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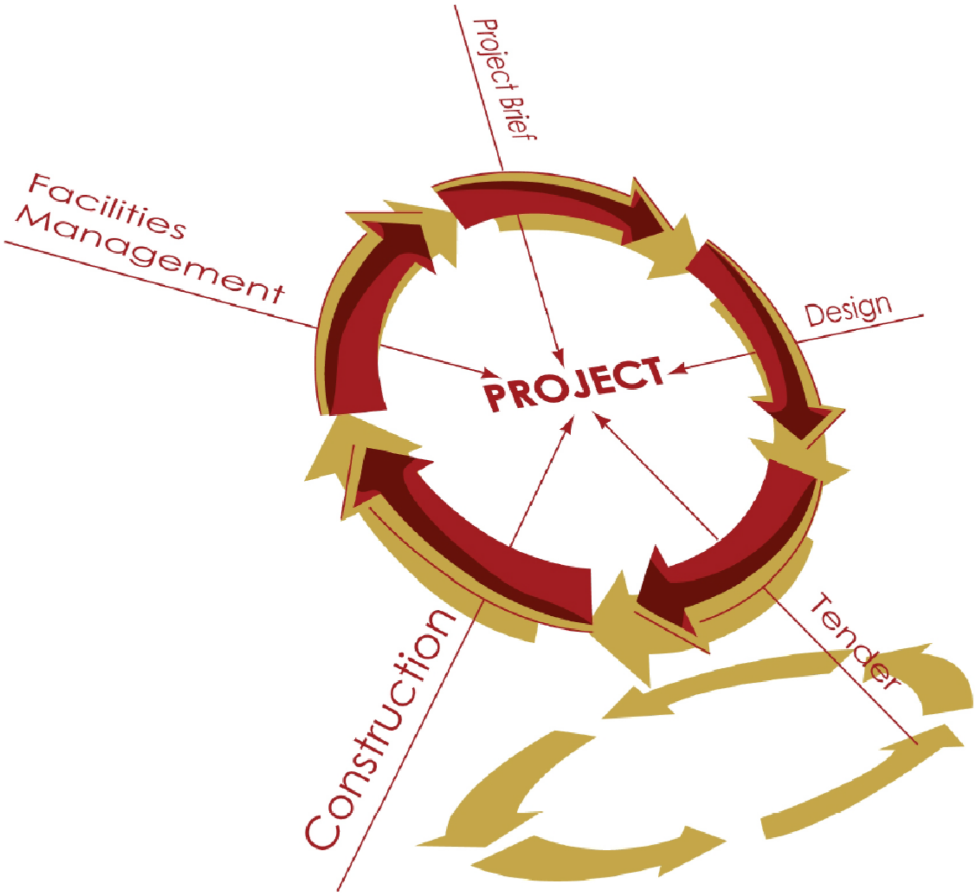

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Contents

Introduction

Welcome to the Malaysian Construction Research Journal (MCRJ) special issue in conjunction with the RISM International Research Conference 2021 (RISM-IRC2021). This conference has been jointly organized by the Royal Institution of Surveyors Malaysia (RISM) and University College of Technology Sarawak (UCTS).

The objectives of RISM-IRC2021 are to (i) provide a forum for open dialogue amongst postgraduates and researchers in the region on contemporary surveying and environmental issues and challenges ahead, (ii) provide postgraduates and researchers a networking opportunity with those from other institutions who have common interests and career paths, (iii) generate awareness on current issues and challenges in the construction and property sectors, and (iv) provide an out-reach platform for potential employers to talent-scout potential employees.

The construction industry, as a significant growth driver of the economy, has been very much affected by the outbreak of Covid-19 pandemic. It is vital for the construction industry to maintain its productivity at a reasonable rate in ensuring a sustainable future for its players. In line with this, the organizing committee has decided the theme as “New Norm: Maneuvering Towards Sustainable Future”. The five (5) sub-themes of this conference are Innovation, Technology & Engineering, Green & Sustainability, Quality, Safety & Productivity, Professional Practice & Management, and Education.

Through this conference, much of new findings and solutions on surveying, construction and environmental issues have been produced by the researchers. This special issue has included twenty (20) papers reviewed by the conference scientific committee and international reviewers. It is anticipated that the works included in this special issue will lead to a better understanding of the new norm, thereby, contributing to preparing our built environment towards a sustainable future.

