the research aim. The following are the research questions for this research:

RQ1: What are the requirements and legislation on public participation for EIA in Malaysia?
RQ2: What are the barriers on public participation practice for EIA in Malaysia?
RQ3: What are the recommendations to alleviate the barriers on public participation for EIA in Malaysia?
RQ4: How to improve the public participation practice for EIA in Malaysia?

The aim of the research is to develop a framework on public participation practice for Environmental Impact Assessment (EIA) in Malaysia. In order to achieve the aim of the research, the following are the research objectives:

RO1: To identify the requirements and legislation on public participation practice for EIA in Malaysia.
RO2: To analyse the barriers regarding public participation practice for EIA in Malaysia.
RO3: To analyse the recommendations to alleviate the barriers on public participation practice for EIA in Malaysia.
RO4: To propose a framework on public participation practice for EIA in Malaysia

RESEARCH METHODOLOGY

A mixture of quantitative and qualitative research was adopted in this research. The quantitative element of research was applied in the first and second stage of data collection. The first stage of data collection consisted of the pilot study and the second stage was the main data collection for this study. Both stages of the data collection utilised questionnaire survey as the research instrument. Consequently, the third stage of data collection comprised of qualitative research which was administered via semi-structured interviews. The third or the last stage of data collection was represented by the validation stage for this research. In order to ensure the reliability of the research, below are the stages of the research methodology that were incorporated into this research.

In stage 1, an extensive literature review was carried out on the background of the research to understand the topic of this research. The background of research included a literature review on the topic of public participation in general and the establishment of public participation for EIA in Malaysia. In addition, the literature review was executed to study on the requirements and legislation behind the application of public participation for EIA in Malaysia. This stage enabled the researcher to analyse public participation practices applied in Malaysia under the context of EIA.

Next, the second stage of the research utilised the quantitative element of the research where a pilot study was conducted. The pilot study was administered to test the reliability and validity of the questions produced for the questionnaire surveys. The pilot study was conducted to 30 respondents from different backgrounds with construction backgrounds. The 30 respondents consisted of academicians, quantity surveyors, architects, building surveyors and planners. All of the respondents have an ample amount of knowledge on EIA and its application in the Malaysian construction industry. According to Thomas (2004), the suggested sample size for a pilot study is said to be within 10 to 20 respondents depending on the complexity of the survey. Thus, 30 respondents are suitable to test the reliability and validity of the questionnaire. The data collected from the pilot study were analysed via statistical analysis using SPSS software. The Cronbach's alpha test was administered to test the reliability of the questions.

In the third stage of the research methodology, questionnaire survey was chosen as the main data collection method incorporated in this research. Questionnaire surveys were distributed to two groups of respondents which were the registered EIA consultants and the environmental NGOs. These two groups of respondents represented both sides in administering the public participation practice under EIA. The EIA consultant represented the organizer and the environmental NGOs represented the participants of the participation process. The principal criterion for each group of sampling subjects were only registered EIA

consultants and only environmental NGOs that are active in the field of EIA were selected as respondents for this research.

A list of 75 registered EIA consultants that resides in Selangor was retrieved from the official website of the Department of Environment Malaysia (DOE). On the other hand, a list of 17 environmental NGOs that were retrieved from the official website of Malaysian Environmental NGOs (MENGO). Selangor was the selected state for this study for having the highest estimated population distribution and the highest amount of projects in Malaysia. The researcher believed that the amount of projects and the amount of population distribution are both essential as the projects that are developed are bound to affect the surrounding community and environment.

The questionnaire surveys were administered to collect the barriers pertaining to public participation practice for EIAs conducted in Malaysia. Furthermore, recommendations to alleviate the barriers on the public participation practice for EIA were also collected. The questionnaire were distributed by hand, by post and also via email for a period of two months. A total of 28 out of 75 EIA consultants and seven (7) out of 16 environmental NGOs have completed the questionnaire survey online and offline. The response rate of 37% and 44% were identified as appropriate to be used for the final data analysis. According to Sekaran and Bougie (2010), a 30% response rate for questionnaire surveys was considered as acceptable. Moreover, two authors also agreed that an acceptable response rate for online surveys may vary within 25% to 30% (Fincham, 2008; Yun and Trumbo, 2000). However, this rate fluctuates depending on proper notification, adequate follow-up procedures, respondents' interest in the study, the quality of the instrument and the use of incentives.

In stage 4, the data gathered from the main data collection were contextualised and analysed. The quantitative analyses administered for the data gathered were the Exploratory Factor Analysis (EFA) and the PLS-SEM. PLS-SEM was applied as the main technique in the data analyses due to the theory development nature of this research. Small sample sizes and a complex structural equation model were the outcome of this research that was appropriate with PLS-SEM. The collected data comprised of the barriers and recommendations to improve the public participation practice for EIA formed the preliminary framework. This research was expected to develop a framework on public participation practice for EIA in Malaysia.

The last stage which was the fifth stage represented the element of qualitative research that was incorporated into this research. The qualitative element in this stage acted as a validation method to validate the research findings that were contextualized into a preliminary framework on public participation practice for EIA in Malaysia. The instrument chosen to represent this qualitative research was semi-structured interviews. Semi-structured interviews were administered with the DOE officers and EIA experts. The DOE officers were chosen as the DOE is the official governing body for the application of EIA in Malaysia. Meanwhile, the EIA experts were EIA consultants that are active in the field of EIA. The two main requirements for the respondents in the validation stage were DOE officers and EIA consultants that have been practising EIA for more than 10 years and/or have been involved in more than fifteen (15) EIA projects.

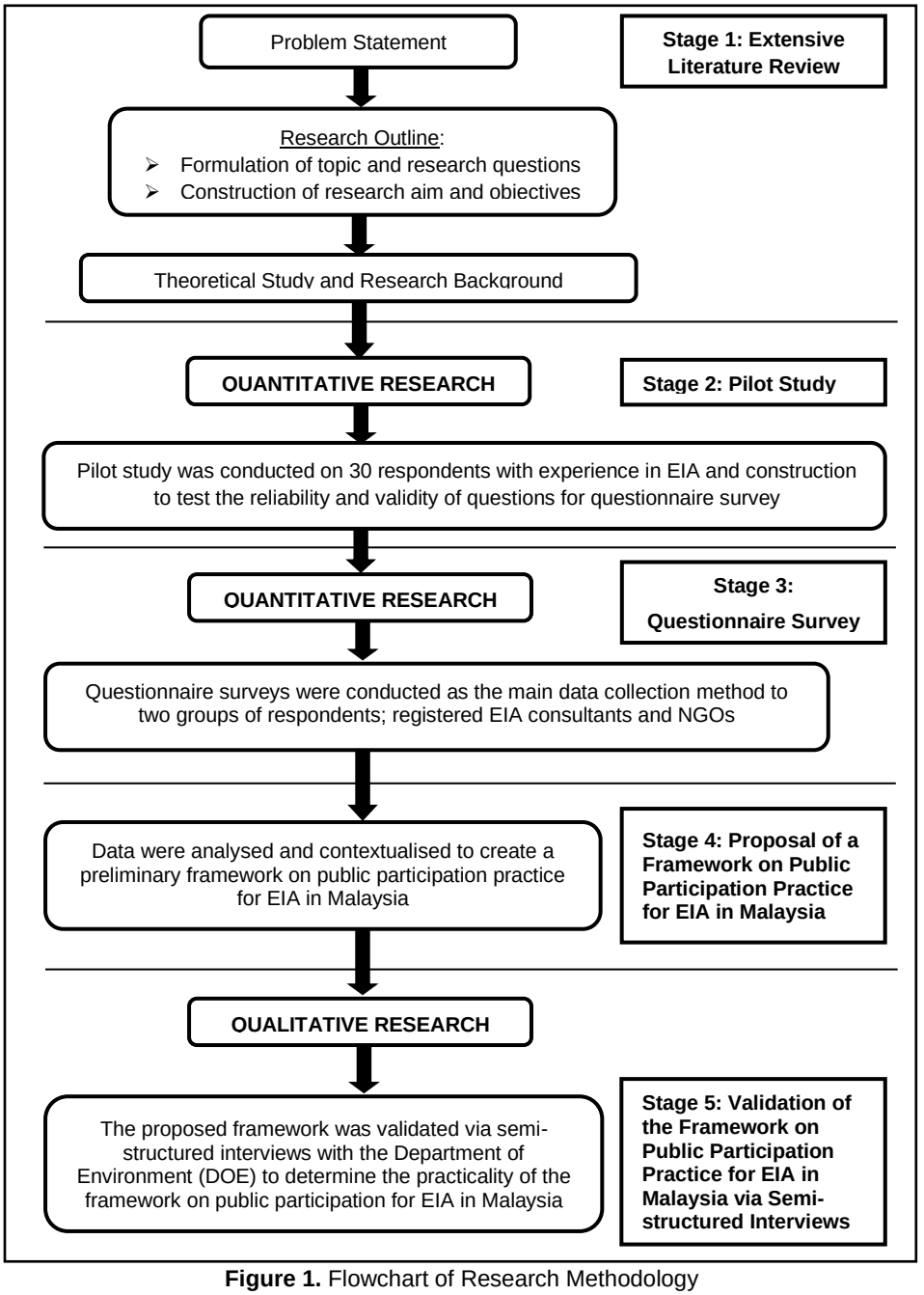

Figure 1. Flowchart of Research Methodology

The validation stage for this research was performed by utilising semi-structure interviews. A group of seven (7) respondents consisting four (4) DOE officers and three (3) EIA experts were interviewed individually to validate the preliminary framework on public participation practice for EIA in Malaysia. The purpose of this validation stage was to determine the practicality of the framework to be applied in the world of environmental impact assessment in Malaysia. Analyses of the qualitative data collected were performed by utilising the qualitative software, NVivo 10 and quantitative software, IBM Statistical Package for the Social Sciences (SPSS) version 20.

The responses from the semi-structured interviews were gathered and applied where relevant in the framework on public participation practice for EIA in Malaysia. The flowchart of the research process is illustrated in Figure 1.

THEORETICAL FRAMEWORK

A theoretical framework is important in any research as it supports a study and it consists of the concepts and definitions from the theory that are significant to your area of study (Grant and Osanloo, 2014). The theoretical framework in Figure 2 illustrated the EIA theory embedded in this study. The EIA has three main components. EIA procedures, legislation, requirement and regulations represent the first component of EIA. Meanwhile, public participation and post-monitoring and environmental management planning (EMP) represent the second and third components for EIA respectively. With the implementation of EIA in a proposed development, it minimises the environmental impacts, reduce costs and time taken for a development. EIA also provides mitigation measures at an early stage of a development. These are the main objectives of EIA implementation in a development. Effective EIA can be achieved when all three objectives of EIA are achieved (Figure 2). There are four dimensions of effectiveness that constructs effective EIA which are the procedural effectiveness, substantive effectiveness, transactive effectiveness and normative effectiveness. The EIA procedures, legislation, requirement and regulations formulate the main elements for procedural effectiveness. Conversely, decision-making and mitigation of environmental impacts represents the main element for substantive effectiveness. As for transactive effectiveness, it is achieved when the implementation of EIA reduces the cost and time for the development and skilled stakeholders are easily available. Lastly, normative effectiveness is achieved when the social and individual norms such as sustainable development is achieved.

CONCLUSION

Public participation in EIA emphasises on allowing effective communications between relevant entities thus empowering the community in decision-making process of a proposed development. Better decisions may result from quality public participation practice in EIA that integrates fairness and democracy thus generates positive impacts towards the environment as a whole. This research focuses on the analyses of the practice of public participation for EIA in Malaysia. The scope of this study comprise of the overall view on the practice of public participation being practiced for EIA in Malaysia. A framework to improve the practice of public participation for EIA in Malaysia is the product outcome from this study. The framework consists of opinions from two sides of the public participation practitioners which are the registered EIA consultants and the active environmental NGOs in Malaysia. This research is expected to emphasize on the importance of effective application of public participation practice in EIA in Malaysia. The framework highlights the barriers related to the application of public participation practice for EIA in Malaysia. Moreover, the framework also provides relevant recommendations to further enhance the existing application of public participation practices for EIA in Malaysia. Further, this framework will undergo a validation stage with the DOE as the governing body of EIA in Malaysia to ensure its practicality in the industry. Ergo, this research will not only benefit the government and private organizations in enhancing the practice of public participation, but also benefits the public by encouraging better public engagement process in the application of EIA in Malaysia. The outcome of this

research will induce the multiple efforts taken by the Malaysian government to improve public engagement and to induce sustainable development and environmental protection awareness among local communities.

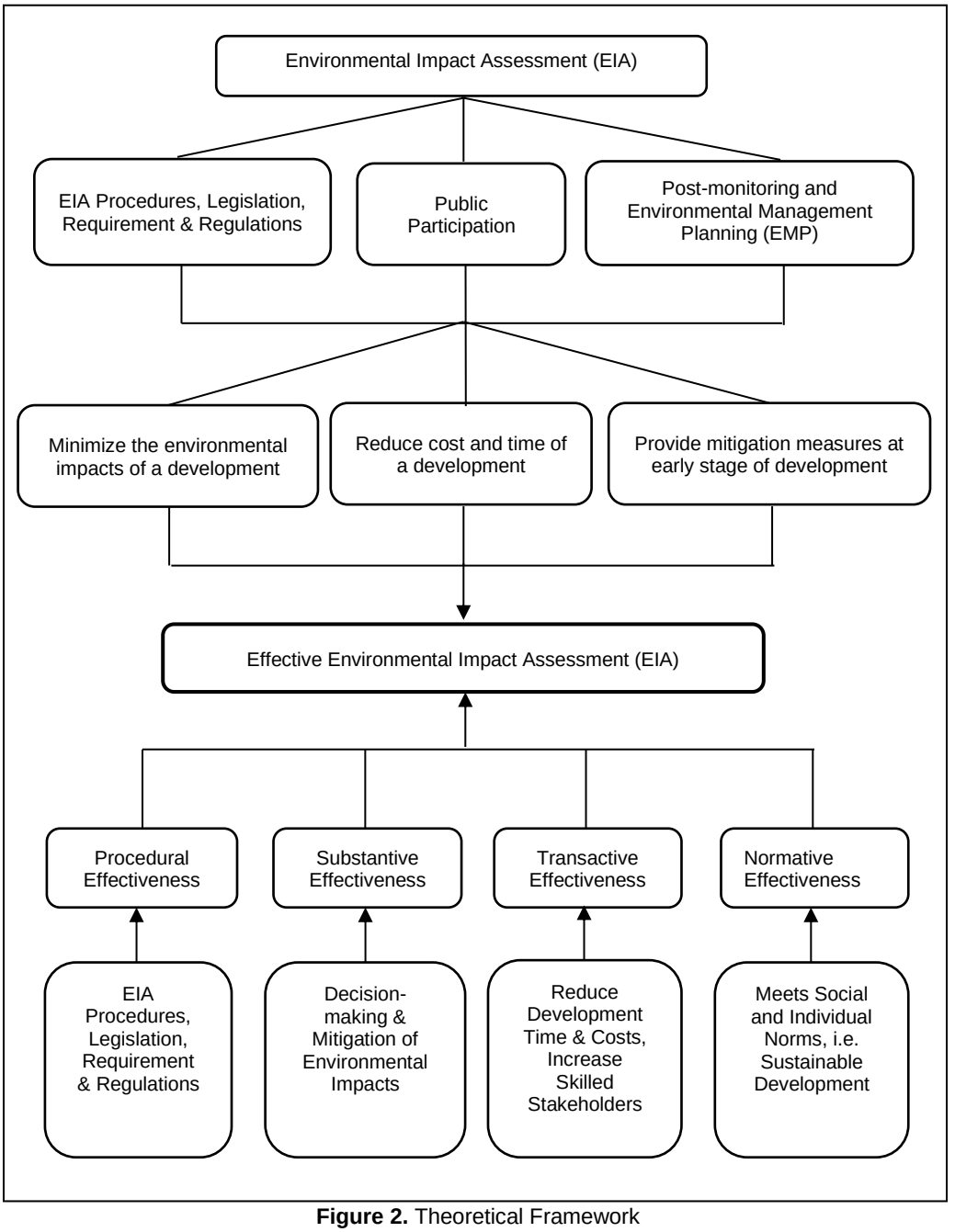

Figure 2. Theoretical Framework

ACKNOWLEDGEMENT

The authors would like to express their gratitude for the financial support from University of Malaya (UM) under the Postgraduate Research Grant (PPP), PG055-2015B and MOHE (Minister of Higher Education) under MyPhD (MyBrain15) given to this research.

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STRATEGIES FOR QUANTITY SURVEYING CONSULTANCY FIRMS TO ACHIEVE PROFITABILITY: RESEARCH PROPOSAL FROM A MALAYSIAN PERSPECTIVE

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Abstract
Quantity surveying (QS) consultancy firms need to adopt appropriate strategies to survive and grow in an emerging business environment. Nevertheless, it is difficult to select suitable strategies that would increase profitability as there are simply too many strategies available for implementation. This proposal proposes to: first, rank the strategies for QS consultancy firms to achieve profitability; second, examine the underlying structure caused by latent strategies for QS consultancy firms to achieve profitability; and third, develop a structural equation model of latent strategies for QS consultancy firms to achieve profitability. The data required will be collected using a structured questionnaire administered through personal interviews with over two hundred company directors each from one of the QS consultancy firms located in Klang Valley, Malaysia. Random samples will be drawn from the record on registered consultant QS practices available from the online database of the Board of Quantity Surveyors Malaysia (BQSM). Mean ranking, exploratory and confirmatory factor analyses, and structural equation modelling will be used in the data analyses stage. The findings will comprise the ranking of strategies, identification of latent strategies, and development of a structural equation model of latent strategies for QS consultancy firms to achieve profitability. Ultimately, this research could inform practitioners of the best strategies that would improve profitability. Foreign QS consultancy firms that intend to venture into the Klang Valley Malaysian construction industry may also use the findings to assist them to expand and develop their businesses in this sector.

Keywords: *Strategies; quantity surveying consultancy firms; profitability; research proposal; a Malaysian perspective.*

INTRODUCTION

According to Malaysia Productivity Corporation (2016), the construction industry plays a vital role in any country's economic growth. It offers great support to aggregate economy by backward and forward associations with other sectors of economy. Moreover, it contributes in producing of massive employment in the economy. Thus, Malaysia began to develop this sector since Malaysia has realised the importance of the construction sector in the early days. Malaysian construction sector is wide and can be classified to four subsectors. One of the subsectors of the Malaysian construction industry is Professional construction services. Surveyors were recognised as one of the professionals of the Professional construction services. This has showed the significance of the Surveyors in contributing Malaysian economic development.

Up to December 2019, there are 373 Quantity Surveying (QS) consultancy firms which were registered with Board of Quantity Surveyors Malaysia (BQSM); which were actively practice in the industry. This number covered small, medium and big QS consultancy firms

(BQSM, 2019). These numbers of QS consultancy firms are playing the significant role in the Malaysia's construction business. Although our last global financial crisis was in year 2008 incepted by the United State (US) subprime market (Tee, 2018). But weaker global growth is still a big issue to developed and developing countries such as Malaysia. Zakariah and Ablliah (2018) reported Malaysia's economy is expected to grow slower than expected due to the cancellation of large infrastructure projects and dimmer trade and export prospects. Today, one of the important questions in business has been why some organisations succeeded while others failed. Kana (2016) reported intense competition has been seen in Malaysian construction industry. Consequently, all constructions players including QS consultancy firms may face difficulties to compete and survive in the emerging environment since there are intense competitions among themselves and from new or foreign entrants. The survival and eventually the growth of the firms depend on the number or continuity of projects they secure without interval. QS consultancy firms need to respond to new opportunities, new geographical locations and new ways of doing business (Davies et al., 2005). Managing a construction business is increasingly difficult. According to Abidin et al. (2014), all construction firms including QS firms must be continuously enhance their services to build a competitive edge.Thus, an appropriate choice of strategies helps firms to survive and grow in an emerging business environment is necessary.

This present proposal adopted the above theoretical background to study issues relative to the effect of strategies on profitability of QS consultancy firms operating in Malaysia's construction market.

BACKGROUND INFORMATION

The Concept of Profitability

Kithii (2008) as cited in MD Yusoff (2017), profitability is a key measure of a successful business. A business that is not profitable may not survive while a business that is highly profitable has the ability to reward its owners with large returns on their investment. Innocent et al. (2013) mentioned that every firm is most concerned with its profitability. One of the most commonly used tools of financial ratio analysis is profitability ratio which is used to determine the company's bottom line. Profitability measures are vital to company managers and owner alike.