Editorial Advisory Board

Secretariat Special Issue

Editorial

Welcome from the Editors

Welcome to this special issue in Malaysian Construction Research Journal (MCRJ) for the RISM International Research Conference 2021 (RISM-IRC2021). We would like to express our sincere gratitude to our contributing authors, reviewers, organizers and readers.

This special issue in MCRJ for RISM-IRC 2021 contains twenty (20) interesting papers covering the theme of "New Norm: Maneuvering Towards Sustainable Future". It is hoped that the readers would be greatly benefited from the scientific content and quality of papers published in this issue. Brief introduction of each article is given as hereunder:

Lam Tatt Soon et al., have formulated a pragmatic framework for on-site sorting of construction waste. A qualitative research method based on in-depth interviews with contractors was employed to obtain comprehensive data on the research topic. It was found that waste management in Malaysia is still under-developed as contractors do not generally practice on-site sorting. A large portion of the waste stream produced is collected and disposed of as a mixed stream. This paper mapped the waste generated on-site into individual waste streams based on data obtained on current waste management practices. It was also found that practices on-site are highly influenced by profitability, budget constraints and regulations imposed by the government. Thus, a pragmatic framework on on-site sorting was formulated in hopes that construction waste management practices can be enhanced.

Kenn Jhun Kam et al., have identified the common challenges that subcontractors in the Malaysian construction industry faced during the economic downturn and the survival strategies that could be adopted to cope with the challenges. A detailed literature review was conducted to sort out the challenges and common survival strategies that have been discussed in previous research. Questionnaires were designed and distributed to contractors in Klang Valley who are registered under CIDB. The collected data was analysed by using the Relative Importance Index (RII). The results show that the most significant challenges are low demand of construction projects, shortage of local workers due to 3D factors, and inflation. Besides, the majority of subcontractors preferred to adopt contracting-related and financial related strategies during the economic downturn. The findings identified through this study could be considered by subcontractors when facing the challenging economy.

Sitti Diana Tamjehi et al., have reviewed the status of sustainable construction practice in Malaysia. This paper contains two (2) objectives which are to explore current developments in Malaysia and to determine the status of sustainable construction practices in Malaysia which covers government support, regulation enforcement, a rating system and the consciousness of both developer and consultant in terms of implementation. This article employs a theoretical review of the literature on the status of sustainable construction practice in Malaysia. From the review, it can be concluded that Malaysia is still progressing towards sustainable construction but needs further improvement.

Chu Sheng Ding et al., have proposed a conceptual quantitative model for the assessment of constructability of river-crossing girder bridge designs at the design stage in Sarawak, Malaysia. Two stages of questionnaire survey were conducted in order to achieve the aim. At the first stage of survey, 143 responses were collected from professional engineers and G6 & G7 contractors in Sarawak. The collected data was analyzed using factor analysis and descriptive statistics of IBM SPSS Statistics. At the second stage of survey, another 136 responses were collected from professional engineers and G6 & G7 contractors in Sarawak. The collected data was analyzed using descriptive statistics of IBM SPSS Statistics and Relative Importance Index (RII) method. The results of the two stages of survey were then integrated to form a quantitative constructability assessment model. This model is the first in Sarawak that can be used by professional engineers at the design stage to quantify the constructability of river-crossing girder bridge designs. By using this model, the assessment of river-crossing girder bridge constructability can be carried out more efficiently and effectively.

Yoke Lian Lew et al., have investigated the current practice of waste management in the Malaysian construction industry through identifying the causes of construction waste and exploring the current waste practices. A questionnaire survey has been conducted after a thorough literature review. The findings reported are based on feedbacks from 121 construction practitioners who are the developers, contractors and consultants that acquire sufficient knowledge concerning the waste management in construction projects. The findings showed that the top factors contributing to construction waste are on-site management and planning; design; material storage; site operation; and material handling. The findings also discovered that recycling; reduction of construction waste; reuse of construction; other disposal sites; and construction and demolition landfill as the five most frequently used current disposal methods in the Malaysian construction industry. The outcome of this study helps to develop a better understanding on waste management in the Malaysian construction industry.

Nur Farhana Azmi et al., have identified the potential of the application of BIM in the heritage sector and challenges that hinder its implementation. A semi structured interview was conducted amongst a purposive sample of ten (10) stakeholders from different organizations who have the knowledge in BIM and heritage matters in Malaysia. The study found that the integration of BIM in conservation activity provides opportunities for documentation, cost and time reduction, sustainable project, elimination of lengthy traditional works, integration of different kinds of data into single model, and better communication and coordination between project teams. Using the NVivo 8.0 software, these potentials are further classified into four emergent themes: management tool; information sharing; sustainability; and knowledge enhancement. While lack of the software expertise and specialist has been identified as the most fundamental issue facing the implementation of HBIM in heritage sector of Malaysia, the paper concludes with recommendations in promoting the HBIM adoption in Malaysia conservation activity.

Foo Yeu Wong et al., have presented an analysis of the existing literature on the interprofessional collaboration (IPC) among the stakeholders' practices in the BIM projects. A total of ninety-six research journal articles regarding IPC in BIM-based projects was guided by the PRISMA Statement (Preferred Reporting Items for Systematic reviews and Meta-Analyses) review method. Six main themes and thirty-nine sub-themes were identified as an outline of IPC, namely collaboration, individual characteristics, interactional characteristics, team interactional characteristics, organisational features, and professional roles characteristics. In the thematic analysis, team interaction was noticeably the most frequently discussed aspect. Future studies about the social aspects of IPC in BIM-based construction projects could be focusing on quantitative or mixed-methods approach.

Azrina Md Yaakob et al., have identified the barriers to and benefits of implementing green buildings construction in commercial buildings and studied the methods to increase the implementation of green development. Qualitative approach was used for this research in order to obtain descriptive data that allows in-depth understanding of underlying reasons, opinions and intentions. The respondents which consist of three (3) engineers and two (2) architects from developer company had provided information based on their experience in green projects. This research finds out that the developers are facing different kind of barriers despite of aiming for green building projects. With a good coordination and efforts done by different parties, the implementation of green commercial building will be secured in the future.

Angela Mee Yii Ting et al., have identified the green building maintenance criteria for Higher Education Institutions (HEIs). Quantitative research approach was adopted to gather data from 120 respondents who have been involved in building maintenance works in HEIs. Rasch model was used to analyse the collected data. The results show that thermal performance and energy efficiency are the most important criteria in practicing green building maintenance in HEIs. It is expected that the research findings would broaden the existing knowledge of green building maintenance in HEIs.

Bilal bin Mohamed Jamri et al., have reviewed the previous research on the implementation of green cemeteries as part of green infrastructure in the urban landscape. Literature selection is performed carried out using systematic literature review (SLR) with online digital search using selected keywords. The research findings have identified three components discussed from the researchers' study, namely biodiversity, cultural and open space. The features of extensive and landlocked cemeteries in urban areas are indeed desirable for the use of open spaces. In addition, historic cemeteries keeps the tangible cultural architecture of the former societies while preserving nature biodiversity. Overall, the finding which can be addressed here behind the greenery of the cemetery is that the urban landscape can be established by utilising the existing space with a significant intensity on the environment, society and economy.

Husam S. Al-Duais et al., have examined passive methods and mechanisms of extracting water from ambient air that can be used in tropical buildings compared to rainwater harvesting systems. The methodology is based on a comprehensive review to explore the potentials methods, challenges and opportunities for collecting atmospheric water on-site in the tropics. Analytical evaluation of approaches, mechanisms, systems' productivity and performance was conducted. The research results revealed two technical ways that would be effective to extract water from humid air, namely: regenerative solar desiccant/collector and dew water condensation systems. This study would help to shape the application of Atmospheric Water Generation (AWG) that is expected to be more cost-effective, sustainable and adaptable to tropical building applications.

Sherlly Maulana et al., have determined the levels of H factors and V factors for flood risk in urban areas of Medan, Indonesia. Series of simulation scenarios applying 60% of Extensive Green Roof (EGR) in the total roof area of a building, using the rainfall data of the year 2019 and the spatial data from Geospatial Information Agency Indonesia and Seamless Digital Elevation Model (DEM) National Batimetri (DEMNAS) of the year 2019. Results show that the level of flood risk to this urban area could be reduced by up to 4% compared to before implementing the EGR. This is a promising indicator that EGR can potentially be included as one of the sustainable green architectural strategies that helps to reduce flood risk in the urban areas.