Strategies to Achieve Profitability

To maximise profitability of a firm, firms need to implement appropriate strategies and practices. In a study by Li and Ling (2012), the theoretical framework used to study the practices and critical strategies implemented by Chinese architectural, engineering and construction (A/E/C) firms are underpinned by three concepts: Generic competitive strategies, Military strategies: Sun Tzu's Art of War and Network strategies. The authors reported that profitability could be achieved by some critical practices which are underpinned in these three strategies. They found that profitable Chinese A/E/C firms are more likely to implement practices that differentiate them from competitors instead of pursuing focus strategy or low-cost strategy. Beside that, the practices that can make them become more flexible and adaptable also in their list. Furthermore, profitable firms also implement the practices involve partnership, knowledge sharing, and gaining resources from firms in the network.

In few decades ago, Porter (1980) suggested that a firm needs to adopt generic competitive strategies – differentiation, overall low-cost and focus to succeed in a business. With the differentiation strategy, a firm must be unique by offering exclusive services and unique products that are widely valued by customers to differentiate itself from others. A firm can improve its competitive stance by lowering its production and marketing costs with the overall low-cost strategy. A firm would have strategic advantage with the focus strategy. A firm can narrow its competitive scopein the industry and modifies its strategy to serving to the exclusion of others, instead of serving broadly in the market. Tansey et al. (2014) also supported that Porter's model is a well-known theoretical framework among business strategists and industrial economists worldwide. The analysis in their study provides strong support for the adoption of cost leadership strategies to surviving the 2007 economic recession. The findings also provide valuable assistance for construction contractors in developing effective strategies and thus reducing business failures during declining periods.

Moreover, many business books have come lately about the Sun Tzu's and the art of business. These business books have studied the Sun Tzu's principles and put the art into practice. In the opinion of McNeilly and McNeilly (2012), Sun Tzu's principles are ideally suited to the today's competitive modern business situation. Sun Tzu's appeal has extended beyond the military realm into the war of business. They introduced six Sun Tzu's principles into practice in their book. The six principles are win all without fighting: achieving the objective without destroying it; avoid strength, attack weakness: striking where the enemy is most vulnerable; deception and foreknowledge: maximising the power of market information; speed and preparation: moving swiftly to overcome resistance; shape your opponent: employing strategy to master the competition; and character-based leadership: providing effective leadership in turbulent times (McNeilly and McNeilly, 2012). A firm may succeed in the business with adopt these six strategic principles due to the 'flexibility' of these principles.

In Chinese, Guan xi is a general term for social networking and is often translated as "relationship" or "connection". Guan xi was the one item which was consistently chosen by the respondents as a key success factor in the long-term business based on Yeung and Tung (1996). Wong (2007) also found that guan xi plays the important role in setting the rules in doing business in Chinese society.

Beside of the Generic competitive strategies, Military strategies: Sun Tzu's Art of War and Network strategies as discussed above. Ogbu (2015) urged application of Marketing Strategies in Nigerian QS firms (NIQS) is necessary to improve firm performance. He stated the implementation of marketing strategies in QS firms is a key management tool for the achievement of firm performance. He recommended NIQS to develop their marketing strategies that can lead to the achievement of firm performance.

RESEARCH METHODOLOGY

A systematic literature search was done to collect data from published research which comprises scholarly articles published in peer-reviewed journals and conference proceedings, trade publications, study reports and books. The following databases: EBSCO Host, Emerald, Sage Journals, Science Direct, Scopus, Springer Link, Taylor and Francis, Wiley Online Library, and Google Scholar were used to search potential literature sources referring to the contents.

Pilot literature search was conducted to assess the size of the literature which addressed the strategies and profitability. It was observed that the literature which addresses the strategies and profitability in various fields ismassive and wide.Since the main objective of this research paper is to review the strategies for QS consultancy firms to achieve profitability, the search was limited to strategies, profitability and QS firms. To meet this selected criterion, the terms "strategies", or "profitability" and "QS firms" were used in the title or keywords of the publications in the search field of the database. Nevertheless, EBSCOHost, Springer Link and Google Scholar were excluded which the search field was restricted to publication titles only due to the unavailability of keyword search option.

Table 1 shows the summary of the search result. It is worth to sum up the result does not provide significant information due to few databases do not have the relevant publication and some publications appear in more than one database search. As a result, a literature source was considered in this research if it meets the following criteria: (i) the publication addresses the strategies to achieve profitability as a main topic in the research, and (ii) the publication addresses the strategies for quantity surveying firms or construction firms. In summary, the publications which do not meet the mentioned criteria will be excluded from this study.

Table 1. Summary of the Search Result

No	Database	Search fields	Number of retrieved results for each search item	
			"Strategies" and QS firms	"Profitability" and QS firms
1	EBSCO	Title	18	5
2	Emerald	Title, keywords	20	6
3	Sage Journals	Title, keywords	0	0
4	Science Direct	Title, keywords	10	3
5	Scopus	Title, keywords	75	8
6	Springer link	Title	17	4
7	Taylor and Francis	Title, keywords	0	0
8	Wiley Online Library	Title, keywords	0	0
9	Google Scholar	Title	512	225

Table 2 shows the overview of the research design for this research proposal. Quantitative method will be used for this research. A structured questionnaire will be prepared once the literature review part is completed. The data collection methods are by mail, email and face-to-face interview. Stratified sampling will be implemented to select only QS consultancy firms that operated in Klang Valley since there is the central of the city and majority firms headquartered in that area. QS consultancy firms operating in Kuala Lumpur and Selangor (Klang Valley) which are members of Board of Quantity Surveyors Malaysia (BQSM) will be selected as subjects for this study due to there is no formal list of all the QS consultancy firms operating in Malaysia. Questionnaires will be collected and analysed by using mean ranking and factor analysis methods. Lastly, the Smart Partial Least Squares (SmartPLS) will be used to develop a model of strategies to explain causal relationships among the strategies groupings.

Table 2. Overview of the Research Design

Phase Objective		
Phase 1 – To rank the strategies for Malaysian Klang Valley QS consultancy firms to achieve profitability	**Phase 2 – To examine the underlying structure caused by latent strategies for Malaysian Klang Valley QS consultancy firms to achieve profitability**	**Phase 3 – To develop a model of latent strategies for Malaysian Klang Valley QS consultancy firms to achieve profitability**
Source		
Literature review of the strategies, profitability for QS consultancy firms	Significant strategies identified from Phase 1	Latent strategies for QS consultancy firms from Phase 2
Approach		
Quantitative	Quantitative	Quantitative
Method		
Literature review	Statistical analysis	Statistical analysis
Instrument		
Closed and open questions included in the questionnaire	Responses (raw data) based on the five-point Likert scale	Responses (raw data) based on the five-point Likert scale
Procedure		
Listing, grouping, reviewing, rewording, reliability analysis, Terrell's transformation technique, coefficient of variation, Kendall's concordance test, and chisquare test	Factor analysis involving Bartlett's Test of Sphericity, Kaiser-Meyer-Olkin Measure of Sampling Adequacy, maximum likelihood factor extraction method, and promax rotation	Structural equation modelling – confirmatory factor analysis and testing of structural model for convergent validity, discriminant validity, construct reliability, and goodness of fit
Result		
Ranking of strategies based on transformed scores	Strategies groupings and their variables	Model of strategies groupings

RESEARCH GAP

Numerous previous studies have donewith the topics related to the "profitability" in the construction industry (Chiang et al., 2002; Makori and Jagonga, 2013), "critical strategies" for architectural, engineering and construction (A/C/E) firms in China's construction industry to achieve profitability (Li and Ling, 2012) and application marketing "strategies" in Nigerian "QS firms" (Ogbu, 2015). The research gap is that hitherto, there are no research studies to show the specific practices that enable QS consultancy firm to achieve profitability in Malaysia's construction industry. Hence, this proposal aims to bring aMalaysian perspective to select suitable strategies that would increase profitability as there are simply too many strategies available for implementation.

CONCLUSION

This study will reveal the significant strategies which assisting QS consultancy firms when they are trying to achieve their profitability. Analysing the strategies for QS consultancy firms is vitalas it will have impacts on the firm's profitability. Maximise the profit is the common target in the construction industries worldwide but the firm able to produce a return on an investment based on its resources is a question. This study aims to investigate the practices that lead to profitabilityof QS consultancy firms. Therefore, the strategies for QS consultancy firms must be identified at the first place. QS consultancyfirms will achieve their profitability by taking the significant strategies effectively.

For that reason, this research will be conducted to reveal the significant strategies groupings pertinent to the QS consultancy firms in the Klang Valley of Malaysia. Seeing that

understanding of the interrelationships among strategies groupings for QS consultancy firms will be able to provide a clear direction in maximising profit and increasing the business; this research has then developed a structural equation model to explain causal relationships among strategies groupings. This will be served as a guideline for the local or even foreign practitionersin managing construction business successfully.

ACKNOWLEDGEMENT

Thanks to UTHM and UTAR for the research support.

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TECHNOLOGY AWARENESS OF ARTIFICIAL INTELLIGENCE (AI) APPLICATION FOR RISK ANALYSIS IN CONSTRUCTION PROJECTS

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Abstract
Artificial intelligence (AI) is getting increased attention day-by-day owing to its ability to provide more accurate results in uncertain and complex environments. As such, many countries have already applied AI for risk analysis in construction projects. However, it is still relatively new and unknown for some and a lack of knowledge on the available risk management methods such as AI. This research, therefore, aims to determine the level of awareness of the Malaysian construction practitioners of using AI for risk analysis. A survey among 184 construction practitioners found that there are only a number of practitioners who know about AI and its usefulness for risk analysis in the Malaysian construction industry; most of the respondents have a lack of knowledge about AI, majority of them do not practice or use AI in their risk analysis tasks; a large portion do not attend any training on AI or taken some courses at universities; and finally most of the companies in the construction industry in Malaysia do not provide or provide little formal training on AI including follow-up programs. It can be concluded that applying AI for risk analysis still has a long way to go in order to be accepted and recognized in the Malaysian construction industry.

Keywords: *Artificial intelligence; construction projects; risk analysis; AI technology; technology awareness.*

INTRODUCTION

The nature of construction projects is exceptionally uncertain and due to the project complexities, the conditions can change any time (Ansah et al., 2016). Thus, practitioners have to rethink their approaches in analyzing and managing risks within their organizations and projects. Numerous organizations have become more aware and effective in using risk analysis as part of developing any project (Gajewska & Ropel, 2011). Although risk management is vital to the success of projects, there are still a lot of practitioners who are not aware of the significance of integrating risk analysis and management in their daily project tasks (Gajewska & Ropel, 2011). Thus, critical risk analysis is needed to help in avoiding project failures (Aziz, 2013; Norzima et al., 2011; Sorooshian, 2015). Artificial intelligence (AI) methods have been proven applicable in analysing risks in several industries because they provide more accurate and satisfactory results in comparison to the traditional methods (Ebrat & Ghodsi, 2014; Elhag & Wang, 2007; Guzman-Urbina et al., 2018; Guzman et al., 2016; Guzman Urbina & Aoyama, 2018; Islam et al., 2017; Jamshidi et al., 2013; Yazdani-Chamzini, 2014).

Different traditional methods of risk analysis have been used in construction projects in Malaysia (Abdul-Rahman et al., 2015; Ansah et al., 2016; Ghazali & Wong, 2014). The work presented in this paper is part of a much larger project that aims towards an evaluation of AI methods and its application for risk analysis in the Malaysian construction industry. The overall goal hopes to show construction organizations the benefits of AI methods in managing

construction risks effectively. Hence, this study aims to determine the level of awareness of the Malaysian construction practitioners of using AI for risk analysis.

ARTIFICIAL INTELLIGENCE (AI) AWARENESS

Shaughnessy (2017) stated that AI methods are not new products, but they denote an innovative way of undertaking business. He conducted a study and surveyed the risk management community across different sectors regarding how advanced are risk managers in AI adoption and the respondents' results were as follows: 33% believe AI is only one additional innovation and 67% consider it as an initial attempt which is capable of changing the way business is done; 76% noted that AI is not used in any of their risk management applications, while only 15% responded they use AI, and 9% were unsure. Regarding the risk managers' opinion of over what period of time might AI become applicable in their jobs: 13% of respondents answered certainly within 12 months, 41% responded between 1 to 3 years, while 46% answered after 3 years.

Kentouris (2017) argued that industry analysts and operations experts claimed that risk managers are not aware of how to integrate AI in risk matrices and the decision-making process; they are not even sure whether AI should be applied at all. AI is nothing more than a development of computer technology, such as what was developed by fuzzy logic and block box trading, and therefore, it is just a matter of time before AI is combined into risk modeling. Kentouris (2017) also argued that there is no need and it is not required for risk managers to be technologists in having much knowledge understanding AI. However, risk managers are required to play a role in the process of decision-making. Risk managers need to be able to successfully work with technologists to translate and convert their risk management expertise into machine learning, which is the underpinning of AI.

Shaughnessy (2017) concluded that it is obvious that the risk management profession might soon notice itself trying to catch up with AI adoption. Similarly, the risk management role in supporting, monitoring and mitigating adoption or non-adoption risk will soon be needed. Moreover, risk managers tend to accept that talent pipeline is a hindrance but several enterprises and industries have overcome the obstacle. Therefore, risk management will have to align with artificial intelligence when there is a need to handle and evaluate unstructured data.

AI techniques using Fuzzy variables were first introduced on PERT diagrams, one of the planning, scheduling and controlling approaches for project risks, by Kerzner (2003). The durations were determined through BETA distributions using fuzzy technique on estimations provided by experienced managers. Ko and Cheng (2003) also proposed a hybrid use of AI techniques for construction management tools. They have proposed object-oriented Evolutionary Fuzzy Neural Inference System (OO-EFNIS) for solving construction management problems. The potential of the AI system can be used as multifarious intelligent decision support system for decision-making to solve manifold construction management problems.

Blanco et al. (2018) stated that AI is the next frontier for construction technology as they survey on the applications and algorithms to help bridge the technology gap. However, the general need to understand organisation and separated structures is required to answer the

transformation of complex situations into just complicated tasks. It is imperative to determine the range of AI support to this transformation of human task into an automated model (Eber, 2020). Bigham et al. (2018) proposed the development of an AI platform for construction safety risks by implementing safety standards by OSHA codes for compliance. The decision making that was relied on experiences and knowledge was automated using for prompting of OSHA standards' risk mitigation strategies.

With these AI potentials in construction industry, this study attempts to understand the AI risk management scenario in the Malaysian construction industry by determining the level of awareness of the Malaysian construction practitioners of using AI for risk analysis. In Malaysia, previous studies found that the maturity of risk management in the construction industry is low and risk management tools are simple and not applied systematically in most projects (Abdul-Rahman et al., 2015; Kang et al., 2015). In addition, Siang and Ali (2012) stated that risk management methods are not practical in most of the existing companies which have contributed to many issues such as low-quality performance, schedule slip and cost overrun. Traditional risk management methods such as checklists and other qualitative methods are commonly used because they are reasonable, fast, simple, and low in cost (Yusuwan et al., 2008). They deduced that this is due to a lack of knowledge on the available risk management methods such as AI. Therefore, by increasing the level of awareness of construction practitioners on AI methods for risk analysis, this would increase the likelihood of AI methods being applied in their organizations to facilitate risk analysis tasks.

METHODOLOGY

This study started with literature review on the awareness on AI methods. It then proceeded to design a questionnaire and collected data surveyed on AI awareness among the Malaysian construction practitioners to determine the level of awareness of the Malaysian construction practitioners on using AI for risk analysis. Thirteen statements about the awareness level of AI are established and distributed to several construction practitioners in the Malaysian construction industry. The questionnaire was sent to those in managerial and/or consultancy roles, specifically project managers and risk management managers. However, with the increasing complexity of construction works, organizations involving in construction projects are becoming more comprehensive, different professionals are widely distributed in those organizations. Hence, the researcher examined respondents from the target population of different stakeholders, categorized into three main categories, i.e. contractors, consultants, and developers.

Prior to the distribution of the questionnaire, a pilot survey was conducted by sending the questionnaire online via email to six practitioners. The pilot survey was to ensure that the wording and format of the questionnaires were appropriate for the targeted Malaysian construction practitioner, thus ensuring the questionnaire validity. Several significant and useful alterations were made to derive the final version of the questionnaire. A Likert 5-point scale was used for gauging the variables of the questionnaire from 1 (Totally Disagree), to 5 (Totally Agree). The questionnaire was sent via online to 500 construction practitioners in Malaysia using e-mails and LinkedIn. The response rate was approximately 37% with a total of 184 valid questionnaires received from the targeted respondents.

Method of Data Analysis

In this study, the data collected was analysed using SPSS (Statistical Package for the Social Sciences) Version 20 (IBM). Two types of quantitative measures were used for analyzing the collected data. Firstly, descriptive statistics or descriptive analysis that deals with the collection of data and summarizing them into an understandable and simpler format (Salkind, 2010). The results were analysed to frequencies, measures of central tendency (the Mean), measurements of dispersion based on the Mean (Standard Deviation), and Relative Important Index (RII). RII was used in this study to rank the items according to the received responses to the level of awareness on AI. The RII was calculated using the following formula as by Field (2013):

$$RII = \sum W / (A*N)$$

Where:

RII = Relative Important Index
W = the weight of each factor as obtained by the respondents (1 to 5).
A = the highest weight (5 in this questionnaire).
N = the overall number of respondents.

The RII has a range of 0 to 1 (0 not included), and the items that scored the highest value of RII are the most important items.

Secondly, the One Sample T-test was used for the inferential statistics to identify whether the obtained values were statistically different from a neutral value. This same method has been applied in a study on energy and sustainable awareness for construction industry (Enshassi et al., 2019).

RESULTS AND DISCUSSION

The questionnaire survey began with soliciting demographic information from the respondents. The respondents' profiles are presented in Table 1. Demographic data received from the respondents shows that male respondents contributed to 82.1% while the female was only at 17.9%. In addition, 91.3% of the respondents have either bachelor or master's degree. Project directors, project managers, engineers and quantity surveyors made up 76.7% of the respondents. Besides, half of the respondents were from the contractor's firms (51%) and the rest were divided between consultant firms and developers. These suggest high credibility of the respondents that have responded to the questionnaire.

A total of 63.6% of the respondents were from the private sector. The respondents were involved in infrastructure and mixed development projects. Majority had been active in construction and risk management for 1 to 10 years (52%). The experience in construction projects, in general, is crucial for the contribution in the decision-making process and making vital decision-making related to risk management in particular and project management in general. A 33.2% of the respondents were qualified with PMP certification and majority held other project management certifications. Since most of the respondents owned project management certifications, they were more likely to be able to comprehend modern methods used in risk management, especially for risk analysis, which helped in shaping their level of awareness.

Table 1. Respondents' profiles

Attributes	Frequency	Percentage
Gender		
Male	151	82.1%
Female	33	17.9%
Highest educational level		
Bachelor	89	48.4%
Master	79	42.9%
Ph.D.	5	2.7%
Other (Diploma & Professional certificate)	11	5.9%
Position in the organization		
Project director	26	14.1%
Project manager	52	28.3%
Site manager	10	5.4%
Risk manager	8	4.3%
Engineer	38	20.7%
Quantity surveyor	25	13.6%
Other	14	7.6%
Type of organization		
Contractor firm	94	51.0%
Consultant firm	52	28.3%
Developer	38	20.7%
Sector of the company		
Private sector projects	117	63.6%
Public sector projects	25	13.6%
Both	42	22.8%
Type of construction projects you involved (a multiple-selection question)		
Office buildings		
Housing projects	52	28.3%
Infrastructure projects	55	29.9%
Oil & gas projects	120	65.2%
Social amenities projects	36	19.6%
Mixed development projects	23	12.5%
	66	35.9%
Experience managing project risks (years)		
No experience	34	18.5%
<1	19	10.3%
1 to 10	96	52.2%
10 to 20	21	11.4%
>20	14	07.6%
Project management certifications (a multiple-selection question)		
PMP: Project Management Professional		
PMI Risk Management Professional	61	33.2%
Certified Project Director	14	7.6%
PRINCE2 Foundation/Practitioner	8	4.3%
CAPM: Certified Associate in PM	6	3.3%
Associate in PM - GAQM	4	2.2%
CPMP: Certified PM Practitioner	4	2.2%
PPM: Professional in PM - GAQM	3	1.6%
PMITS: PM in IT Security - EC-Council	1	0.5%
Other	0	0.0%
None	38	20.7%
	66	35.9%

The level of Awareness of the Malaysian Construction Practitioners of Using AI for Risk Analysis

This part determines the awareness level of AI by the practitioners in the construction industry in Malaysia. A set of 13 statements were presented in the questionnaire to assess the respondents' level of awareness of using AI for risk analysis. Those statements were surveyed among the respondents for their opinions and the results were presented in Table 2. The Means, Standard Deviations, RII, t-values, P-values and rankings are shown in Table 2. Figure

1 shows the Mean according to the ranking of the level of awareness towards using AI, with the rank 1 level of awareness at a mean of 3.77 (A6) and the three lowest ranked level of awareness at mean of 2.22 (A7, A3 and A10).