Asmah Alia Mohamad Bohari et al., have explored the perception of the current green procurement practices in Malaysia's construction industry. A purposive random sampling technique was used to select one hundred and fifty (150) respondents out of which ninety seven (97) responses were used for the data analysis. The research involved experienced practitioners in green building projects in Malaysia. The outcome from this research revealed that green procurement practices had been adopted in Malaysia's construction industry, which included the Industrialised Building System, passive green materials, Environmental Management System, and energy efficiency products. This research can guide the construction stakeholders and provides evidence on the importance of green procurement as an effective tool for green growth and construction projects.

Yew Hou Tung et al., have explored the feasibility in applying agile project management by the construction practitioners. Online questionnaires were distributed to collect data for this study. Based on the total 152 responses received, four hypothesis tests were conducted. The study has hypothesized four values, 70 practices, 15 knowledge areas and 16 benefits of agile project management by using median test. The results indicated that all the respondents are inclined towards the agile values of project management and all the current project management practices are indeed expected in the agile project management. The questionnaire survey also found statistically significant result on the group who has yet to decide on applicability of agile project management in construction project, tend to be more consistent on their perception rather than those who affirmed the applicability. This research concluded that there are positive responses to the agile approach of project management and most of the project management practices are aligned with the agile project management.

Myzatul Aishah Kamarazaly et al., have established the priority score of motivation factors and compared both intrinsic and extrinsic factors in accordance to Herzberg's Two-Factor Theory of Motivation. This study applied quantitative method through questionnaire and was analysed using content and multi-attribute analysis. Upon data collection, there were approximately 47% response rate for this study. Findings in terms of overall priority score had revealed that extrinsic factors had a greater significant effect towards job satisfaction and voluntary turnover rate among Generation Y Quantity Surveyor graduates in their firms. Hence, employers were recommended to prioritize salary and relations with superior in order to address job dissatisfaction and high voluntary rate.

Azrina Md Yaakob et al., have identified the challenges faced by graduates and analyzed the disparities between education and employability skills required by the employer and establish practical solutions for Quantity Surveyor students. This research paper have adopted a survey methodology in which questionnaires are sent to students and employers to determine the perceptions of both the concept of employability. The feedbacks are collected and analyzed to find out practical solutions that can be applied to improve employability of Quantity Surveyor graduates in the construction sector. It was concluded that an effort must be made between the two parties to overcome the divide. Employability capabilities will therefore be defined to reduce unemployment soon.

Amirhossein Mehdipoor et al., have studied the critical success factor for BIM-FM system implementation among FM service-providing companies in Malaysia and found evidence about the level of efficiency in terms of performance of the BIM-FM system. Quantitative data analysis is used to calculate the level of effectiveness for each critical success factor which contributes to the overall efficiency of the system performance. This study shows that the level of the overall efficiency of the BIM-FM system in Malaysia is at the “adequate” level. Evaluation of the relationship between each success factor in terms of strength and influence on the overall efficiency of system performance shows the usefulness of manual has the strongest influence and stability is the weakest factor to the overall performance. The findings of this study would guide different stakeholders to enhance the effectiveness of BIM-FM implementation in Malaysia.

Noor Aishah Mohamad Hamdan et al., have identified relevant legal provisions bearing the principles and practices of interest for a late interim payment for the Malaysian construction works contracts using the doctrinal analysis approach. Fifteen cases were selected from the Construction Industry Development Board (CIDB) Law Reports from 2015 until 2018 for the analysis. The doctrinal analysis was conducted in two stages; the first stage was to locate the law sources, and the second stage was to synthesis the findings of the analysis. Through the analysis, seven themes and nineteen sub-themes based on the case judgements and principles related to interest for late interim payment were developed. The findings were subsequently presented to legal experts for validation and comments. This study helps the employer and the contractor be more prudent in forming and treating contractual interest provisions for late interim payment. Also, a better understanding of the legal implications for the said provisions might reduce disputes between the contracting parties.