Table 2. The level of awareness towards using AI in the construction project risk analysis in Malaysia

The awareness statement	Mean	SD	RII %	t-value	Sig.	Rank
A6: I have heard about AI	3.77	0.94	75.3	11.02	0.00	1
A13: I think AI will be a useful tool for risk analysis	3.52	1.16	70.4	6.11	0.00	2
A9: I think AI can help and add value to my daily work	3.51	1.05	70.2	6.59	0.00	3
A5: I know that AI technology is important for risk analysis in the Malaysian construction industry	3.30	1.09	66.1	3.79	0.00	4
A2: I have read some research and studies about AI	3.16	1.03	63.3	2.15	0.03	5
A1: I have knowledge about the concept of AI technology	3.16	1.00	63.2	2.13	0.04	6
A4: I have knowledge of how to use AI technology tools	2.59	1.10	51.7	-5.08	0.00	7
A12: People within my organization are talking about using AI in risk analysis	2.50	1.16	50.0	-5.85	0.00	8
A8: I practice AI in my job	2.40	1.18	47.9	-6.92	0.00	9
A11: I use AI in risk analysis	2.36	1.17	47.2	-7.47	0.00	10
A7: I have attended training on AI	2.22	1.13	44.5	-9.33	0.00	11
A3: I have taken some courses at university about AI	2.22	1.13	44.3	-9.32	0.01	12
A10: My company provides formal training on AI including follow-up programs	2.22	1.14	44.3	-9.28	0.00	13
Total Average	2.84	1.09	56.8	--	--	--

**t-test value = 3 at significance level 0.05 (2-tailed)*

The obtained results from responded survey indicated the level of awareness of AI among practitioners in the construction industry in Malaysia. To interpret the questionnaire responses, all statements (A1 to A13) were ranked from 1 to 13 to determine the respondents' level of awareness on AI. The established ranking was based on the highest Mean, RII and the lowest Standard Deviation. When the statements had similar mean, and RII like in the case of A3 and A10, the ranking then depended on the lowest Standard Deviation. For instance, despite A3 and A10 received the same Mean, A3 was ranked higher than A10 due to its low SD. The statements' ranks were ranging from RII = 44.3% to RII = 75.3%.

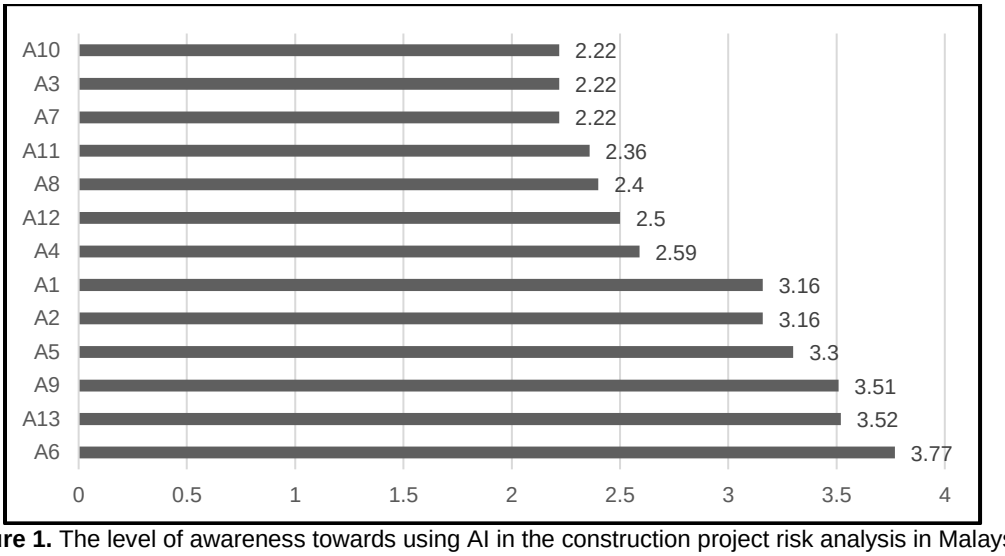

Figure 1. The level of awareness towards using AI in the construction project risk analysis in Malaysia

The results showed that "I have heard about AI (A6)" with (RII = 75.3%, Mean = 3.77) had the highest ranking according to the overall responses. This indicated that AI is a popular topic usually discussed among the practitioners within the construction organizations in Malaysia. Moreover, "I think AI will be a useful tool for risk analysis (A13)" with (RII = 70.4%, Mean = 3.52) took the second rank. This showed that the respondents knew the significance of AI in the construction industry. Lastly, "My company provides formal training on AI including follow-up programs (A10)" was ranked in the 13th position as the last statement of the field of the awareness level of AI by the practitioners in the Malaysian construction projects with (RII = 44.3%, Mean = 2.22) according to all respondents. This was supported by the additional responses from the respondents when they added possible ways to promote AI in the construction industry, they were in favour of companies to provide training and follow up programmes towards increasing the awareness on AI. They explained that doing free seminars and workshops on AI would be a proper and effective way to increase exposure of AI to construction practitioners.

The overall results of "the level of awareness of AI among practitioners in the construction industry in Malaysia" had a Mean of 2.84. However, the five-point Likert scale has an average score of (3). Based on all of that, and as shown, the total Mean 2.84 is less than the average of the Likert scale (3). The total RII equals 56.8% and for the evaluation of these results, it was vital to compute the natural value of RII and compare it to the total RII. As it is stated above, the five-point Likert scale has an average score of (3). Thus, the neutral value of RII is (3/5)*100 = 60%, where 5 denotes the five-point Likert scale and 3 indicates the average score of the same scale. According to the value of the neutral RII, it is shown that total RII = 56.8% is less the neutral RII = 60%. Also, the test value of t at significance level = 0.05 is 3, whereas the value of t-test equals -1.65 which is less than the test value of t (3). In addition, the total P-value of all statements equals 0.00* as it is less than the significance level (0.05). Based on the above results, the level of awareness of AI by the practitioners in the construction industry in Malaysia was found to be low.

These results also concurred with the results obtained by Abdul-Rahman et al. (2015) who found that the risk management process was applied at low levels in the Malaysian construction industry and most construction companies did not implement systematic risk management in their projects. This was due to a lack of awareness among construction personnel on different and available methods of risk management that can be used in construction projects such as AI methods. Furthermore, Yusuwan et al. (2008) conducted a survey ten years ago to measure the level of awareness among the clients' organizations in Malaysia towards risk management, it was found that the level of awareness was low.

This was further supported by what was added by the respondents in the open-ended question about the other barriers to the application of AI. The respondents felt that the Malaysian construction culture itself is considered a big barrier to implementing AI for risk management practices as they are slow to adapt to the latest technology, hence, the low acceptance level. Some said that in Malaysia, risk management is being practiced in the construction industry continuously. Some may not have proper documentation; hence the knowledge is not retained but brought along with the employee if he/she leaves the organization. Documenting risk management and incorporating this mindset into the day to day construction operation involves changing the cultural landscape of the construction industry, which is still at its infancy stage (Siang & Ali, 2012). Hence, to incorporate AI, the

culture must evolve first. Also, the construction industry in Malaysia is quite behind in using basic core technology like ERP, BIM, Primavera and Collaboration Technologies. However, most companies have started initiatives to fix this. AI, IOT, and other solutions are far away from the immediate focus for this industry but the ones who invest in these technologies will eventually be the industry leaders.

To obtain a clearer measure for the level of awareness on AI, the respondents were asked about their awareness level of using AI for risk analysis. The scale was from 1 to 10 and the results are presented in Table 3. The results show that, 33 respondents (17.9%) rated their level of awareness with a 6 score which represents the highest score of level of awareness among the respondents, this was followed by a 8 score with 25 respondents (13.6%) while the lowest level was a 10 score with only 3 respondents (1.6%). Overall, the first five scores (1 to 5) of the awareness level were selected by 97 respondents (52.7%), while the other remaining five awareness levels (6 to 10) were selected by 87 respondents with (47.3%). This indicated that the level of awareness of AI among the practitioners in the Malaysian construction industry as moderate.

Table 3. The practitioners' level of awareness on AI

Level of awareness	Frequency	Percentage	Rank
6	33	17.9%	1
8	25	13.6%	2
4	24	13.0%	3
5	23	12.5%	4
3	22	12.0%	5
7	19	10.3%	6
2	16	8.7%	7
1	12	6.5%	8
9	7	3.8%	9
10	3	1.6%	10
Total	**184**	**100.0%**	**--**

The level of awareness taking into account the respondents' attributes

The following is the level of awareness of the Malaysian construction practitioners in relation to respondents' attributes (Table 4). The analysis was conducted based on the total Mean of each respondents' attributes.

Firstly, the level of awareness versus the practitioners' gender. It was found that female practitioners were more aware of AI technology than their male counterparts. The level of awareness was also measured in relation to the highest educational level. It was found that the practitioners who held a Ph.D. degree were well aware of the usage of AI for risk analysis, followed by master's holders and finally bachelor holders. This clearly indicated that the education level had a significant impact towards the awareness of the practitioners as they were better exposed to related knowledge.

The level of awareness was gauged based on the practitioners' position in the organization to determine whether the position on the organization played a role in shaping the employees' level of awareness. From Table 4, it was found that quantity surveyors were most aware of using AI in analyzing risks in construction projects. This indicated their concern on technological trends. The project directors came second to be most aware of using AI, which was then followed by project managers, engineers, risk managers, and site managers. It was

concluded that there was no connection between the position in the organization and the level of awareness on AI as it was simply the exposure among the profession. Several respondents commented that this was because the quantity surveying profession had provided plenty trainings and awareness talks on the use of AI in quantity surveying tasks such as those related to BIM.

Table 4. The level of awareness based on respondents' attributes

Respondents' Attributes	Total Mean
Level of Awareness vs Gender	
Male	2.80
Female	3.04
Level of Awareness vs Highest Education Level	
Bachelor	2.79
Master	2.88
Ph.D.	3.15
Level of Awareness vs Position in Organization	
Project director	2.95
Project manager	2.78
Site manager	2.70
Risk manager	2.72
Engineer	2.74
Quantity surveyor	3.10
Level of Awareness vs Type of Organization	
Contractor firm	2.83
Consultant firm	2.81
Developer	2.82
Level of Awareness vs Sector of the Company	
Private sector projects	2.84
Public sector projects	2.74
Level of Awareness vs Years of experience in construction projects	
Less than 1 year	2.84
1 to 10	2.89
10 to 20	2.97
More than 20 years	2.60
Level of Awareness vs Years of experience in managing project risks	
No experience	2.77
Less than 1 year	2.85
1 to 10	2.86
10 to 20	2.89
More than 20 years	2.75
Level of Awareness vs Project management certifications	
PMP: Project Management Professional - PMI	2.88
PMI Risk Management Professional (PMI-RMP)	3.04
Certified Project Director	3.11
None	2.66
Others	2.94

The level of awareness versus the types of organization was assessed. It was found that the type of organization had no significance in shaping the practitioners' level of awareness. There was only a slight difference in the level of awareness among practitioners working in construction firm, consultancy firm or developer firm.

As for the sector of the company, it was found that practitioners who were involved in private sector projects were more aware of using AI for risk analysis than those in public sector projects as shown in Table 4. This could be due to the high level of competitiveness among the private projects which required the use of advance technology in project management.

The practitioners' level of awareness was gauged taking into account their years of experience in construction projects in general. It was found that practitioners with 10 to 20 years of experience were most aware of using AI for risk analysis in construction projects. This was due to their day to day job in decision making giving them the exposure to different types of technology to assist them in managing projects. On the other hand, respondents with 20 years' experience had the lowest level of awareness, which could be due to their old school thinking.

The similar trend when gauging level of awareness against the practitioners' years of experience in construction risk management. Results in Table 4 show that practitioners with risk management experience of 10 to 20 years have the highest level of awareness among the respondents, which was similar to those who had 10 to 20 years of experience in construction projects in general. This was followed by 1 to 10 years, less than 1 year, and those with no experience in construction risk management. Surprisingly, respondents with more than 20 years' experience in construction risk management had the lowest level of awareness on AI even less than those who had no experience. This could again be due to their old school thinking and the lesser intention to explore new trend within their area of expertise.

Finally, project management certifications played an important role in shaping the level of awareness of Malaysian construction practitioners. Table 4 shows that practitioners who hold a certificate of Certified project director were most aware of AI among the respondents. This was followed by those who hold a certificate of Risk management professional (RMP), other certifications like Master of project management, and then those who hold a certificate of Project management professional (PMP). On the other hand, practitioners who do not hold any professional project management certification were the least aware practitioners among the respondents surveyed.

The application of AI for project risk analysis in Malaysia

The results of the questionnaire show that some of the respondents had practiced AI in their jobs and used AI for risk analysis as shown in Table 3. Thus, this section introduces the areas of risk analysis in construction projects where AI was applied. The respondents were asked to choose one of the following three options "applied, not sure, or not applied" for each of the statement, which represents the AI application area for risk analysis in their organisations. The results are presented in Table 5.

The results in Table 5 show the difference in the application level of AI methods by respondents. It was found that using AI in understanding optimistic scheduling was the highest area of application, which was confirmed by 71 respondents (38.6%). This was followed by using AI in predicting delays of schedule during execution which was applied by 69 respondents (37.5%), using AI in assessing the subcontractors and suppliers' performances was applied by 59 respondents (32.1%), using AI in predicting demand based on economic indicators was applied by 46 respondents (25%) and lastly was using AI in finding optimal project bidding strategy was applied by 46 respondents (25%). However, a total of 98 respondents (53.3%) also responded that AI methods were not used when finding optimal project bidding strategy in their organisations.

Table 5. The application of AI in risk analysis

Application of AI	Scale	Frequency	Percentage
We use AI in predicting demand based on economic indicators	Not applied	78	42.4%
	Not sure	60	32.6%
	Applied	46	25.0%
We use AI in predicting delays of schedule during execution	Not applied	77	41.8%
	Not sure	38	20.7%
	Applied	69	37.5%
We use AI in finding optimal project bidding strategy	Not applied	98	53.3%
	Not sure	40	21.7%
	Applied	46	25.0%
We use AI in assessing the subcontractors and suppliers' performances	Not applied	91	49.5%
	Not sure	34	18.5%
	Applied	59	32.1%
We use AI in understanding optimistic scheduling	Not applied	75	40.8%
	Not sure	38	20.7%
	Applied	71	38.6%

A total of 60% of the respondents did not use any AI method for risk analysis, this indicated high level of traditional tools usage and reflected the low level of awareness of using AI tools for risk analysis in construction projects. This is supported by Kentouris (2017) who stated that industry analysts and operations experts claimed that risk managers are not aware of how to integrate AI in their risk matrices and contribute in the process of decision-making and to identify whether AI should be applied at all.

Many firms were still facing difficulties to apply AI for risk analysis in construction projects. Generally, AI methods were expensive for some organizations to invest in. This was supported by the few project management training and low skill level of the respondents, showing most organizations had little intention to adopt and invest in such expensive methods for risk management. These results demonstrated the extent of AI application for risk analysis among the construction organizations in Malaysia, also indicating that it would take time for AI to be accepted and recognized in the Malaysian construction projects. It was suggested by some respondents to have proper learning process in place. The exposure of various AI tool applications to be available to all practitioners. Once learning and exposure were available to the industry, this would aid organizations to filter and handpick the appropriate AI risk analysis tools for their organisation.

Based on their experience, the respondents also added to the list of AI applications used by their organizations. The said applications included forecasting time and weather, scheduling program, levelling resources and optimizing cost, planning maintenance work, monitoring project cost exposure year by year, planning robust program, and estimating gas usage. These AI applications gave a clear sign that AI methods were already implemented, though for usage other than risk analysis, in construction organizations in Malaysia. These also indicate the possibilities to increase and expand the application of AI methods for risk analysis tasks in construction projects.

The future of AI

Table 6 shows the respondents views about the future of AI. Based Table 6, only a few organizations were currently using AI to model their work for project risk analysis (V4 and V5). However, the results also showed that majority of the respondents were confident that AI methods would be much effective and useful for the risk analysis tasks and could add value

to their construction projects (V1, V2, and V3). Also, the results showed that some companies had been providing formal training on AI including follow-up programs (V6).

The results indicated positive sign for the way forward and future of AI in the Malaysian construction industry. Construction related organizations should consider setting future plans and requirements to allow AI application to take place in their risk analysis work and project management. For the future development of AI, more training and support are needed to be offered by the government and construction bodies in Malaysia.

Table 6. The view of respondents about the future of AI

No.	Respondent's views	RII %
V1	I think AI will be a useful tool for risk analysis	70.4
V2	I think AI can help and add value to my daily work	70.2
V3	I know that AI technology is important for risk analysis in the Malaysian construction industry.	66.1
V4	I practice AI in my job	47.9
V5	I use AI in risk analysis	47.2
V6	My company provides formal training on AI including follow-up programs	44.3

CONCLUSION AND RECOMMENDATION

This paper determined the level of awareness of the Malaysian construction practitioners toward using AI for risk analysis in construction projects. The main results showed that the level of awareness was low where most of the respondents lacked knowledge about AI; majority of them neither practice nor use AI in their risk analysis tasks; a large portion did not undergo any training on AI or taken some courses at universities; and finally most of the companies in the construction industry in Malaysia did not provide or provide limited formal training on AI including follow-up programs. In addition, their awareness was primarily focused on three main aspects which were: hearing about AI; AI is a useful tool for risk analysis, and AI can add value to the daily work. Moreover, AI was not applied for risk analysis tasks by most of the respondents which confirmed the lack AI application in the Malaysian construction industry. Few respondents used AI for risk analysis tasks in areas such as understanding optimistic scheduling; using AI in predicting delays of schedule during execution; and assisting the subcontractors and suppliers' performances. This study contributed to the knowledge of project management on the AI awareness in practice especially in the context of risk analysis for construction projects. The limited literature on AI awareness in the context of the Malaysian construction industry calls for the need of this study. The limitation in this study is the biasness of sample selection. Since this study is on awareness, the study opted to focus generally on all three main construction players-contractors, consultants, and developers. Future research can focus on specific sampling frame by selecting practitioners from one category such as main contractors, private client, etc. Additionally, future research can study impact of culture in construction industry towards the adoption of AI for project management.

ACKNOWLEDGEMENT

This research was funded in part by grant from the Impact-Oriented Interdisciplinary Research Grant (IIRG) under the University of Malaya. Grant number: IIRG007C-2019.

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ENERGY-EFFICIENT FEATURES FOR OFFICE BUILDING SUSTAINABILITY IN MALAYSIA

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Abstract
Building sector in Malaysia is developing fast along with the high economic growth, therefore leads to a dramatic increase in energy consumption particularly electrical energy use in commercial and residential buildings which consumed almost half of the total electricity generated. With the rising population and increasing urbanisation, an upturn in the construction of high rise building especially office building has been created. As the demand for energy will be increasing associated with the booming of office building, concerns about energy consumption and its implications for the environment shall be addressed by building sector, economic benefit such as reduced life-cycle costs and social benefit of improved occupational health and comfort have also driven the industry to prioritize energy efficiency to fulfil the principles towards achieving building sustainability. This study looks into the current energy use in Malaysian office building and the importance of energy efficiency to be promoted among building sector. This study aims to investigate how energy-efficient features related to building envelope, lighting system, HVAC system and office equipment can be incorporated at the same time creating a conducive working environment without compromising occupants' satisfaction and well-being. Semi-structured interview was conducted to obtain an insightful picture of the industry regarding the adoption of energy efficiency in the real-world situations. This study is to be very important as it is significant for the building sector to reduce energy consumption to ensure an efficient energy use in the path of aligning with building sustainability and creating a greener built environment.

Keywords: *Building sector; energy efficiency; office building; energy-efficient features; building sustainability*.

INTRODUCTION

Buildings and the built environment around us have the competency to make a major contribution to a more sustainable future for our planet. As defined by ASCE (1996), sustainable development is the challenge of meeting human needs for natural resources, energy, industrial products, food, transportation, shelter, and effective waste management, while at the same time conserving and protecting environmental quality and natural resource base crucial for future development. It encourages builders and designers to emphasize on ensuring an efficient usage of resources and to take into considerations of the impacts that might be created to the environment from the way of acquiring material as well as from the building process. Sabnis (2012) has mentioned that the industries who incorporate sustainability shall aim to maximize the positive effects on society through education and employment, whilst minimising the negative society impacts created to achieve social sustainability. Economic sustainability can be achieved through ensuring and securing the company's operations to be carried out with maximised long-term profit in order to sustain the value of the contributions done by the company to both environmental and social sustainability.

Hassan et al. (2014) has reported that in Malaysia, buildings consume a total of 48% of the electricity generated in the country. Commercial buildings including offices consume up to 38,645 Giga watts (GWh) while residential buildings consume 24,709 Gwh. This has

highlighted the need for designers and occupants to look into the importance of energy efficiency, which acts as one of the major categories in achieving sustainable development.

ISSUES

The growth of population and wealth are believed to be associated with the rise in demand of energy supplies. Brown et al. (2012) has presented their findings of every 1% increase in wealth per capita (per person) will be bringing the increase of 0.76% in their energy consumption after surveying 220 countries over the period of 24 years on the relation between regional economic growth and energy consumption. Energy demand and consumption which grow rapidly in the modern societies of developed and developing countries with little or even without sign of slowing down has become one of the major driving factors for the construction industry to go for energy efficiency.

With fossil fuels being the predominant energy sources over the years in Malaysia, the environmental impact created through the usage of these non-renewable resources such as the capability of emitting unwanted greenhouse gases, the continuous subtraction and consumption over these finite resource are leaving a worry end to our built environment.

Not only the material chosen and construction method applied will affect the environment, how the building is built to operate also represents a large portion of impact created to the environment. Therefore, alterations and improvement shall be resulted in energy technologies from time to time to cater current conditions of the industry, such as by modelling the existing technology to be resource-efficient, for example, through integrating variable speed motor in air conditioning unit, or by fully incorporating sustainable systems, both are able to create significant changes to the global environment in which the problem of global warming can eventually being reduced and thus leads the industry towards a greener future.

OBJECTIVES

The objectives of this study are stated as below:

1. To identify the impact and importance of energy efficiency in office building;
2. To investigate how does energy-efficient features contribute in building sustainability to office building.

LITERATURE REVIEW

Factors Promoting the Importance of Energy Efficiency in Office Buildings

Energy demand and consumption has increased dramatically since Malaysia's economy sector undergoes rapid growth continuously over the years. As mentioned by Yang et al. (2008), office buildings consume about 70–300 kWh/m^2 per year, in which the usage is 10 to 20 times more than residential sectors. Table 1 shows the key factors that promote the importance of energy efficiency in office buildings.

Environmental Factors

Malaysia, as a developing country, where the country's development and welfare will be largely depending on having access to reliable and secure energy supplies. Malaysia relies heavily on fossil fuels such as coal, oil, and natural gas for power generation, however, these energy sources will be depleted in reserve over the years and will create environmental damage such as global warming and climate change. Relating to carbon and greenhouse gases (GHG) emissions, Suzaini et al. (2015) has mentioned that approximately 40% of global GHG emissions come from building sector through the combustion activity of fossil fuels for electricity generation. These have strengthened the need for building sector to adopt energy efficiency to minimise the negative impact created to the built environment.

Table 1. Factors Promoting the needs of implementing energy efficiency in office buildings

Categories	Factors
Environmental Factors	• Energy crisis • Carbon emissions and greenhouse gases • Water conservation • Light pollution
Economic Factors	• Increase building's value • High returns on sustainable features-relevant investment • Cost savings through reduced Building Energy Index (BEI) • Drive the development of green construction and job opportunity
Legislation and Initiatives	• Improve green credentials • Government legislations and initiatives • Sustainable assessment and rating tool
Productivity Factor	• Better occupational health with the installation of sustainable features

Economic Factors

Yaron & Noel (2013) proof that the improved performance and reputation among the market provided by sustainable building certification will increase the building's value. Besides that, although the initial cost for the investment in developing sustainable buildings may be higher than the traditional buildings, in fact, fast return of the investment and favourable revenue can be obtained through the lowered energy and other operating expenses (F.C., 2006). Through studying on the Low Energy Office (LEO) case, KeTTHA (2015) presented that the Building Energy Index (BEI) values for Malaysian office buildings can be lowered down further with an additional 5% of capital investment against the total capital cost, and the additional capital cost are shown to have a pay-back period of 8 years.

Legislation and Initiatives

As mentioned by Aziz et al. (2018), government can be leading in this way through benchmarking of energy efficiency related initiatives and pioneering in adopting these policies by implementing them internally and large transformation impact can be created by them as a regulator to the market as well as to the nation. The problem of paying high amount of money for energy supply faced by nation and excessive carbon dioxide emissions can be considerably mediated as long as the government and people manage to transform the typical energy consumption by nation towards sustainable direction. This can be supported in study carried out by Samad et al. (2010) in which government promoting efficient utilisation regarding to energy resources especially in transport, industrial, commercial sectors and also

government buildings. Promotion such as tax incentives are to be offered to sectors who adopt high efficiency systems and equipment.

Productivity Factor

Ries et al. (2006) mentioned that other than direct cost savings, which for example such savings can be created through the increased property value and reduced operating expenses, sustainable buildings are also able to provide indirect economic benefits to building owners and societies. This can be achieved by installing sustainable features which promote better occupational health and comfort, in turn upgrading the employee's well-being and productivity while completing the assigned task. A study of overcooled office building is carried out by Zahirah et al. (2017) and the finding shows that other than being wasteful upon energy supply, thermal discomfort has been created and caused the reduction of worker productivity and loss of performance while completing the assigned task.

Features Contribute to Energy Efficiency for Office Buildings

Building Envelope

Jayamaha (2006) raises up the matter that heat transfer takes place in each component of building envelope and air leakage through conduction, convection and radiation, while infiltration and exfiltration result in buildings gaining or losing heat through air leakage. Djamila et al. (2018) has mentioned that there will be significant loss in energy when the building is not designed to be airtight and will result in uncontrolled infiltration happening through cracks or doors and windows of building. Selection of components such as automatic doors as well as high quality construction shall be prioritised in which Djamila et al. (2018) revealed that the potential saving of 20% of energy especially in tropics may be gained through the minimisation of air infiltration. For window glazing, Carmody & Haglund (2012) had discussed that special coatings such as low-emittance coatings shall be taken into consideration to reduce emissions and radiation of heat from windows in the form of long-wave infrared radiation, whereas multiple layers of glazing will help to increase thermal resistance and minimise heat loss resulted from convection between layers. Gibberd (2014) mentioned that solar shading device shall be promoted to reduce heat gains from the direct sunlight on facades or through windows and incorporating insulation to the main building components such as walls, windows, and roof where heat transfer predominantly takes place will also be one of the strategic ways to preserve energy efficiency.

Lighting System

As mentioned by Wagiman & Abdullah (2018), lighting is one of the main sub-systems of building which accounts for large portion of energy consumption just after HVAC systems. According to Jayamaha (2006), incandescent lamps can be replaced by compact fluorescent lamps or linear fluorescent lamps which have a higher efficacy and longer service life. Jayamaha (2006) has also proposed the adoption of general lighting and task lighting to each provide overall illumination and the light needed for particular task such as reading or computer works. Installation of lighting control system such as occupancy sensors will also help to reduce the energy consumption through lighting equipment. Besides, daylight could be implemented together with electric or artificial lighting in which Abdul-Rahman et al.

(2011) supports that energy can be saved through reducing the lighting power demand such as by dimming or switching off electric lights when daylight is sufficient.

HVAC System

According to Suruhanjaya Tenaga (2014), efficiency in air-conditioning system can be achieved if the indoor conditions are designed according recommendations, which include to record 24°C to 26°C for dry bulb temperature, air movement ranging from 0.15 to 0.50m/s whereas possess relative humidity of 55% to 65%. Besides, individual thermostatic controls shall be provided in different zones and off-hour control with automatic control to shut-off the supply shall be installed to reduce the energy usage during off-peak or non-occupied hours. Other general considerations such as cleaning the filters in regular intervals, preventing air leakage through improving the insulation of pipes, installing shading devices both internal and external to minimise heat gain shall also be adopted to achieve proper maintenance as well as to reduce the energy consumption.

Office Equipment

Studies carried out by Roy et al. (2005) has indicated that office equipments contribute their own part in high electricity demand and consumption which resulting in additional cooling load required. Roy et al. (2005) highlighted that offices equipped with Energy Star-certified computers or energy labelled computers which incorporate software that automatically reduces energy consumption during idle periods, such as by entering power saving mode automatically when non-occupied for a period will be ideal for energy-saving. LCD screens shall replace the traditional CRT screen in terms of less reflection which result in better user comfort as well as lesser space on the desk will be required. Purchasing more laptop computers which optimise maximum battery life will also contribute in achieving energy efficient as compared to the using of desktop computers.

Contributions of Energy Efficiency towards Building Sustainability

Environment Sustainability

Kibert (2005) has highlighted that the reduction of resource consumption, resources reusing, as well as committing to provide protection against nature environment such as the elimination of toxics as some of the core principles emphasized in sustainable building throughout its whole life cycle. According to Kats (2003), a sustainable building can be defined as building that has an efficient usage over key resources such as energy, water and materials, and this implies efficient resource consumption to be as a part of the environmental sustainability criteria. Other than resource and energy efficiency, John & Clements-croome (2005) has identified that a sustainable project shall also meet the requirement of CO_2 and GHG emissions reduction, pollution prevention and improved indoor air quality. Therefore, an energy-efficient building can achieve environmental sustainability as long as it comprises features of energy and water efficiency, reduction in CO_2 and GHG emissions, optimisation in materials used as well as other parameters which will contribute to a sustainable built environment.

Economic Sustainability

As mentioned by Heli et al. (2002), life-cycle cost analysis (LCCA) is a method used in assessing the total cost of owning a facility. Fregonara (2018) stated that LCCA is one of the main tools for evaluating projects' economic sustainability. According to Kale et al. (2016), energy consumption cost is considered as one of the key element in order to reduce the life-cycle cost of the building, as it has a large contribution towards the expenses in commercial buildings. Therefore, energy-efficient building that contributes to life-cycle cost efficiency, improved market value or other economic benefits will be able to achieve economic sustainability.

Social Sustainability

Regarding to the social aspect, Akadiri et al. (2012) has highlighted that protecting health and comfort of the occupants is considered as one of the evaluation criteria under social sustainability, where the building is able to prioritise human needs and comfort and to enhance productivity. An energy-efficient building that provides better lighting quality, thermal comfort or other requirements which fulfil a healthier work environment will be having the potential to achieve social sustainability.

RESEARCH METHOD

In this research, qualitative method is selected and interview is used as the instrument to collect the data required. Semi-structured interview is chosen to be the method of data collection in this research, where a set of interview questions will be prepared and serve as a guideline to ask. Qualitative method is chosen instead of quantitative due to a holistic view from the industry regarding the entire development of energy efficiency ranging from the installation and performance of the technology itself to the maturity level of energy management practiced in the industry is required. Besides, as information required in this research are relatively technical, views and suggestions in depth expressed by the experts and consultants relevant in this field during the interview will be useful in achieving the research aim. Secondary data will be collected through literature review, journals, reports and others to serve as a basis to make out the similarities and gaps between the data collected through interview, as well as providing additional information or different perspectives to achieve a better understanding and further enrich the analysis of data collected. Figure 1 below shows the conceptual framework of this research.

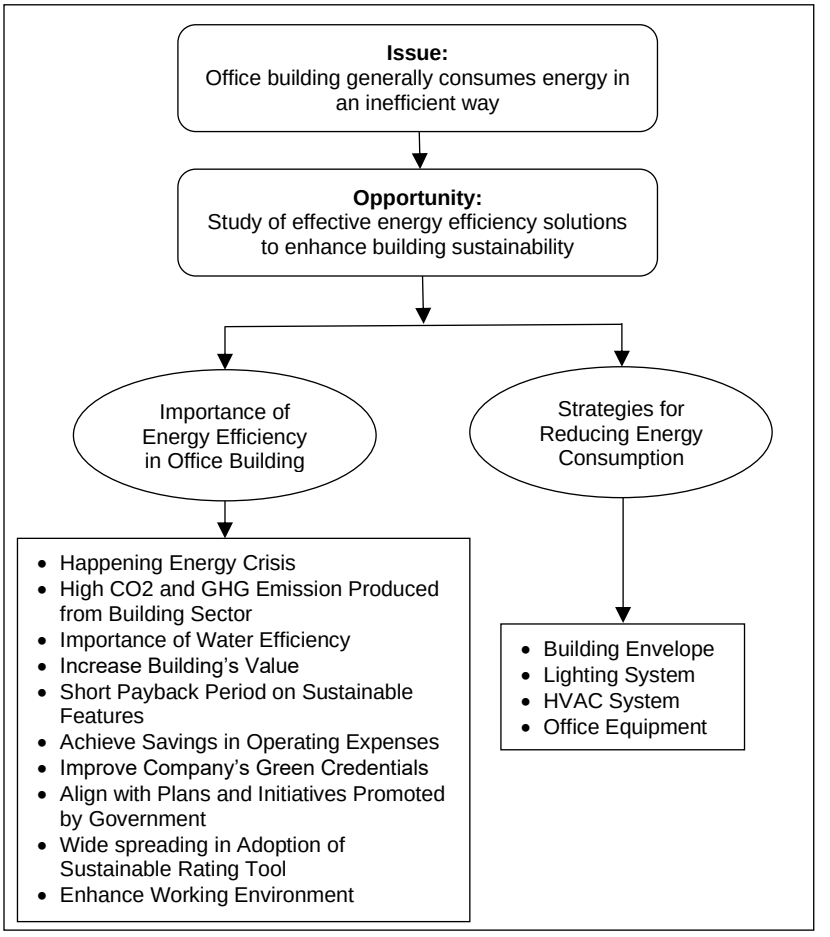

Figure 1. Conceptual Framework

Content Analysis

Content analysis is adopted in this research as the data analysis method together with coding. According to Parveen & Showkat (2017), content analysis is the process of studying the content of recorded human communications such as newspapers, videos and text messages, where the meanings and messages contained behind the messages could then be revealed and derived. Interview transcripts will be the case in qualitative research where content analysis is conducted upon to find out the underlying messages behind those communications with the participants.

Coding

Coding process is defined by Belotto (2018) as a data analysis method which allows large segments of text and portions of information to be interpreted in new ways. According to Saldaña (2009), a code can refer to a word or short phase, which symbolically assigns a summative attribute for a portion of qualitative data. Cope (2016) has mentioned that since qualitative research typically produces masses of data in forms that are difficult to be interpreted, coding helps us to reduce data through categorizing them into small packages, which are the codes and categories to ease the data analysis process.

Sampling

Purposive sampling is selected to be the sampling method in this research. In purposive sampling, individuals equipped with knowledge and experiences in the particular research area will be selected as the respondents in research interview. In this research, energy consultants and advisors will be focused on and selected as the respondents to explore and obtain an in depth understanding on the research issues concerned. The target respondents in this study are consultants and facilities manager who are involved in handling the advisory and management responsibilities in energy-efficient buildings. Due to time limitation only 5 respondents who have working experiences of 6 to 21 years in this relevant field agreed to participate in the interview.

KEY FINDINGS AND DISCUSSION

Factors Promoting the Importance of Energy Efficiency in Office Buildings

Based on the question of 'In your opinion, what are the factors that drive the industry and client to go for energy efficiency in building projects?', each respondent had expressed several factors which promote the importance of energy efficiency. Energy crisis had been identified by 4 out of 5 of the respondents to be the main driver for building sector to implement energy efficiency. Respondent 1 highlighted that the decreasing amount of fossil fuel resources has risen out the importance of energy efficiency and the development of renewable energy. This is supported by Yatim et al. (2016), where the findings showed that fuel diversification and renewable energy adoption shall be more emphasised in our country. For this, respondent 5 had also highlighted its importance due to the majority of coal used for power generation in Malaysia are imported. Move on to the demand side, respondent 4 had mentioned that significant increase over the past 10 years were observed in Malaysia's final energy demand and hence a reduction of energy consumption becomes critical. Respondent 2 had pointed out how paying the real price for energy through levelling the playing field could impact on energy usage in Malaysia.

There were 3 respondents who mentioned that water efficiency is also an important part under energy efficiency in order to contribute in creating a sustainable built environment. Rainwater harvesting system had been highlighted by respondent 2 and 5 to be having the ability to save 50% of water usage. However, the lack of attention by the industry towards water efficiency was observed due to our country having a relatively cheap water price. Benefit of better staff's productivity and performance which resulted from the conducive working environment created in energy-efficient building had been mentioned by respondent 2, 3, and 5 to be one of the most significant factors that drive the industry to adopt energy efficiency.

2 out of 5 respondents agreed that energy efficiency will help to reduce the negative environmental impact created by carbon and greenhouse gases emissions. As highlighted by respondent 1, most of the CO2 emissions in our country come from the combustion of coal for electricity generation and this is supported by Suzaini, Nik Elyna, Norhayati, & Raha (2015), where building sector was reported to contribute large amount of CO2 and GHG through the combustion of fossil fuel. Respondent 2 continued his viewpoint where restructuration of fossil fuel subsidies by the government can also help to reduce global carbon emissions.

Features Contribute to Energy Efficiency for Office Buildings

Based on the question of 'What are the strategies or building components that can be incorporated in office building for i) Building Envelope; ii) Lighting System; iii) HVAC System; and iv) Office Equipment in order to efficiently reduce energy consumption?', variety of examples were given by the respondent and table 2 shows the summary of the examples given by the respondent according to different systems.

Table 2. Examples of strategies contribute to energy efficiency raised by respondents

System	Examples of strategies contribute to energy efficiency raised by the respondents
Building Envelope	• Wall and Roof Insulation • Minimising Air Gap in Building • Apply Double Glazed Glass Panel with Low-E Coating • Reduce the Number of Window and Having North / South-Facing Window • Tilting Facade Design
Lighting System	• Adoption of LED light • Installation of Occupancy Sensor • Adoption of Task Light • Daylight strategy
HVAC System	• Increase Chilled Water Temperature • Replacing Old Chiller • Efficient Fan and Motors used in AHU and Avoid Oversized System • Installation of Floor Slab Cooling System • Install Thermostatic Control • Having Active Control over air-conditioning system • Use Refrigerant with Lower GWP
Office Equipment	• Use Energy Star-certified Office Material • Maximise Laptop Adoption

For building envelope, all 5 respondents had marked wall and roof insulation as critical because it will help to reduce the thermal heat gained into the building. Other than installing insulation material, designing a thicker wall or adopting a cavity wall are also considered as good solutions for wall insulation.

Respondent 1, 2 and 4 had pointed out that building should be designed to have the characteristic of air-tightened, as mentioned by Djamila et al. (2018) that the gap that exists in wall, door and window will result in air leakage which will then lead to inefficiency in the energy usage. Besides, there are 2 out of 5 respondents highlighted that double-glazed glass panel incorporates with low-e coating will be the optimum window glass material in enhancing the ability of reducing heat transmission occurred between glazing layers. As Jayamaha (2006) presented that glazing unit is the one who contributes the majority of transmission of heat between indoor and outdoor environment, therefore, other than optimising the material selection, respondent 4 and 5 suggested that reduction in the numbers of window shall be considered and those east or west-facing window shall be avoided too. Titling or slanting façade is a unique design observed in Suruhanjaya Tenaga (ST) building, in which respondent 3 explained that the particular design helps to provide protection against direct sun rays into the building.

Strategy of incorporating daylight was proven by 4 out of 5 respondents to be effective in achieving efficient lighting usage. Glare protection shall also be emphasized in this case. Adoption of LED light had been highlighted by respondent 1,4 and 5, whereas for the installation of occupancy sensor, as in line with Jayamaha (2006) findings, they can be

installed in bathrooms, public corridor and other places and it was mentioned by respondent 1 and 2 to be able to reduce energy consumption contributed by lighting systems.

In regard to HVAC system, 3 respondents had suggested that it is crucial to ensure the efficiency of air handling unit, fans and motors as well as other components which form the parts of air-conditioning system, where old equipment models are not encouraged and oversized system shall also be avoided. Thermostat installation had been suggested by respondent 4 and selecting the air-conditioner which uses refrigerant with lower global warming potential was highlighted by respondent 5 which can be achieved through procuring five stars-rated air-conditioner.

For office equipment, all 5 respondents agreed on using energy saving-labelled office materials can efficiently help to reduce energy consumption. Two of the respondents encouraged the adoption of laptop computers to achieve energy savings, which is in line with Roy et al. (2005) findings where the optimisation of battery life compared to desktop makes them become a more preferable option in reducing electricity usage.

CONCLUSIONS

The facts that we are relying mostly on non-finite resources for electricity power generation brings out the importance of why the industry shall go for energy efficiency, as building sector is proved to be one of the major consumer upon the national electricity generations. Through aligning with energy efficiency, efficient resource consumption can be assured in terms of energy and water consumption, which forms a basis to achieve environmental sustainability, whereas the reduction in CO_2 and GHG emissions can be resulted from reduction of fossil fuel combustion for electricity power generation and this also contributes to sustainability in terms of protection to the environment. For economic aspects, the increased market value of energy-efficient building and the ability of resulting whole life cost efficiency enable the building to achieve economic sustainability. In the extent of social benefits, working environment that ensures better occupational health and comfort provided by energy-efficient building can relate them to achieve social sustainability.