Wai Wah Low et al., have explored students’ collaborative learning experience at university level. Responses were collected based on convenient sampling method through questionnaire survey and targeted to university students in one of the Malaysian private higher education institutions. Based on the mean values, it was discovered that the critical issues in collaborative assessments were inactive team members, slow and poor decision making/problem solving and increased in uncertainties. The empirical findings of this study provide information to educators in higher education to take note on these issues in designing collaborative assessments in degree programmes as well as to improve the current teaching methods to ensure collaborative learning is taking place effectively at university level.

Shi Yee Wong et al., have investigated the level of sustainability incorporation in a Quantity Surveying program offered in University College of Technology Sarawak, Malaysia, by using both content analysis and questionnaire survey. Content analysis was conducted to analyze the course synopsis, learning outcomes and topics, to determine the sustainability components in the existing quantity surveying program. The results showed that most of the sustainability components are included as part of a small topic in one course, rather than as an add-on course. The sustainability topics that covered in the program are comparatively broad, including the environmental issues, social issues and technology aspect. Results of questionnaire survey showed that students are quite optimistic with sustainability measures in their future career. This study showed that the students reckoned themselves having quite good knowledge in relation to sustainability. This study addresses the needs of incorporating sustainability elements into the existing course structure, to ensure that the students could have better knowledge and understanding with regards to sustainability. This study could serve as an advising document to the university management to incorporate more sustainability elements into the future quantity surveying syllabus and fills in the knowledge gap within Malaysian education sector.

PRAGMATIC FRAMEWORK FOR ON-SITE SORTING OF CONSTRUCTION WASTE IN MALAYSIA

Lam Tatt Soon, Yin Ru Lim, Kenn Jhun Kam, Boon Tik Leong, Myzatul Aishah Kamarazaly and Habizah Sheikh Ilmi
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Abstract
In an era of rapid urbanisation and population growth, there is a perpetual demand for building and infrastructure developments. This has led to a commensurate increase in the generation of construction waste. As a result, the construction industry contributes significantly to the landfills in Malaysia. Hence, if the industry is stagnant on the progress of sustainable waste management, the landfills in Malaysia would not be able to cater for the amount of waste being generated. In an effort to reduce anthropogenic impacts such as groundwater pollution and climate change caused by the proliferation of landfill sites, it is imperative for contractors to improve their waste management practices. This study aims to postulate a pragmatic framework for on-site sorting of construction waste with the objectives of identifying the current waste management practices on-site and understanding factors influencing waste management procedures adopted on-site. The scope of this research was limited to physical waste produced on-site. A qualitative research method based on in-depth interviews with contractors was employed to obtain comprehensive data on the research topic. It was found that waste management in Malaysia is still under-developed as contractors do not generally practice on-site sorting. A large portion of the waste stream produced is collected and disposed of as a mixed stream. This paper mapped the waste generated on-site into individual waste streams based on data obtained on current waste management practices. It was also found that practices on-site are highly influenced by profitability, budget constraints and regulations imposed by the government. Thus, a pragmatic framework on on-site sorting was formulated in hopes that construction waste management practices can be enhanced.

Keywords: *On-site sorting; construction waste; construction waste management; construction industry; Malaysia.*

INTRODUCTION

Malaysia is on a trajectory where waste generation will surpass population growth. This surge in population has led to an insatiable demand for building and infrastructure developments. Hence, it is unsurprising that the construction industry plays a stable role in the Malaysian economy. In the second quarter of 2019, the Department of Statistics reported that the construction sector registered 4.6% of the Gross Domestic Product of Malaysia at RM35.9 billion worth of work done. Unfortunately, the inevitable by-product of our flourishing industry is an unhealthy increase in construction waste (Jaillon, Poon, & Chiang, 2009). It is estimated that 8 million tonnes of construction waste are generated annually in 2016 (Saadi, Ismail, & Alias, 2016). Currently, the construction industry significantly relies on landfilling as a means of disposal for construction waste (Tey et al., 2012). Landfills are designed to isolate waste from the environment until it is completely degraded biologically, chemically, and physically (El-Haggar, 2019). However, if not adequately managed, landfills are prone to leachate contamination that can pose a threat to the residents around its vicinity which has happened in Klang Valley in 2007 (Agamuthu & Fauziah, 2011).