With the increasing urbanisation, number and size of buildings will also perform an increasing trend which will then raise the importance of energy efficiency among the building sector to cater the increased electricity demand. Same goes to office buildings, as people nowadays spend lots of time in office compared to home, an energy-efficient building which is able to deliver operational efficiency will be the optimum as it fulfils the considerations of environmental protection through reducing the negative impacts generated to the environment, take into account the occupants' health and comfort by creating conducive working environment, as well as achieving reduction in operation cost. A good energy management practice shall also be emphasized to obtain maximum savings and at the same time ensuring such savings will be able to contribute in a long-term context.

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AMBIGUITY EXTENSION OF TIME PROVISIONS IN STANDARD FORMS OF CONTRACT: AN ANALYSIS OF PAM 2018 CONTRACT

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Abstract
The administration of construction contracts in Malaysia is facilitated through standard forms of contract. The application of local documents either Pertubuhan Akitek Malaysia (PAM), Institution of Engineers Malaysia (IEM), Public Works Department (PWD) or Construction Industry Development Board (CIDB) is dependent on the type of project, mode of finance and owner of the project. In any construction contract, the ambiguous contract provisions have a significance impact on the project performance, which in turn affects the achievement of the project completion date. Hence, it is observed that ambiguity provisions can be considered as a source of construction dispute in the event of misunderstanding and ignorance of the contract clauses. This paper aims to examine the relationship between the effects of ambiguity provisions on extension of time (EOT) claim and the moderating effects of contractual complexity. To achieve the aims, case law is examined to illuminate the judicial approach and highlight the ambiguity of EOT provisions in the existing standard forms of contract. Analysis of EOT provisions of PAM 2006 and 2018 is then made to look at certain specific ambiguous provisions so as to serve a catalyst for further investigation, honing and refinement. The findings create awareness and offer new insight into the effect ambiguous provisions have upon the contractor contractual rights to extension of time and nuance understanding of contractual management and governance in project. Therefore, a clear and more complete general condition documentation should end up with win-win situation for various parties involved.

Keywords: *Standard form; ambiguous provisions; construction contracts; extension of time.*

INTRODUCTION

Standard form of contract is a pre-prepared contract which establishes legally binding relation between contracting parties, the employer and the contractor. It is in printed form and published by an authority body of the industry, which is recognized by government and construction industry parties. The standard form can be considered as non-negotiated contract because all the terms and conditions of the contract stipulated earlier are not subject to further negotiation or amendment. According to definition by Nayagam and Pathmavathy (2005), standard forms of construction contract provide a basic legal framework identifying the rights, obligations and duties of the parties; establish the ambit of the powers and duties of the contract administrative procedures necessary for operation of the contract.

Availability of these various types of forms signifies that the standard forms have gone through a process of negotiation, act as a compromise and allocate risks fairly between contracting parties. In fact, the efficiency and effectiveness of standard forms make it becomes a favour. The construction industry parties prefer to use standard form for their contract due to the reason of administrative, time and cost efficiency. Moreover, the standard form is a legal framework with standardize format, so the construction professionals are more familiar with their limitations, procedures, operations which at last will leads to project efficiency. Instead of this, Nayagam and Pathmavathy (2005) gave their view that as there is a body of

judicial pronouncements accumulated over the years on standard forms, there is some certainly in meaning.

The Malaysian construction industry hinges essentially on a litany of standard forms of contract; notably those principal standard forms in common use published under the auspices of various institutions such as the PAM 2018 under Pertubuhan Arkitek Malaysia, IEM 2011 under Institute of Engineers of Malaysia and CIDB 2000 under Construction Industry Development Board. For public sector contracts, Jabatan Kerja Raya (JKR) or Public Works Department drafted and published PWD 203A/203, an employer's specific 'standard' set of forms of contract. However, where employer or contractor contracts on his own amendments of standard form (Chester Grosvenor Hotel Ltd v Alfred McAlpine Management Ltd (1991)) such as JKR or PWD 203A, such modification can and properly will have most unwanted and unexpected result which may involve liability for consultant who advised it.

Other than the standard forms which published by the Malaysian local authority and institution, there are some international forms that are also available in the Malaysian construction industry which include standard forms of contract issued by the Federation Internationale des Ingenieurs-Conseils, Federation of Civil Engineering Contractors, Joint Contracts Tribunal and etc.

The aim of this paper is to review the effect of the general ambiguity extension of time claim provisions in PAM 2018 form of contract in terms of their liabilities, duties, risks allocations, conditions and procedures that affect extension of time claim in Malaysian construction industry. This is to cater the construction industry a deeper knowledge and better understanding of the clauses related to extension of time claim.

AMBIGUITY EXTENSION OF TIME PROVISIONS IN CONSTRUCTION CONTRACTS

According to Hinze (2001), time requirement plays a key role to both employer and contractor in any construction contract. And time has always been said to be as important as cost. It is always in the best interest of the owner and contractor to have the work completed within the scheduled time and budget. Hence, the provision of time aspect in every construction contract has been of paramount significant and is to be treated with care by all contracting parties in order to avoid any ambiguous time related problems and/or disputes.

Definition of Ambiguity

A study by Borthick et al. (2001) defined ambiguity as information requests which adversely affects accuracy and efficiency. Ambiguity can be resolved by reframing a situation to something meaningful, by acquiring contextual knowledge through learning or by having an interpretation externally imposed by others. Ambiguity plays a role in any development process and a better understanding of its nature may improve the ability to manage the process.

To support the argument, a litany of definitions from different authors with different findings are listed as follow. Camerer and Weber (1992) defined ambiguity as uncertainty about probability, created by missing information that is relevant and could be known.

Schrader, Riggs and Smith (1993) mentioned that ambiguity refers to a lack of awareness of the project team about certain states of the project or causal relationships.

Weick (1995), term ambiguity viewed as a combination of equivocality and lack of clarity. Lack of clarity according to Weick (1995), stems from ignorance which will be reduced by the availability of more information. Equivocality, stems from confusion where two or more meanings can be assigned to the same cue. Resolving equivocality is possible, information but by providing different kinds of information, constructed by face-to-face interaction. Zhang and Doll (2001) defined ambiguity as a measure of the organization's ignorance of whether a variable exists as the primary source of fuzziness in planning.

Zack (2001) mentioned that ambiguity represents an inability to interpret or make sense of something. This inability may result either from not being able to recall or activate the necessary interpretive knowledge, or from activating an inappropriate interpretation. From the various definitions stated above, ambiguity can be redefined as clearly uncertain and incapable of being made certain stems from ignorance. Ambiguity needs to be analysed and dealt with in PAM 2018 standard form of contract. Table 1 creates distinctions that may be useful for the understanding in various definitions of ambiguity.

Table 1. Definitions of ambiguity

Author	Definition
Borthick et al., 2001	Information requests which adversely affects accuracy and efficiency.
Camerer and Weber, 1992	Uncertainty about probability, created by missing information that is relevant and could be known.
Schrader, Riggs and Smith, 1993	Lack of awareness of the project team about certain states of the project or casual relationships.
Weick, 1995	Lack of clarity stems from ignorance.
Zhang and Doll, 2001	As a measure of the organization's ignorance.
Zack, 2001	An inability to interpret or make sense of something.

(Source: Author derived)

Interpretation

One of the cardinal principles for the construction of contracts is that the entire contract must be taken as constituting an organic synthesis, embodying provisions which balance the sum of reciprocal rights and obligations. It is through the prism of that principle that the terms of the compromise decree must be analysed.

In order to give harmonious interpretation to an agreement, the instrument must be construed as a whole so as to ascertain true meaning of several clauses. A document should be read and interpreted as a whole. Construction of portions of a document treating them as separate entities is not the proper mode of construction.

Ambiguous Provisions

Where ambiguous terms or phrases are found in the contract, evidence usage is admissible to explain the meaning of the expression in the written document, and where a contract is silent in respect of some incidental term or condition in the contract will have the effect of introducing something repugnant to or inconsistent with the tenor of the written contract. The effect of these ambiguous terms and conditions of extension of time claim PAM 2006 and 2018 would alter fundamentally the nature and character of the contract, can neither determine

nor affect the rights and obligations of the parties engaged in the transaction (Markanda, 2009). The various ambiguity issues in relation to its effects are highlighted in Table 2 as below.

Table 2. List of cases related to ambiguity issues

Ambiguity Issues	PAM Clauses	Cases/Citations	Verdicts
Letter of Intent/Award	Article 7(q) (i)	RTS Flexible System v Milkerei Alois Muller (2010)	- Disputes arise as to the rights and applications of the parties.
		Cunningham v Collett and Farmer (2006)	- Architect acts amounting to an act of negligence.
Ambiguous legal words	Clause 23.0	U.P. v Babu Ram Upadhaya	- Dual interpretations and meanings cause confusion.
Work Programme	Clause 3.6	Yorkshire Water Authority v Sir Alfred McAlpine & Son (Northern) Ltd (1985)	- It ties the hands of both main contractor and consultant in carried out their duties.
		English Industrial Estates Corporation v Kier Construction Ltd and Others (1992)	- Difficult for contractor on prove of entitlement of extension of time.
Specified extension of time application	Clause 23.1	Pilley and Combes, 2001	- Breach of contract.
Date of Commencement	Clause 21.0	Glenlion Construction Ltd vThe Guiness Trust (1987)	- Cause disputes between architect and contractor when matters of extension of time arises.

(Source: Author derived)

Letter of Intent

The ambiguity Article 7(q) (i) letter of intent/award is one of the clauses that has negative effects on the extension of time claim of PAM 2006 and 2018 in construction industry. The main difficulty with letters of intent is that there is no standard format and no universal agreement as to their purposes, other than to provide a mechanism to allow work to commence. Each letter of intent is drafted on an ad hoc basis, leaving a great deal of uncertainty as to its meaning. All too often, where work is commenced on the basis of a letter of intent, in the absence of proper agreement, the likelihood of disputes arising is high. The main difficulty is that letters of intent come in all shapes and sizes and can be very uncertain in the wording as to the rights and obligations of the parties. This led Lord Clarke in the case of RTS Flexible Systems v Milkerei Alois Muller (2010) stated:

> "This case is another example of the perils of proceeding with work under a letter of intent".

The problem lies not so much with the letter of intent, with its objectives of getting work started, but in doing so when crucial contractual matters are still to be agreed and a failure to quickly follow up with a formal contract. When the formal contract fails to materialize and the parties get into dispute, there is often extreme difficulty in sorting out the respective parties' rights and obligations. Disputes, as a result, are a common feature and negative effect of letters of intent ambiguity.

There is further confusion and negative effect engender by Article 7(q) (i). Judge Coulson in Cunningham v Collett and Farmer (2006) opined that architect acts as recommending the use of a letter of intent, in the absence of agreement on these matters was inappropriate.

Therefore, this matter amount to an act of negligence. This legal case creates awareness to construction practitioners the shortcomings in the use of a letter of intent and also leaving the final decision to the employer as to whether or not to use a letter of intent.

"Shall" and "May"

Generally, the provisions of PAM 2006 and 2018 have complicated and ambiguous legal words which need to be redefined as it has dual interpretations and meanings which cause confusions in contractual provisions. The use of the word 'shall' raises a presumption that the particular provision is imperative51 but this prima facie inference may be rebutted by other considerations such as object and scope of the enactment and the consequences flowing from such construction. There are numerous cases where the word 'shall' have, therefore been construed as merely directory (Markanda, 2009). The word 'shall' "is ordinarily mandatory but sometimes it is not so interpreted if the context or the intention otherwise demands".

In State of U.P. v Babu Ram Upadhaya, the Supreme Court held:

> "When a statute uses the work 'shall', prima facie it is mandatory, but the court may ascertain the real intention of the legislature by carefully attending to the whole scope of the statute."

If different provisions are connected with the same word 'shall', and if with respect to some of them the intention of the legislature is clear that the word 'shall' in relation to them must be given an obligatory or directory meaning, it may indicate that with respect to other provisions also, the same construction should be placed (Markanda, 2009). If the word 'shall' has been substituted for the word 'may', by an amendment, it will be a very strong indication that use of the word 'shall' makes the provision imperative (Markanda, 2009). The use of the word 'may' at one place and 'shall' at another place in the same section may strengthen the inference that these words have been used in their primary sense and that 'shall' should be construed as mandatory (Markanda, 2009).

The words 'shall and may' are construed imperatively (Markanda, 2009). As pointed out by Lord Brougham:

> "If the words are it 'shall and may' be so and so done, by such and such officer and body then the word 'may' is held in all soundness of construction to confer, a power but the world 'shall' is held to make that power, or the exercise of that power compulsory (Markanda, 2009).

The use of the word 'must' in place of 'shall' will itself be sufficient to hold the provision to be mandatory and it will not be necessary to pursue the enquiry any further (Markanda, 2009).

In the quest of developing the better forms and conditions of contract, there is an urgent need to incorporate the views of the construction practitioners, stakeholders, employers, designers and contractors within the construction industry. Thus, comparison of time related ambiguous clauses and provisions of different standard forms of contract PAM 2006 and 2018 are reviewed according to the effects they have when used by our construction industry (Hinze, 2001).

According to Ashley and Workman (1986), a literature search unearthed that there is a lack of extensively study on the standard form of contract time related clauses. Nevertheless, much has been written on the subject of contract types, scheduling methods and techniques, and cost and risk management. In fact, very few researches have conducted studies on how contract clauses affecting time can impact contract administration.

Work Programme

Among Malaysian standard form of contracts, only PAM 2006 and 2018 form under clause 3.6 had stated the requirement of preparing work programme. Problems related to work programme being given the status of contract document's role arose in the cases of Yorkshire Water Authority v Sir Alfred McAlpine & Son (Northern) Ltd (1985) and English Industrial Estates Corporation v Kier Construction Ltd and Others (1992). However, the work programme requirements are debarred by clause 3.4 of the PAM 2006 form from having any formal significance over contractual obligations. The contractor who fails to produce an effective and realistic programme puts himself at a disadvantage on proof of entitlement to extension of time.

Specified Extension of Time

According to Pilley and Combes (2001), important improvements have been made in relation to the extension of time clause, making it clear that the contractor must continually apply for specified extensions of time, overcoming a deficiency which currently exists in local standard form of contract, where the contractor is not obliged to apply for a specific extension of time until such time as the period of extension required has become known. It also overcomes problems of the principal being in breach of the contract if the superintendent fails within 28 days to assess an extension of time application made by the contractor.

Date of Commencement

Rajoo (1999) opined that clause 21.0 deals with dates of commencement, dates of commencement given for sections, postponement and date for completion. Under this clause of the PAM 2018 form, the new sub-clauses clause 21.2 and 21.3 go on to improve the inadequacy of the PAM 2006 form in dealing with commencement and completion in phases or sections. This is due to the employer's failure to give possession of the site is not covered by the provision of clause 21.2 of the PAM 2006 form, which merely entitles the architect/superintendent of the job to postpone 'any work to be executed under the provisions of the contract'. This ambiguity is highlighted in the case of Glenlion Construction Ltd v The Guiness Trust (1987) which implies that late possession is not likely to cause delay to completion.

From this overview on the comparison different construction standard forms PAM 2006 and 2018, it is found that time related clauses and provisions differ from one standard form of construction contract to another. By reviewing on the existing comments on various time clauses in standard forms of construction contracts by some researchers, it was divulged that there are ambiguities that are caused by ineffective time related clauses and provisions. The following includes some examples on less than adequate provision that makes less than effective time related clauses.

Firstly, time provision in standard form of contract may or may not state that the requirements for submission of work program. In Malaysian standard form of contract, only PAM 2006 and 2018 Form stated the requirement of preparing work programme in document contracts. Idris (2006) stated that the contractor's failure to submit the work programme may reduce the number of expressed provisions operating in favour of him when delays occur.

Notification of Compensation

Besides, notification of compensation event is an important clause under time provision to recover additional payment or modification to time for completion. Under PAM 2006 and 2018 clause 23.1 provides that the contractor was to notify the contract administrator of the occurrence of a compensation event after two weeks. Notification of a compensation event by the contractor after two weeks is considered as ineffective. The contractor failure to notify the compensation events procedure will subsequently resulted in no entitlement to any additional extension of time claim and payment.

Contractor Not Obliged to Apply Extension of Time

Other than that, extension of time is also one of the important time provisions, which extends the time of completion. Looking into extension of time PAM 2006 and 2018 Clause 23.1, it is stated that the contractor is not obliged to apply for a specific extension of time until such time as the period of extension required has become known. Problems arise when the contractor is found not applying and hence, not fulfilling his obligations because the superintendent fails within 28 days to assess a previous extension of time application made by the contractor. This may result in the contractor unable to complete the project within a reasonable time frame.

To sum up the certain ambiguous time clauses and provisions in standard form of construction contract may have affected the entitlement of extension of time and the performance of the contractor contractual obligation. The contractor may encounter difficulties in materializing project time target especially when their contractual obligations are ambiguous which often make it extreme difficulty in sorting out respectively parties' rights and obligations. Therefore, it is apt to study in depths certain time related clauses and provisions in different of standard forms of construction contracts that hinder the effectiveness of extension of time claims.

RESEARCH METHODOLOGY

For the purpose of this study, the methodology adopted is qualitative as standard forms with traditional general contracting will be discussed. Standard form of contract PAM 2018 will be used where bills of quantities form part of the contract and conditions of contract for construction. Nevertheless, this paper includes the latest PAM 2018 edition although it is still at its nebulous stage or transitional period with many consultants having not aware of this latest development with many projects still using the old edition.

Fundamentally, the methodology document analysis has been adopted in conducting in depth review of PAM 2006 and 2018. The purpose of having proper document analysis is to identify significant ambiguous provisions and to determine the guideline and scope of the

paper in the form of contract. Besides, through the review of PAM form of contract, an assessment of ambiguous extension of time provisions will be made in term liabilities, duties, risks allocation, conditions, procedures and method of dispute settlement. This helps to identify the relationship between the effect of time related ambiguity provision on extension of time claim and the moderating effect of contractual complexity under PAM contract 2018 in Malaysian construction industry.

Based on the extension of time clauses in PAM 2018 can be tabulated in these eleven (11) major sections which are notice of delay procedure, relevant events of extension of time, possession of site, act of prevention, variations, any special circumstances of any kind whatsoever, construction plant or labour, delay by architect, delay cause by trades employ by employer, dispute resolution, force majeure, exceptionally inclement weather. The eleven (11) sections would be compared with respect to the completeness. Completeness is defined as whether time clauses and provisions cover all the basic and necessary contractual aspects of extension of time.

Another parameter of comparison is with respect to clarity. The lack of clarity in the contract would give rise to misinterpretation difficulty in understanding the terms used for the standard form of construction contract. This is because the interpretations of contract clauses are usually not attached within contract. From the result obtained from the analysis and comparison, it is hopeful that a better understanding on adequate of time related clauses and provisions can be achieved and what is offer in various local and international standard forms of construction contracts can be better known. Any recommendations made will be in view of helping the contractor's performance in carrying out their contractual obligations and better and more effective administration of the contract.

RESEARCH ANALYSIS

Results from Forms Analysis

Key Issues	PAM 2006	PAM 2018	Finding and Recommendation
Written notice as condition precedent to an entitlement of extension of time to architect or engineer.	a. Within 28 days from the date of AI, CAI or the commencement of the Relevant Events stipulated under Clause 23.8, whichever is earlier. b. Within 28 days of the end of the cause of delay	a. Within 28 days from the date of AI, CAI or the commencement of the Relevant Events stipulated under Clause 23.8, whichever is earlier. b. Within 28 days of the end of the cause of delay	**Findings** a. All to comply with the contract's procedural to submit timely notification of delay b. Definition given is vague and the term "is or will be" is very subjective. **Recommendations** a. Required systematic extension of time mechanism/framework.
Events causing extension of time	Clause 23.8 - incomplete, unclear and ineffective	Clause 23.9 - incomplete, unclear and ineffective	**Findings** a. Ambiguity and dearth of proper record and documentation b. Contractor's claim inflated albeit differently to proper justification c. Contract administrator inclines to have a negative and defensive attitude **Recommendations** a. Required systematic extension of time mechanism.
The effect of requiring contractor to submit detailed particulars of extension of time claimed	Clause 23.1 "... notify the architect in writing identifying the relevant events causing the delay, giving particulars of the expected effect and an estimate of the extension of time required. The notice shall contain sufficient information and reason why delay to completion will result..."	Clause 23.1 "... notify the architect in writing identifying the relevant events causing the delay, giving particulars of the expected effect and an estimate of the extension of time required. The notice shall contain sufficient information and reason why delay to completion will result..."	**Findings** a. Tasks of managing projects and handling contractual claims to be delegated to different people b. Lack of clear and precise responsibility and at various level of management to perform his/her task unambiguously. **Recommendations** a. Need to have a well-trained and knowledgeable professional in this field. b. Need to start collecting data when the sign of delay first occurred and not wait till the last minutes.
Does minutes of site meeting served as adequate notice of delay?	No	No	**Findings** a. Depend upon the precise wording of the contract **Recommendations** a. Must emanate from claimant/contractor b. Constitute a good delay unless the parties specifically amend the contract in this respect.
Possession of site	Clause 23.8(f) - incomplete, unclear and ineffective	Clause 23.8(f) - incomplete, unclear and ineffective	**Findings** a. Delay of possession of site by contractor frequently resulted from project that have not been obtained authority approval.

Key Issues	PAM 2006	PAM 2018	Finding and Recommendation
			Recommendations a. Specified date of "Date of Possession of Site" b. Clearly state the definition of the partial site to avoid any arising problem. c. Date stated for possession of site could be earlier than the date of commencement of work.
Act of prevention	Clause 23.8(m) - incomplete, unclear and ineffective	Clause 23.8(k) - incomplete, unclear and ineffective	**Findings** a. Party to a contract cannot insist on compliance with its provision if the reason for non-compliance is some action or omission of the party insisting on compliance. b. Where a contract requires the contractor as the condition precedent to the right to an extension of time to serve delay notice and he fails to do so. c. No firm decision has been achieved as to its application in respect of delay notices. **Recommendations** a. Employer need to have a well-planned all-round project management team to reveal all drawings and detail drawings before inviting any tenders.
Variation works	Clause 11.0 - incomplete, unclear and ineffective	Clause 11.0 - include temporary works within 28 days and can be extended through consent - incomplete, unclear and ineffective	**Findings** a. Not always precise as to how variation is to be fairly valued. b. The quantum of variation or approved by contract administrator has a limit. **Recommendations** a. The constituent item which make up the fair rate should be provided.
Any special circumstances of any kind whatsoever,	No provision	No provision	**Findings** a. The phrase too subjective in nature with an uncertain not well-defined and difficult to enforce. **Recommendations** a. Revisitation of such ambiguous terms as to what it might mean. b. Invite more problems and disputes rather than making the contract more useful should be omitted totally as the provision of the contract.
Construction plant or labour	Clause 6.0	Clause 6.0	**Findings** a. Difficult for entitlement of extension of time as the nature of causes is highly disputable and debatable.

Key Issues	PAM 2006	PAM 2018	Finding and Recommendation
			Recommendations a. To have a proper, effective and efficient documentation and management record system to enhance and facilitate extension of time claim.
Delay caused by architect	Clause 23.8(e)	Clause 23.8(e) and 24.3(a) - new relevant events - incomplete, unclear and ineffective	**Findings** a. Entitled to extension of time but not necessarily additional cost. **Recommendations** a. Apportionment of risks between architect and contractor. b. Each extension of time claim has to be judged on its merits. c. Decisions must be act in a fair and reasonable manner.
Delay by tradesmen employed by employer	Clause 23.8(j)	Clause 23.8(k)	**Findings** a. Entitled to extension of time but not necessarily additional cost. **Recommendations** a. Apportionment of risks between architect and contractor. b. Each extension of time claim has to be judged on its merits. c. Decisions must be act in a fair and reasonable manner.
Force majeure	Clause 23.8(a) - incomplete, unclear and ineffective	Clause 23.8(a) - incomplete, unclear and ineffective	**Findings** a. Force majeure should ideally be defined to avoid dispute. b. No legal doctrine on this particular issue c. Left to their own devices to decide whether an event constitute a force majeure d. Based on self-judgement, discretion and interpretation of the term. **Recommendations** a. Should have an ideally well-defined definition of what constitute force majeure b. More research on the terminology is needed.
Exceptionally inclement weather	Clause 23.8(b) - incomplete, unclear and ineffective	Clause 23.8(b) - incomplete, unclear and ineffective	**Findings** a. No detail definition of the term. **Recommendations** a. Must develop a proper measurable definition.

(Source: Author Derived)

DISCUSSION

The study set out the extension of time clauses in full and will not go through each ground for an extension of time individually. However, this paper will refer to the main provisions and raise issues for analysis.

The most fundamental difference between the forms of contract is that PAM 2018, PWD 203A, IEM 2011 and CIDB 2000 form of contract are based on common law. In common law, the agreement must be in written form and a fixed period must be stipulated. Civil law on the other hand limits the practitioners by statutes and codes, the idea of "good-will" is practiced in civil law (Zakaria, Ismail & MdYusof, 2013). In the PAM 2006 and 2018 forms of contract, the procedure essentially begins with the notification of the architect pertaining the delay in the project. In the case of PAM 2006 and 2018, there is lack of a specific timeline for which the notification procedure should take place.

To start with the local standard form of contract, Clause 23.8 PAM 2006 and 2018, set out the grounds for an extension of time claim. This paper only analyses seven (7) ambiguous extension of time provisions, which are:

i. Notice of delay procedure
ii. Relevant events
iii. Possession of site
iv. Act of prevention
v. Variations
vi. "Any special circumstance of any kind whatsoever"
vii. Plant or labour

Extension of Time Procedure

Under sub-clause of the PAM 2006 and 2018 forms of contract, a contractor must give notice of a claim for an extension of time or additional payment "as soon as practicable, and not later than 28 days after the contractor became aware, or should have become aware, of the event or circumstances". If the contractor fails to give such notice within 28 days then time shall not be extended and the contractor loses the right to payment (Bunni, 2005).

The argument arises as the definition given is vague and the term "aware" is very subjective. So when actually does the 28 days period as referred in the sub-clause 20.1 start? It runs from when the contractor "became aware" of the situation instead of actual occurrence of the event or circumstances giving rise to the claim. The current system requires for a systematic extension of time assessment and application mechanism in order to assist the contactors to become "aware" of the delay in the overall progress of construction project being handled. The extension of time assessment and application mechanism aims to create a harmony and cooperative atmosphere between the contractor and the client or owner, aiming to resolve disputes over the delay of project and the ripples that follows.

Notification Clause Not as Condition Precedent

However, even if the notification clause is not written as a condition precedent, contractors must claim within the times specified in the contract. The failure to do so is a

breach of contract. Cases related to this ambiguous provision of extension of time are Education 4 Ayrshire Ltd v South Ayrshire Council (2009), Steria Ltd v Sigma Wireless Communications Ltd (2007) and City Inn v Shepherd Construction (2003) whereby important practical points were disclosed.

In sub-clause 23.1 of PAM 2006 and 2018 form of contract, it is dictated that if the contractor is of the opinion that the completion of the works 'is or will be delayed' beyond the completion date, he may apply for extension of time provided that the claim is duly supported with all particulars to enable the architect to assess any extension of time to be granted (Agreement and Conditions of PAM Contract 2018). In order for the extension of time claim to be granted, it is necessary for the contractor to back his claim up with proper records showing that the delay is not caused by the contractor. Again, it is greatly questionable as what forms the basis of the opinion of the contractor that the work will be delayed and what will be the mechanism to determine the validity of the basis of the opinion? These issues ought to be overcome by the development of an effective extension of time application and assessment mechanism.

Site Meetings' Minutes

Whether site meetings' minutes constitute a good delay notice will depend upon the precise wording of the contract. It would seem, however, following the Scottish decision of John L. Haley Ltd v Dumfries & Galloway Regional Council (1988) that in the case of the majority of the standard forms of contract, the site meeting minutes will not constitute good notice, unless the partied specifically amend the contract in this respect. The decision in the case of Steria Ltd v Sigma Wireless Communications Ltd (2007) held that the notice must emanate from the claimant, and therefore minutes of a meeting which were not written by Steria did not constitute good notice. It left unanswered whether minutes written by the claimant would qualify.

Possession of Site

Besides, delay in giving possession of the site or any part of the site to the contractor for the execution of works constitutes a ground for extension of time claim in all of the form of contract mentioned above (Bunni, 2005). This is fundamental and curtail because only with giving the contractor right of access to, and possession of, all parts of the site, the works can be executed. Delay in such procedure is employer caused, preventing the normal execution of works leading to timely completion of the works as stated in the contract. The contractor shall not suffer loss from the delay in such ground and thus shall be compensated in the form of granting of extension of time accordingly.

Experienced Contractor

Under Clause 23.8 PAM 2006 and 2018 form of contract, the contractor is entitled to extension of time for completion if the contractor suffers delay and incurs cost from executing works which was necessitated by any errors in the specified and notified setting-out points, lines and levels, and an experienced contractor could not reasonably have discovered such error and avoided this delay. The content or any clause similar to this is not stated or dictated in other forms of contract discussed above. In fact, the lack of detailed definition of

'experienced contractor' will eventually become a source of dispute. For example, during the assessment of extension of time claim by the contract administrator, the said contract administrator may interpret that the delay caused may be avoided by the contractor that is reasonably experienced therefore not granting extension of time for the delay, but this is not the same in the perspective of the contractor who has submitted the extension of time claim. The contractor will perceive that not granting the extension of time due to such delay is partial and unfair as he regards himself as experienced and he has not yet been able to discover such error.

Nature of Document

The specification of the type and nature of the supporting documents backing up the extension of time claim in all the forms of contracts. This poses difficulties in the assessment of the validity of the extension of time claim by the architect or the superintending officer, thus causes disputes and arguments to arise. There is also lack of a consensus and systematic manner in recording and keeping track of the progress of work which may later be utilized for the process of extension of time claim submission and analysis. Therefore, there ought to be a consensus extension of time claim application and submission mechanism in order to maintain a cohesive atmosphere in the construction industry.

Breach of Natural Justice

Disputes arising out of construction contracts often involve extensive detail, because of ambiguous extension of time provisions and the complexity of the matters in dispute. Delays to progress and completion, involving claims for extensions of time and liquidated damages, where many delaying factors have to be considered, employing a very detailed delay analysis, are commonplace. Argument concerning a contractor's entitlement to payment can involve enquiry into hundreds and sometimes thousands of variations and changes. Is it possible for an adjudicator to consider all these matters and arrive at a decision within 28 days? Will the responding party have the adequate time to reply to the great amount of detail provided in the referral? It has been argued in a few cases that, because of the complexity of some disputes, there is a danger of a breach of natural justice. Due to the short timescales involved in the adjudication process, the complexity of the cases and the amount of the detail to be considered, it has been suggested that the adjudicator may not have fully comprehended the case or had time to read all the documentation submitted to him.

Variations

The grounds upon which contractors can claim extensions of time under PAM 2006 and 2018 form are fairly extensive. However, the wording is not without problems. For instance, the ground for an extension of time for variations, only applies to variations under clause 11 PAM 2006 and 2018, the right to issue variations is not without limit. If it can be proven that the superintending officer has exceeded his empowered power and as a result clause 24 does not apply, then there is a strong argument that the extension of time clause also does not apply and the employer cannot claim liquidated damages.

Even the ordering of a variation which prevented the contractor from completing on time has been held to be an act of prevention, leading to the result that the employer could not

claim liquidated damages. That is the Australian case SMK Cabinets v Hili Modern Electronics Pty Ltd. If the prevention principle applies, the date for completion will be set aside and time is said to be at large. This implied that the contractor has a reasonable time to complete and that the liquidated damages provision will not apply. If the extension of time clause negates the contractor the right to claim an extension of time for all possible relevant causes of delays by the employer, then there is a risk that the right to claim liquidated damages will be set aside. Again – note that only variations under the contract allow an extension of time. Any additional work claims which are properly quantum merit or outside the contract would set time at large.

"Any Special Circumstances of Any Kind Whatsoever"

Further, the last ground "any special circumstance of any kind whatsoever" seems very unclear. This wording reflects similar wording in the FIDIC and ICE contracts and surprisingly, there is very little legal authority as to what it might mean. The word "special" implies "of a particular kind, not general or exceptional in amount degree or intensity". Therefore, any delay which is caused by something common will not be covered by this clause. Presumably the clause covers any special risks, which are accepted by the government, but given that the terms 'special circumstance' is a different term than special risks, then it is likely to have a different perhaps wider meaning.

Best Endeavour

Many contracts require a contractor or subcontractor to use constantly his best endeavours to prevent delay. For examples, PAM 2018, clause 23.6, states: "the contractor shall use constantly his best endeavours to prevent delay in the progress of the works".

'Best endeavours' means that all steps to achieve the objective must be taken. Keating on Building Contracts, 5th edition, at page 575, has this to say with regard to the wording as it appears in the JCT forms of contracts:

> "This proviso is an important qualification of the right to an extension of time. Thus, for example, in some cases it might be the contractor's duty to reprogramme the works either to prevent or to reduce delays. How far the contractor must take the other steps depends upon the circumstances of each case, but it is thought that the proviso does not contemplate the expenditure of substantial sums of money".

In Victor Stanley Hawkins v Pender Bros Pty Queensland (1994), it was held that the term 'best endeavours' should be construed objectively. The test as to whether it had been fulfilled would be that of prudence and reasonableness. Two cases have involved the court in having to decide the meaning of best endeavours. In Midland Land Reclamation Ltd v Warren Energy Ltd (1997), the judge in deciding the case said:

> "I reject the submission made on behalf of the defendant that a best endeavours obligation is the next best thing to an absolute obligation or guarantee".

Work Suspension

There is further confusion caused by clause 30.7 PAM 2018. This seeks to confirm what the contractor cannot claim an extension of time for. Specifically, it states that the contractor cannot claim for a suspension to the works described in clause 30.7 PAM 2018 – the most important of which is suspension caused by the default of the contractor or a shortage of constructional plant or labour.

The ambiguity with clause which confirm what the contractor cannot claim for is not what they say, but which they leave out. For instance, this clause confirms that the contractor cannot claim an extension of time for shortage of constructional plant or labour, but there is no mention of whether or not the contractor can claim an extension of time for a shortage of materials. Can a contractor argue therefore that a shortage of materials was caused by a "special circumstance", then he can claim an extension of time? Further if the materials are being imported and if as a consequence of inclement weather either in the country of origin or during transit, resulted in a delay to the progress of the works, can the contractor claim an extension of time?

Force Majeure

The clause 23.8 PAM 2006 and 2018 has very different wording for extension of time clause. It also sets out twenty-five (25) grounds to claim an extension of time. Again four (4) ambiguity provisions will be analysed for this study due to time constraint.

i. force majeure
   This term is unclear and not at all well-defined in the contract and would encourage anyone using this form of contract to include a good definition of force majeure.
ii. inclement weather or the subsequent effects of such inclement weather - which is expressly defined
iii. delays by the architect in providing instructions, drawings, details or levels
iv. by artists, tradesmen or others engaged by the employer.

Some contracts provide a definition as to the meaning of force majeure. The standard forms of contract produced by the PAM use the term force majeure, but include no such definition. The presence in PAM contracts of force majeure is important, as it is one of the relevant events which provides contractors and subcontractors with an entitlement to extension of time for completion. By the way of contrast, the ICE conditions make no reference to force majeure.

The FIDIC conditions of contract are one of the few standard conditions which include a definition of force majeure. It is defined as an exceptional event or circumstance:

- Which is beyond a party's control;
- Which such party could not reasonably have provided against before entering into the contract;
- Which having arisen, such party could not reasonably have avoided or overcome;
- Which was not substantially attributable to the other party.

Force majeure does not have a precise meaning, nor does it give rise to any legal doctrine under the laws which apply in the UK; it is a legal concept developed under French law. Under the French Civil Code, force majeure is a good defence to a claim for breach of contract; however, to succeed, convincing evidence must be produced to demonstrate that:

- Performance was impossible;
- The event was unforeseen and unavoidable.

In the absence of a definition in this ambiguous provision and the lack of a legal doctrine under English law, the parties to a contract which included a force majeure clause are left to search through case law for assistance. From the few cases where force majeure has been interpreted in the English courts, it is considered that force majeure involves matters which are outside the control of the parties. It includes Act of God and also events such as strikes and breakdown of machinery. Cases related to this ambiguous provision are Trandin Aviation Holdings Ltd v Aero Toy Store LLC (2010) and Thames Valley Power Ltd v Total Gas and Power Ltd (2006) which provide the explanation for force majeure.

Inclement Weather

"Exceptionally inclement weather" is stipulated as one of the reasons or events that may account for extension of time by the contractor. In PAM 2018 form of contract which is commonly adopted in Malaysian construction industry, there is no further detailed definition of the term which allows for dispute to arise during the extension of time assessment. This is because the lack of a measurable definition of the term may cause the contractor to submit inflated claims of extension of time or in the case of contract administrator, partial extension of time lesser than the actual may be granted to the contractor. This is due to the ambiguity of the term which there is no further detailed definition commonly agreed upon. In the case of FIDIC form of contract, some of the countries adopting the form of contract have detailed definition of the term "exceptionally inclement weather" which prevents arguments and dispute to arise. For example, the weather in Hong Kong is deemed to be inclement only when:

- Rainfall in excess of 20mm in a 24-hour period as recorded by the HK Observatory station nearest to the site, and/or his consequences adversely affecting the progress of the works
- The hoisting of tropical cyclone warning signal No.8 or above or the announcement of a Black Storm Warning (Lo, Fung & Tung, 2006).

Architect's Caused Delay

Unlike the government form contract, there is no general provision which states that a default by the employer will allow the contractor to claim an extension of time. This is a mistake. Similarly, the clause allowing a contractor to claim an extension of time as a result of delays by the architect is very ambiguous and narrowly worded. This permits the contractor to claim an extension of time only if it is not received in due time.

When reviewing this clause, it should take into consideration that the extension of time provisions should be strictly interpreted. Presumably, that this clause was written in such a

manner due to the assumption that that when the contract was signed, the contractor would have a full design and that the only elements of the design that he would still need would be details. However, this clause is usually applied in a fast track design and build project, whereby the contractor had extremely limited design details at the outset. It is clearly inapplicable in those circumstances. It is not difficult to think of other things which the architect has to provide which could be a cause of delay. For instance, would approvals be included? Possibly. How about an entire sub-contract specification? Bear in mind that the extension of time clause must be interpreted strictly. Unfortunately, case law does not provide answers to these questions. However, the lesson to be learnt is that the clause should not be ambiguous.

Amendment to Standard Form of Clauses

Invariably, majority of the local standard form of contract clauses are amended by consultants acting for the employer. Normally, the amendments restrict the grounds upon which a contractor can claim an extension of time. Nevertheless, employers and their consultants see a benefit in restricting these grounds, it is important to take great care. However, if the extension of time clause is not properly drafted and an act of prevention occurs, then the employer will be deprived to claim liquidated damages and the whole purpose of the extension of time clause will be lost.

CONCLUSION

It is suggested to allocate these problems encountered in the application and submission of time claim by contractor and justify certain of claims entitlement by contract administrator in.

Adherence to agreed procedure for preparation and assessment of delay claims, implementation of a set of agreed uniform delay analysis methodology, proper documentation of and management of project records for purpose of claims and overcoming disputes by both parties mitigating. Also recommended that other research methodologies such as questionnaires, surveys and triangulation methods be used in future research to provide more insights and possible remedies into the problems encountered in the application of and assessments of time claims.

Clauses need to be drafted again and redefined to alleviate or mitigate the issues of dual meanings. Promptness of processing and finalising and documentations of project records claims purposes for claims purpose are of utmost important issues in relation to claims. Perhaps, most increased sense of professionalism in construction could overcome some of these problems related to claims and extension of time.

Construction practitioners and stakeholders need to focus or breakthrough innovation. Breakthrough comes from jettisoning old ideas and habits, practicing and evolving and adapting as circumstances change. It also requires a culture that nurtures innovation. A company's culture alters only when the people who work in it alter how they think, talk, decide and act - and that happens only when top management shows the way. This suggests that uncertainty and stakeholders correlations also depending on discarding old ideas and breakthrough innovation.

It is expected that findings from this research will offer a significant contribution to the industry players, construction organisations, researchers and also academicians the helping to identify assess for further improvements. "Lessons learned'' associated with post project reviews where learning has significant potential to reduce uncertainty. However, these reviews have been undermined due to cultural issues. On this issue, Senge (1992) opined that there is a need for reflection and reviews, unless those lessons change working practices, no organizational learning has taken place.

Standard forms contravene the very cornerstone of the law of contract, i.e. the doctrine of freedom to contract. By imposing standard forms on the parties, these parties are prevented from freely deciding on whatever terms and conditions that they deem fit to govern their legal and commercial leadership. Owing to the multitude and the varied nature of the contracts encounters in the engineering construction industry, it is a fallacy to have a standard form covering all eventualities. There is no way in which such a contract is able to cover all the various situations envisaged in the industry. Moreover, such forms rarely record the terms of the agreement between the parties accurately.

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EXPLORING THE POTENTIAL APPLICATION OF BIG DATA IN THE CONSTRUCTION INDUSTRY

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Abstract
Big Data is often described with five Vs characteristics: velocity, volume, variety, veracity, and value. Big Data analytics tools and techniques are arising in demand. The interest through Big Data increases day by day due to its opportunities in transforming most of the industries and business into an intelligent way of operating. Construction projects involve high volume of data exchange between different stakeholders, which are generated throughout the project's life cycle. Such a huge and complex data set can be collected by smartphone, jobsite sensors and other mobile solutions; however, text data, sound data, image data, video data and sensor data captured are seldom being processed and analysed adequately. This paper reviews published literature on methods and techniques of big data analytics and its possible applications in cost estimating, cost management, procurement management, site operative management, cost information etc. in the construction industry.

Keywords: *Big data; big data analytics; application; cost; construction industry.*

INTRODUCTION

Big Data is high volume of data, high velocity in terms of speed of processing data, and high variety information assets that required new forms and different forms of processing to enable to enhanced decision making, insight discovery and process optimisation in analysis (Gartner, 2014).

In construction, Big Data has not gains its popularity as it has in other industries. However, it is a sector that has potential to innovate and to unleash productivity. Typically, traditional data processing applications are inadequate to handle large and complex amounts of information.

While some data-driven solutions have been proposed for the fields of the construction industry, there are limited studies targeting the application of Big Data in the context of the construction industry. This study addresses the approaches and techniques of big data analytics and its possible applications in construction industry such as cost estimating, cost management, procurement management, site operative management, cost information etc.

LITERATURE REVIEW

What is Big Data?

According to some authors, the definition of 3Vs is more representative that considering big data should meet three characteristics: volume, variety and velocity. People tend to accept the definition that was asserted by IBM that big data three main characteristics has included data volume, velocity and variety (three Vs) (Zikopoulos and Eaton, 2011). Volume is large amount of data, the quantities of terabytes, records, transactions, tables, or files; velocity finds expression in batch, near time, real time and streams; and variety is the different forms of data

produce, data can be structured, unstructured, semi-structured and a combination of them (Russom, 2011).

In addition, the definition of 4Vs and 5Vs is put forward by some other person to trying to add some new feature based on 3Vs (Zhang, 2015). Veracity is the accuracy of the massive amount of data. The data should be acquired from correct resources and its security should be provided in order to prevent misinterpretation of the collected information. Value reflects economic benefits from the data. Analytics provide the fifth and perhaps the most important V of Big Data-Value.

Big Data Analytics

To understand the subtleties of Big Data, users need to disambiguate between two of its complementary aspects: Big Data Engineering (BDE) and Big Data Analytics (BDA). The domain of BDE is primarily concerned with supporting the relevant data storage and processing activities, needed to analytics (Provost and Fawcett, 2013). BDE provide an infrastructure to support BDA. However, BDA is a broadening of the field of data analytics and incorporates many of the techniques that have already been performed. BDA has a rich intellectual tradition and borrows from a wide variety of fields. There have been traditionally many related disciplines that have essentially the same core focus: finding useful pattern in data (but with a different emphasis).

Statistics is the study of collecting, analysing, and drawing conclusions from the data, with the primary focus on selecting the right tools and techniques at every data analysis stage (Wasserman, 2013). Data Mining is concerned with the automatic or semi-automatic exploration and analysis of large volumes of data to discover meaningful patterns or rules. For patterns discovery and extraction, Data Mining is primarily based on the technique(s) from statistics, machine learning, and pattern recognition (Kantardzic, 2011; Berry M., 2004). Databases are crucial to empowering various aspects of data mining, in particular by taking care of the activities of efficient data access, group and ordering of operations and optimising the queries to scale up data mining algorithms.

Current Big Data Application in other Sector

Previous research has found that industrial organisations see a considerable upside in The Industrial Internet of Things (IIoT) as a complement to big data analytics. The more conservative forecasts in Shekhar's research estimate that this activity could be worth $500 billion by 2020. The research found that nearly three out of four (73%) companies are already investing more than 20% of their technology budgets in big data analytics and almost as many expect to increase spending in that area in the coming year. Exploiting the data from IIoT is a key part of those budgets (Shekhar, 2017).

In recent times, many organizations have taken steps to utilizing the big data value effectively. A survey made by Gartner in 2015 proved that companies have incrementally increased their investment in big data to 75% from 58% recorded by the same survey in 2012. The extensive scope of big data has provided a massive scale and potential of opportunity and value that can be generated across various industries such as retail sector, manufacturing as well as the upstream industry.

Retail sector is one of the leading sector to recognise the potential and opportunity of big data (Laney, 2001).The potential and usage was further extended in analysing the large amount of data to support decision in expanding businesses, cost efficiency improvement and revenue forecasting (Meneer, 2015).

Manufacturing is another leading sector that has moved towards big data exploration in product quality management and operational cost management. Big data analytics was applied to analyse varieties in enhancing the efficiency of manufacturing and the operational process by providing the bird's eye view of the processes which led to a better decision making and product quality improvement and machinery efficiency (Oracle, 2015).

The oil and gas industry has also benefited from big data application. Big data's advanced analytics assisted in the decision making where big data insights were used to plan for predictive maintenance and reduction in maintenance cost through digital monitoring and predictive maintenance extends towards detecting errors on equipment. Big data enhances production and addressed the financial impacts before it eventually occurs.

Big Data's value is less in its size and more in how it can help supply chain management in sufficient decision making and more accurate predictions for firms and firms' partners by making use of existing information and data.

RESEARCH METHODOLOGY

List of potential applications of big data is compiled through journal article, conference paper and website. After literature review, there are four (4) number of application in big data application in construction industry. These are: construction worker management, material management, procurement management and cost management. The details of each application are discussed comprehensively in the following sections.

The Application of Big Data Analytics in Construction Industry

The construction works to be carried out in a project is dynamic (Wood, 2016) and involve vast data exchange from various stakeholders (Shrestha, 2013). Data is generated throughout the various phases of construction projects from planning phase to completion stage. As shown in Table 1, the stream of data includes design and financial data, sensors and equipment data, photos and videos and others. This data is often large in volume, highly diverse in format and dynamic.

Various fields of analytics are applying techniques from statistics including construction industry. The industry is employing statistical methods in a variety of application areas, such as identifying causes of construction delays, learning from post-project reviews (PPRs), decision support for construction litigation, detecting structural damages of buildings, identifying actions of workers and heavy machinery (Muhammad Bilal et al., 2016).

Examples of construction research using Data Mining: Kim et al. (2008) employed data mining techniques to identify the key factors that cause delays in construction projects. Carrilli et al. (2011) used data mining to learn from past projects and improve future project delivery. Approaches such as text analysis, link analysis and dimensional matrix analysis are

performed on data from multiple projects. Liao et al. (2008) employed association rule mining to proactively prevent occupational injuries.

Muhammad Bilal et al., (2016) highlighted that although the construction industry generates massive amounts data throughout the life cycle of a building, the adoption of Big Data technology in this sector lags the progress made in other fields. With the commoditisation of the technology necessary for storing, computing, processing, analysing, and visualising Big Data, there is immense interest in leveraging such technologies for improving the efficiency of construction processes. Concepts of Big Data Engineering and Big Data Analytics are demarcated; the works utilising these technologies across various subdomains of the construction industry are deliberated. Muhammad Bilal et al., (2016) also concluded that while data-driven analytics have long been used in the construction industry due to the broad applicability of such techniques in many construction subdomains, the adoption of the recent, much agiler and powerful Big Data technology has been relatively slow.

Construction Worker Management

A large amount of construction site worker relevant data can be generated throughout the whole construction site operation and activities. For employee hiring and selective issue, big data analytics can be applied in capturing their past track record such as criminal records, past performance records, commitment levels, experiences, worker's backgrounds. Worker with unpleasant past track record can be eliminated to maintain project efficiency or avoid unnecessary loss to the employer (Mi et al., 2018).

By using big data analytics, worker personal information (gender, age, race, and background), attendance, safety awareness, quality of work, salary, skill, etc. can be captured and analysed. Resource allocation and task assignment can be distributed base on the outcome of data analytics. This can improve labour productivity, safety issue, avoiding dispute, quality of work and project efficiency can be improved.

Safety issue can be improved by big data analytics by conducting a test on worker's safety awareness and knowledge such as plant and machinery operation manual, rules and regulations, safety tools and equipment. Corrective action can be taken by analysing test results, such as provide training to enhance worker's safety knowledge and safety awareness to prevent site accident.

It is common practice in the Malaysian construction to have labour-only subcontract. Thus, various relevant data cannot be collected and unable to apply in strategy planning and decision making by using data analytics. Furthermore, on-site data collection manually is costly, low efficiency, low accuracy, low data reliability due to high turnover rate of site workers. This is the cause work study not properly carried out in the construction industry. Unlinked data also is one of the factors that cause the data value is low due to the difficulty in data analysis.

Material Management

The common problems of conventional material data management are unorganised and unsystematic record keeping. For instance, loss of invoice, unorganised handling of record and unorganised reporting system. Insufficient data handling method will lead to insufficient supply chain of material due to lost tracking in material acquisition in site activities. Currently, there is a lack of proper or systematic platform for the supplier and customer to capture and share the relevant data or information about the material management. Big data analytics can be applied in material analysis such as material cost and quality analysis, storage control, equipment spare part and accessories control and costing.

In material pricing control, data can be analysed through some bulk material price such as ready mix. Big data analytics can be applied in information sharing platform which can be accessed through cloud computing technique, website or mobile internet. By doing so, material price can be standardised and this will ease the process of material cost forecasting and procurement system can be customised. In quality aspect, raw material inspection system which combining with big data technique such as GPS and some other tracking system that allows the project team member to grasp the material quality condition and implementing the material control process speedily.

Big data analytics can be applied in storage control in the production process to reduce the material storage cost and eliminate the risk of project termination. Supplier input on the complex evaluation and assessment system by adopting flexible procurement model. "Zero storage" and "economical storage" concept can be achieved. Necessary arrangement can be made on procurement and delivery timing upon material requisition based on the ongoing site activities. This can prevent the material shortage and surplus problem which affecting construction cost and budgetary control.

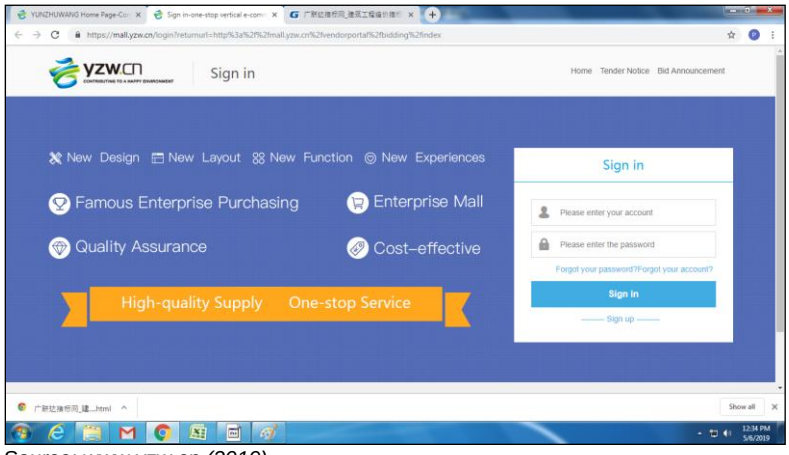
Plant and machinery are important assets in the construction development or organisation as it is one of the key element that affecting construction productivity. Data can be collected and analysed through procurement and usage, repair and maintenance frequency of those equipment accessories and spare parts. It helps to analyse and evaluate the demand of different equipment spare parts and accessories in different task operation to improve the equipment operation efficiency, prolong the life span of equipment, improve maintenance of equipment and cost saving (Mi et al., 2018).

Procurement Management

There is some common issue in construction project such as lack of transparency in procurement process, lack of cost indicator, lack of control of procurement operation, lack of appraisal approach for procurement performance. In recent year, construction industry has adopted procurement management systems by implementing better process tracking and data utilisation in order to improve efficiency of procurement process and cost control.

For example, yzw.cn s a comprehensive e-commerce platform that committed to create a new model for online trading in the construction industry in China (Figure 1). It relies on the stable procurement needs of China Construction and its strategic partners, reliable supplier resources and efficient and convenient financial support. Yunzhu has built five business

segments, namely cloud-built mining, cloud-built shopping mall, cloud-built labor service, cloud-built gold service and cloud-built Zhilian.



Source: www.yzw.cn (2019)

Figure 1. Yunzhu e-commerce platform

As a sporadic material procurement platform, Yunzhu Mall is built on the goal of reducing costs and increasing efficiency of central enterprises. Relying on personnel authority and organisation management system, the procurement and approval management process of each order of Yunzhu Mall can be traced back to the real thing, and the real procurement of sporadic materials is realised.

Yunzhu Zhilian is a smart building cloud platform that realises "vertical integration of digital intelligent services, application-to-user integration, data network connectivity and sharing". It works through the platform, Unicom applications and applications, devices and devices, devices and users, applications and applications. Users form an intelligent, ecologically-developed ecosystem that is open, shared, and ecologically integrated.

Yunzhu Zhilian has an on-site intelligent management system in the core application of independent research and development, and the cloud-built electronic acceptance inspection system and cloud-built labor service system cover the main scenes of project site management. The on-site intelligent management system comprehensively uses BIM, Internet of Things, artificial intelligence, mobile Internet, cloud computing and other information technologies to collect project site data in real time, and comprehensively monitor and transforming the project in a controlled, data-based and visual way. Respond to achieve multi-party collaborative work (Mi et al., 2018).

Cost Management

In traditional cost management, it is resources consuming for data collection yet those data sometimes lack of accuracy and efficiency. By applying big data analytics in cost management, organization is able to grip variety of cost indicator and its variation status which could provide the realistic and suitable scientific management basis for cost planning, cost control and performance appraisal. It is necessary to prepare the cost estimating before project commencement to ensure that construction site progress implementing successfully, maximizing profit and minimizing losses.

In cost estimating and cost planning stage, big data can provide sufficient data support for reference such as market economy trend can be captured accurately; historical cost data for similar project, key element for cost control, precedence case for cost management can be a reference to ensure the accuracy of cost estimating. Apart from that, big data analytics also able to estimate construction cost, management cost and uncertainty cost based on type of project, material build up rate, size of project and location of project. Big data analytics also can be applied in cost comparison for resource such as material, labour, plant and equipment based on the resources consumption for the specific project or some other factors. In cost control stage, big data analytics able to track market changes and condition accurately, different key elements for activities process control, provide dispute resolution regarding claiming issue. In performance appraisal stage, big data analytics able to trace variety key factors for cost control for current undergoing project, and provide the data support as reference for performance appraisal. Currently, big data application in cost management has obtained positive results in solving the organisation problem successfully such as construction operation cost control, material cost control, organisation ration database production analysis.

In data collection stage, cloud platform can be linked between trading and e-tendering system. Thus, material price can be capturing easily and speedily form the large amount of data.In data processing stage, machine learning and probability distribution increasing the efficient of massive data processing extensively. At the same time, it also able to discover the correlation feature like, utilise cost data on the market trend observation and improve decision making.

Cost information are supporting by cost data for build-up rate, labour, material and machinery cost information, cost index, cost indicator and industry trend element. For instance, a project cost indicative is based on project area, size, length to indicate labour, material and machinery consumption and costing. Cost indicator data can improve the project cost efficiency by assisting quantity surveyor or cost consultant by solving the issue in cost estimating and cost evaluation such as insufficient cost data, insufficient historical data and insufficient cost index.

Source: www.gldzb.com (2019)

Figure 2. Glodon Artifact

Glodon Index Artifact is an artefact that automatically performs index calculation and engineering review (Figure 2). It speedily analyses the civil construction calculation, steel reinforcement calculation and pricing project into unilateral content and unilateral cost. For the horizontal analysis of the projects that have been analysed, Glodon Cloud Index Library provides the vertical comparison of the project is clearly visible; fast and efficient indicator calculation and accurate audit can greatly improve work efficiency.

One of the important elements in construction industry is construction cost costing due to the large amount of costing involved in the construction project. Ye (2013) pointed that the factors in compiling tender's prices were complicated. From the perspective of big data, the concept of project cost data should be generalised, including engineering information data, construction cost data and technology scheme data, etc. Considering from the amount updates of data, project cost data has typical feature of big data: large, emerging quickly, multi-sourced and heterogeneous (Zhang, 2015).

CONCLUSION AND FUTURE DIRECTION OF RESEARCH

The methods and techniques of big data analytics and its possible application in construction industry were reviewed. Most possible big data application has been discussed.

The study has managed to draw the importance of big data application in construction industry. Further research recommendations are:

- The database creation of the information on the site operation in different stage of project life cycle.
- A mean to improve construction production process.
- Enhancement of time cost quality efficiency in the construction project.
- Improve the data management whereby the problem of information and time loss in locating the necessary supporting documents and information are avoided.

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A CONCEPTUAL FRAMEWORK FOR MANAGING HIGHER DIMENSION KNOWLEDGE IN BIM ENVIRONMENT

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Abstract
Sharing of information and knowledge effectively and timely among the team members in the construction industry is critical to improving the productivity of the industry. Following the proliferation of the Building Information Modelling (BIM) or n-D modelling technology, a new form of higher-dimension (i.e. 3D and higher) information and knowledge has been created. Compared to the lower dimension (i.e. 2D or lower) information and knowledge, such as 2D design drawings which can be printed on paper, the higher-dimension information and knowledge are deeply embedded in the n-D models created using the BIM systems. Such knowledge can be leveraged for the improvements of on-going projects, or adapted to resolve problems encountered. The prevailing methods, however, are unable to represent the rich information and context of knowledge that are associated with the 3D and higher dimension model. Hence, a new approach to address this problem is needed. This paper presents a conceptual framework for a Building Knowledge Information Modelling (BKIM) system, whereby the mechanisms for managing construction knowledge will be closely integrated with a Cloud-based BIM system to facilitate the management of higher dimension knowledge. The framework presented focuses only on the management of knowledge related to contractual claims at this stage. It is envisaged that this could improve the current practice with regard to the management of higher dimension knowledge, and help move "Level 1 Lonely BIM" to "Level 2 BIM" or even the higher maturity of BIM, namely "integrated BIM, iBIM".

Keywords: *Building Information Modelling; higher dimension knowledge; knowledge sharing; knowledge management; cloud-based.*

INTRODUCTION

The traditional method of design-bid-build causes the various stages of construction project disjointed and siloed. The heavy-reliance on skilled labour, underinvestment in technology, reluctance to integrate changing business models and flawed performance management has caused the construction productivity to be stagnant. Only recently the industry began to adopt digital technologies, gradually changing how infrastructure, real estate and other built assets are designed, constructed, operated and maintained (Buehler et al., 2018). The technologies adopted include Building Information Modelling (BIM), Blockchain, Artificial Intelligent (AI), Big Data, Cloud-computing, prefabrication, wireless sensors, 3D printing and automated and robotic equipment. These have helped satisfy the clients' increasingly higher demand for "value of money" project, and also improve productivity and sustainability of construction organisations. Consequently, these have also redefined the skills and competencies needed by the construction players to thrive in the competitive industry.

In a construction project, the sharing of information and knowledge in the networked environment among the team members is critical to the effective coordination and delivery. However, construction projects inherently involve different professions and geographically

dispersed team members. As such, the problem of fragmented design and construction processes has always been a challenge, causing the effective communication and efficient management of the information difficult. Furthermore, if the useful information and project knowledge are not captured on time, they will be lost when the staff possessing them has left the project team upon the completion of project (Tan et al., 2010). As a result, the team will miss the opportunity to apply the knowledge for improving other projects or to prevent the repetition of similar mistakes. Moreover, with the higher expectation by the clients, construction projects are getting more complex which entails the need for a systematic information and knowledge management. Without it, the number of claims and disputes are likely increase which might cause negative impact on the projects' cost, time and quality.

Related to this, there are attempts to incorporate knowledge management (KM) into Building Information Modelling (BIM) tool, thus creating a repository of project knowledge and shared digital building information models. Most of knowledge are currently represented in text-based 2-D formats, but it is envisaged that more knowledge will exist in the 3-D, or higher dimension format, and even embedded in the nD of the digital model itself. These new developments may pose new challenges to existing practice for managing project knowledge, which will require knowledge management systems to be redesigned to cater for the existence of higher dimension knowledge types.

This paper starts with a review of the types of knowledge, the challenges for managing higher dimension knowledge, the advantages of integrating KM within BIM framework and the current approaches of knowledge management within BIM framework. Subsequently, the findings from the interviews conducted on BIM practice by the companies are reported. Lastly, a conceptual framework of a Building Knowledge Information Modelling (BKIM) system is introduced for the better management of construction knowledge about claims in the projects adopting BIM.

TYPES OF KNOWLEDGE

In the context of knowledge management, knowledge is defined in various ways reflecting different research perspectives. Philosophical debates about Knowledge Management (KM) in general start with Plato's definition of knowledge as "justified true belief" (Goldman, 1967). The Oxford Dictionary (2019) defines knowledge as the facts, information, and skills acquired through experience or education; the theoretical or practical understanding of a subject.

Knowledge is a multi-faceted concept, which is embedded within many entities in an organisation including the organisation’s culture, policies, documents, and members themselves (Yap and Lock, 2017). In the real world, however, a clear-cut distinction between knowledge, information and data is not always possible as the differences between these terms are just a matter of degree (Davenport and Prusak, 2000). Furthermore, depending on the relevance of the knowledge for one person may be interpreted as information to others and vice versa (Bhatt, 2001). Similarly, Bigliardi et al. (2014) note that the terms - knowledge, data and information - are having the same meaning.

Knowledge is commonly grouped into two categories, i.e. explicit and tacit knowledge, as proposed by Nonaka and Takeuchi (1995). According to Yusof and Bakar (2012), tacit

knowledge is gained by individual from informal and non-format learning, such as beliefs, intuition, assumptions, behaviour and etc. Nonaka and Takeuchi (1995) state that tacit knowledge is subconscious; it is understood and used but not identified in a reflective, or aware way. On the other hand, explicit knowledge is captured or stored in an organisation's manuals, procedures, and information systems, and is hence easily communicated or shared with other people or parts of an organisation (Robinson et al., 2005).

According to Nonaka and Takeuchi (1995), knowledge can be a mixture of explicit and tacit knowledge as it is rare to find absolute tacit knowledge or absolute explicit knowledge. In other words, the distinction between explicit and tacit knowledge should not be viewed as a dichotomy but as a spectrum with the two knowledge types as the poles at either end. The mixture of both knowledge would create new knowledge. The interaction between the tacit and the explicit knowledge, which is called knowledge conversion, expands human knowledge (Iwasaki et al., 2017). Robinson et al. (2005) also state that construction project knowledge is created through the actions of individuals, project teams and construction organisations and the interactions of tacit and explicit from concept design to hand over.

Most of the time, knowledge is to be shared strategically in order to achieve mutual benefits between the collaborative partners. With the advancement of new technologies such as data mining and intelligent agents, the tacit and explicit knowledge can now be transformed to electronic/ digitalised knowledge effectively to break down silos and be shared more successfully. This type of knowledge can be termed "e-knowledge" (Warkentin, 2001). The growing interest by the organisations to efficiently use these information and knowledge has entailed knowledge management systems to be redesigned. The blooming of digital economy and 4th industrial technology revolution may become the critical enabler for knowledge/ data exchange within and among the companies. The previously localised knowledge/ data is now being shared among and across various networks for the benefit of the network members as a whole, which makes both the capture and sharing of knowledge across these networks even more important than the past.

THE CHALLENGES FOR MANAGING HIGHER DIMENSION KNOWLEDGE

Construction industry is knowledge intensive and hence relies on effective KM. The success of an organisation depends on its ability to understand the value of knowledge resources in order to exploit the competitive advantages (Egbu, 2004). In construction projects, knowledge may exist in the form of texts. However, it can be challenging to fully understand the knowledge contained in the reports if it is in free-text form without any intuitive visualisation (Yang et al., 2018). Kasvi et al. (2003) note that capturing knowledge from the written documents is a resource hungry exercise which is susceptible to human mistakes. The existing IT-based knowledge capture methods fail to identify the knowledge required by different project parties due to the volume growth of the captured knowledge, which in turn lead to the redundancy and inaccuracy of knowledge retrieval (Wang and Meng, 2019).

Knowledge is increasingly created in the higher dimension format due to proliferation of BIM technologies. Such knowledge is associated with the nD model and difficult to be detached from it without losing the contextual information and details. This prompts the need to manage higher dimension knowledge with the emerging technologies such as BIM, Data

mining and Artificial Intelligence. Some of the existing IT tools or KM systems can work without the need for a virtual model as the former only capture text-based data. The increasingly more popular BIM technologies will change the way and formats of the information created, i.e. from one that is paper-based to digitalised, and from 2D to 3D and higher. The parametric modelling nature of BIM makes it different from the other existing IT tools, whereby the unique identifier in BIM helps to identify and classify the model elements unambiguously. As such, knowledge captured from KM could be tied to the model's elements when the two systems are integrated. Consequently, new knowledge created is likely to be in digital format and in 3D or higher dimension. The higher-dimension knowledge will become more abundant if it is captured once it is created and updated to the digital model. It can be spontaneously shared with others and easily located and retrieved. As a more comprehensive approach, the digital model and associated knowledge can be linked and synchronised with external database.

The associated digital knowledge in the virtual or n-D model could be leveraged to direct the key operations of the on-going project, detect and prevent mistakes in actual construction, smoothen the processes, identify the best practice or even help improve the process of claim management (Hamid et al., 2018). The adoption of it is essential to ensure seamless data flows throughout the integrated systems. With the valuable higher dimension knowledge, the project team will be in a better position to formulate effective strategies for project improvements. The main challenge, however, remains that the benefits brought about by the higher dimension knowledge can only be reaped if an effective approach for its management is in place.

ADVANTAGES OF INTEGRATING KM IN BIM FRAMEWORK

The advantages brought about by BIM have been widely reported, inter alia, include effective communication, capture of reliable information, and enhancement of decision making and problem solving between various parties.

Effective Communication

According to Grover and Froese (2016), users can "interact" with others by sharing ideas or continuously giving feedback to a problem through a BIM cloud-based platform to achieve effective communication. Best practice could be captured and reused by other participants in future projects. Deshpande et al. (2014) highlight that the 3D BIM models could act as an effective communication tool as it provides visualisation context to the discussions between stakeholders in order to facilitate the sharing of information or knowledge. Konukcu and Koseoglu (2012) advocate that the integration of knowledge management system with BIM will create a collaborative work environment for effective communication, which in turn may enhance the supply chain performance. Compared to the standalone KM system, the resulting efficiency and productivity by the integrated system is much significant (Liu et al., 2013). BIM is able to assist the process of knowledge capture and storing during the construction process due to its' parametric and object-oriented nature of digital model (Deshpande et al., 2014). The effective communication between the team members is reached where the client and other members are informed about the latest update in BIM model without sending requests to others (Fruchter et al., 2009).

Capture Reliable Information

Bouazza et al. (2015) pointed out that BIM provides an exceptionally rich context platform for knowledge management for the capture and dissemination of the knowledge created during the design and construction phase in a project. Konukcu and Koseoglu (2012) contended that the integration of KM in BIM will act as a trusted practical guide for the standard implementation of supply chain activities, as any latest updates will be captured in the model. With such feature, the BIM model could also be used to help predict future risks such as delays, clash of elements and site progress and hence minimising variation in the project (Grover and Froese, 2016). However, Deshpande et al. (2014) stated that the information and knowledge created needs to be reviewed and validated by the subject expert to authenticate the accuracy and appropriateness prior to sharing. Tan et al. (2010) emphasised that it is critical to capture and share knowledge created as soon as practicable to fully leverage the value or benefits brought about through reusing the knowledge.

Enhance Decision Making and Problem Solving

By employing KM system in BIM, the decision making is enhanced in such a way that the most appropriate solution can be identified from the list of best practice to help solve the current problem. Charlesraj (2014) noted that the knowledge shared in the BIM model throughout the project can potentially and greatly decrease the time needed to solve problem which eventually accelerates the decision making process. Likewise, the BIM-based information would be very useful for the client to make informed decisions (Hoogeveen, 2015). Ding et al. (2016) further explained that the time spent for problem solving could be substantially reduced as the knowledge captured in the BIM model could be a potential solution.

CURRENT PRACTICE FOR MANAGING KNOWLEDGE IN BIM

A number of research on the BIM and knowledge management (KM) integration have been initiated to explore the synergy and potential benefits brought about. A rich context platform with the aid of BIM models can further enhance the capture, storing and sharing of knowledge (Deshpande et al., 2014; Liu et al., 2013). BIM with knowledge management feature will encourage the transfer of new knowledge, innovative ideas, practices and solutions to reduce the rework and project duration (Fruchter et al., 2009).

Lee et al. (2015) introduced a BIM knowledge base system that includes various BIM-related statistics and best practices. To develop the knowledge base system, they employ standardised format to collect BIM cases so that the data collected and presented are systematic. The knowledge base is then be linked to Seumteo (the online Architecture Administration Information System of South Korea) for the national level usage. Lastly, the BIM knowledge bases and visualisation modules are being implemented on the global BIM dashboard website. However, the system is not linked to each individual project's BIM model.

Lin (2014) proposed a Construction BIM-based Knowledge Management (CBIMKM) system for general contractors. The knowledge shared is digitised with the BIM objects/models. The system requires a BIM/CAD object related to the knowledge to be created prior to the sharing of knowledge. For some users, it will be cumbersome and time

consuming to create the BIM/CAD objects. The system allows relevant files to be uploaded to provide more details about the knowledge captured, the function however has some restrictions as only one file format is supported.

Motawa and Almarshad (2013) developed an integrated knowledge-based BIM system to capture information and knowledge of building maintenance operations when/after maintenance is carried out, in order to understand how a building deteriorates and to inform preventive/corrective maintenance decisions. A Case-Based Reasoning (CBR) module is used to retrieve the solution for similar cases in order to solve a new problem. The BIM file is accessed through the CBR module whereby the most relevant solutions will be populated to the additional fields. Users can contribute knowledge into the system without the need to associate the knowledge with any BIM model. As a result, the knowledge contributed through this method may not be embedded in the n-D model and hence maybe invisible to search performed in the BIM environment. In addition, there is also no mechanism available for validating the proposed solution captured in the CBR module.

Liu et al. (2013) developed an Integrated Change Knowledge Management System (ICKMS) based on the environments of CAPRI.NET (a web-based Knowledge Management System) to contribute, share and capture knowledge through the BIM server platform. The ICKMS is to synchronise the shared knowledge in the Industry Foundation Classes (IFC) file where the latter is to be uploaded onto the BIM server for updating purpose. The system is a standalone prototype which can work without the need for the BIM models. As such, not all the knowledge captured are represented in the BIM model.

Motamedi et al. (2014) developed the Facility Management Visual Analytics System (FMVAS) that can detect the root causes of failures in facilities. The system is developed through the integration of a computerised maintenance management system with BIM model. Various sources of building knowledge such as fault trees and relationships between components are formally represented in the system. These resources are then used to create custom visualisations, which helps in exploiting the heuristic problem solving ability of field experts to find root causes of failures in a building (Motamedi et al., 2014).

Fruchter et al. (2009) noted that Building Knowledge Modelling (BKM) can help reduce rework, reduce wasted time and project duration, increase possibilities for innovation to keep the organisation ahead of other competitors, and provide training resources for new employees. They integrate three software, namely TEKLA (a BIM software platform), RECALL (a KM software for the capture and reuse of digital knowledge), and TalkingPaper (a system that transforms the document and annotated paper into indexed and synchronised digital content) through hyperlinks to allow knowledge to be disseminated in the BIM environment.

Liu et al. (2013) contended that the current BIM approach is not matured enough for knowledge creation and capture, as knowledge management is still very much a stand-alone process separated from BIM implementation. There is hitherto insufficient research done on the development of building knowledge information modelling management system which helps to capture and associate the model with the relevant knowledge and information throughout the project lifecycle, and capable of supporting other key project operations (e.g. contract administration). They advocate that failure to capture and disseminate the new

knowledge generated during the process of making changes to the projects will have negative impact on the construction projects.

RESEARCH METHODOLOGY

Detailed case studies were conducted with the construction companies in Malaysia and IT companies specialising in BIM. The targeted construction companies are those with experience in using BIM. Semi-structure interviews were carried out to collect detailed information on the problems encountered and requirements for managing knowledge in BIM. The positions of the interviewees range from Senior Associate to BIM Consultant. Background information on the companies is presented in Table 1. The findings will be used to develop an integrated framework for managing knowledge in the BIM environment, which will subsequently be encapsulated into a prototype Building Knowledge Information Modelling System using Microsoft's ASP.net technology. The prototype application will be demonstrated to and evaluated by the industry partners for improvement purposes.

Table 1. Background of Case Study Company

Company	Position of Interviewee	Company Background	Type of On-going BIM project
Company A	Manager	Construction and Engineering Contractor	Residential
Company B	Senior Associate	Consultant Quantity Surveyor Firm	Mixed Development
Company C	Team Leader	Contractor	Residential
Company D	BIM Consultant	BIM Specialist	-

PRELIMINARY FINDINGS AND DISCUSSION

It is found that all the interviewed companies have BIM software and utilised it. Different professions utilise it for different purposes. For consultant quantity surveyor, the BIM model is mainly intended for taking off and quantification purpose during the pre-construction stage. The quantity obtained will then be exported for the preparation of Bill of Quantities (BQ). BIM model is also referred to during the construction stage to verify the work done by the contractor. The main purpose for contractors to adopt BIM is for site management, such as for monitoring the site progress, the delivery of materials, the simulation of construction process, the daily number of workers and their position at site and quantification purpose.

In terms of managing the knowledge in projects adopting BIM, the companies interviewed only share internally the information/ knowledge created. The current practice is that the project related information is saved on the company internal server. Some companies will protect the BIM project with passcode or limit the access by other departments in order to secure the confidential information. The companies are keen to follow the conventional way of using printed forms and spread sheets for the management of information or knowledge. To improve the current practice, the interviewees suggested that knowledge could be shared via cloud-based platforms for the ease of access.

The case studies reveal that the level of adoption of BIM by the Malaysian construction companies is still very low. Most of the construction companies are still at "Lonely BIM" stage where the interoperability and integration of BIM have not been achieved. Although the construction companies have their in-house company servers to keep track and backup the project files, the information and the BIM files are only shared within the department. Due to passcode encryption and the access limitations, knowledge is hence not accessible or shared

effectively with other departments' staff who may need it. Furthermore, knowledge management has not been integrated with BIM systems and the way knowledge is managed in projects adopting BIM is ineffective. The companies still resort to using papers and spreadsheets to manage project's knowledge. Such practice is susceptible to missing document problem, duplication of information, and difficulties in locating knowledge.

Alternatively, effective communication could be achieved if the knowledge is associated with the BIM model and shared with the team members. The digital nature of BIM helps in the capture of reliable information in such a way that any updated information or knowledge could be found instantly in the model. With effective communication in place among the team members and that reliable information is available from the BIM model, the decision makers could make a wise decision to address the problems faced in the project.

It is also observed that a lot of efforts are needed to move the BIM maturity of the local industry to "Level 2 BIM". Related to this, there is also a gap between the current situations of the construction industry with what it is expected following the 4th industrial technology revolution, particularly the transformation into digitalised construction. A more rounded integrated framework for managing knowledge in the BIM environment, as part of the move towards digitalised construction, will be explained in the next section.

MANAGING HIGHER DIMENSION KNOWLEDGE IN BIM ENVIRONMENT

The conceptual framework of building knowledge information modelling management (BKIM) system, as depicted in Figure 1, is developed to assist the contractors to manage higher dimension knowledge. The cloud-based BIM system and cloud-based knowledge base are the main components of the BKIM system. The cloud-based nature of the BKIM system will allow the users to conveniently access it through the Web to contribute or locate useful knowledge.

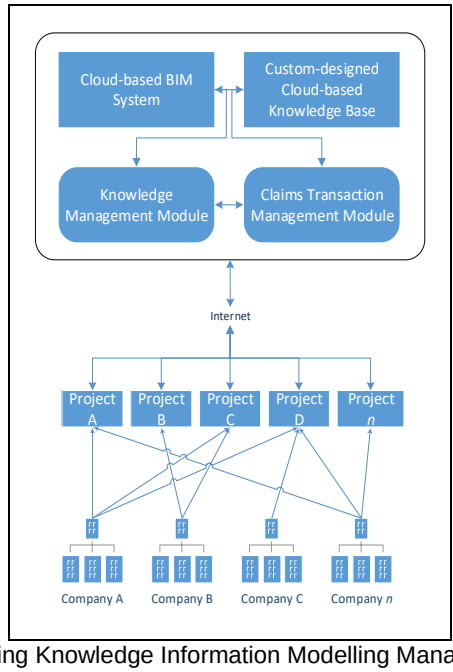

Figure 1. Building Knowledge Information Modelling Management System

In order to effectively manage higher dimension knowledge, the cloud-based BIM system is linked to the custom-designed cloud-based knowledge base. The latter is a platform which consists of knowledge management module for the capture, sharing and dissemination of knowledge. The knowledge management module will pose no restriction as to the file format and dimensions of the knowledge that can be shared. Knowledge can be associated with an element or some parts in the digital model, through the use of unique identifiers. This will allow knowledge relevant to the part of the model to be revealed and "pushed" to the users. The current practice of knowledge management is that it focuses on the capture of text-based details only rather than representing it in 3D or linking it with BIM model. The module enables 2-D digital files or even n-D objects pertaining to the best practice or lessons learned to be added into the system.

To keep track of the knowledge shared, the details such as knowledge status, knowledge contributor, validity of knowledge, categorisation of knowledge, details of knowledge can be located from the cloud-based knowledge base. With the real-time synchronisation between the cloud-based BIM system and cloud-based knowledge base, the list of knowledge shared or any new knowledge added can be retrieved from either system to benefit the on-going projects. In order to address the data confidentiality and sensitivity issues, knowledge classification that stipulates the different levels of access will be developed in the knowledge management module. Knowledge is only made accessible to the people with the required access level.

The knowledge captured in the BKIM could be leveraged to support other key project operations, in particular claims transaction management. As the construction process goes on, the contractor will claim progressively from the client for the work done in accordance with the contract signed. Claims can be submitted by the contractor for the application of extension of time, additional expenses or loss and expenses, due to variations, discrepancies between the documents and etc. Users may prepare a claim through the system and substantiate it with the relevant details available from the system itself. The claims transaction management module may help to facilitate the preparation and tracking of the status of claims, e.g. under reviewed, completed or rejected by consultant. This is more effective than the existing practice for managing claim where majority of the tasks are handled manually.

As the claims transaction management module is synchronised with other modules, any good practice and past knowledge captured in the cloud-based knowledge base could be adapted to resolve problems encountered during claim preparation. The claim could refer to any part(s) of the BIM model as evidence. Any new knowledge created from the claim transactions can be stored in the BKIM system to populate the database. The system may also advise the users if there are relevant knowledge useful for the claim concerned. The unique feature of the system is that the users will have the opportunity to access the knowledge in the virtual and simulated project environment throughout the claim management process.

The benefits brought about by the association of claims transaction management module to BIM model include that the whole process will be less prone to mistake, and it promotes better record keeping. In addition, if new knowledge is created from the claim transactions, it can also be stored in the BKIM system. It is also possible for the BKIM's functions to be extended to cover other project management tasks, and at the same time facilitating better access and reuse of the knowledge.

CONCLUSION

The proposed Building Knowledge Information Modelling (BKIM) system can help facilitate better capture and reuse of the information, files and higher-dimension knowledge than standalone knowledge bases. There will be synergy due to the close-integration between the cloud-based BIM system and the custom-designed knowledge base, whereby information will be synchronised between the systems to ensure data consistency and ease of access to the knowledge. Continuous improvement to the project could be made at different stages by allowing team members to share their digitalised knowledge about the best practice learned on how to carry out tasks in a more efficient way, or some negative lessons learned from the previous projects. The BIM model can be captured and associated with the knowledge concerned for better visualisation and sharing of knowledge during the claims. The features provided will help improve the claims management by preventing time loss in locating the necessary supporting documents, information and knowledge.

The conceptual framework has shown how cloud-based BIM and cloud computing may introduce changes to the ways for managing knowledge, and other project management functions such as claim management in the future. The conceptual framework currently focuses only the management of knowledge about claims, and harnessing such knowledge for better management of claims for the projects adopting BIM. The conceptual framework will be further developed to offer additional project management functions, to facilitate better utilisation of the knowledge captured in the system.

This research is in line with the Malaysian Construction Industry Development Board's 'Construction Industry Master Plan 2016-2020', i.e. the Strategic Thrusts P4: Roll out technology advantage across project lifecycle, which emphasises the use of BIM to enhance the productivity. The maturity of information technology and the efforts of government to promote BIM have further led to the initiatives to develop such systems, which makes this research even more relevant.

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eISSN 2590-4140