It has been previously reported that 26% of our landfills are occupied with construction waste, which is undesirable because of the space it consumes (Nagapan et al., 2012; Peng et al., 1997). With the rapid increase in construction waste paired with poor sustainable waste management, the landfills in Malaysia will not be able to sustain the amount of waste being dumped (Ng, Tan, & Seow, 2017). Jereme et al. (2015) highlighted that in 2007, there were a total of 291 solid waste disposal sites in Malaysia in which only 179 of these sites were still in operation. In 2019, twelve years later, the Minister of Housing and Local Government, YB Zuraida Kamaruddin, reported that 49% out of 150 operating solid waste disposal sites are expected to reach full capacity by 2020 (Zainal, 2019). To subdue the need for new landfills in Malaysia, there must be an increased effort to divert the waste away from landfills. It is important that contractors can reduce the amount of waste sent to landfills by properly implementing the waste management hierarchy. This hierarchy is based on the 3R principle – reduce, re-use, and recycle.

On-site sorting of construction waste before disposal has been established as one of the vital components in sustainable waste management (Poon et al., 2004). Yuan, Lu, & Hao (2013) highlighted that the lifespan of landfills could be extended if on-site sorting is practised. Shen et al. (2004) added that environmental impacts caused by the abundance of construction waste could be reduced by the segregation of waste. This is agreed by Jaillon et al. (2009), who concluded that the availability of on-site sorting drastically impacts the waste management practices on-site. Furthermore, it has been established that on-site sorting is imperative for sustainable construction waste management as it facilitates the process of construction waste and enables a higher rate of re-use and recycle (Wang, Yuan, Kang, & Lu, 2010). Essentially, the separation of waste would lessen the waste stream disposed of at landfills (Yuan et al., 2013). Although it is widely perceived that on-site sorting is effective and on-site sortings in Malaysia have been in place to provide an avenue for recycling; the implementation and effectiveness are still vague. Hence, Malaysia needs to inculcate on-site sorting (Nawi et al., 2016).

In an effort to divert the waste sent to landfills, society must adopt a culture for re-using and recycling products. As mixed waste streams are difficult to process, the process of sorting of construction waste both on-site or at centralised facilities is imperative to re-use or recycle construction waste. Waste generated during the construction stage, such as sand and concrete are generally inert. Due to their dormant composition, these wastes have a high potential to be re-used or recycled. Although construction wastes are classified as inert, Saadi et al. (2016) concluded that the build-up of construction waste poses a significant threat to the environment and disturbs the natural cycle in our ecosystem as construction waste produces harmful leachates and other contaminants (Federle, 1993). Inert waste will not dissolve, burn or otherwise physically or chemically react, biodegrade or adversely affect other matter with which it comes into contact in a way likely to give rise to environmental pollution or harm human health (Twardowska, 2004). On the other hand, the construction waste stream also includes non-inert waste such as metal and timber, which are very reactive to the environment and would decompose over time. Hence, there is a need to separate these waste streams in order to facilitate the recovery of these materials.

It is undeniable that the development and implementation of sustainable waste management systems depend significantly on proper planning from local authorities. It was reported that the Ministry of Housing and Local Government is looking to reduce the number of solid waste disposal sites instead of more environmentally friendly approaches such as sanitary landfills (Zainal, 2019). CIDB's Construction Industry Transformation Programme (CITP) 2016-2020 highlighted the need for our industry to mitigate the high volumes of construction and demolition waste. The board aims to equip landfills with construction and demolition waste recycling facilities by 2020 under the environmental sustainability strategic thrust. Addtionally, Ghazali (2020) also mentioned that CITP 2016–2020 helps to fully transform the construction industry into a resource-efficient, clean, and resilient development, which in congruence with the sustainability of the environment and natural resources. On the other hand, the Selangor government has announced their plans to invest RM1.5 billion in an Integrated Solid Waste Management Centre (ISWMC) located at the Jeram Sanitary Landfill, which will be equipped with material recovery facilities for construction waste such as a waste digestor, composting plant and research and development centre (Cheng, 2018).

As the construction industry consumes various non-renewable resources, the players of the industry must realise the severity of the situation. With continuous extraction, our natural supply of building materials will inevitably perish. There is a blatant need to prioritise recycling to utilise our resources more efficiently. In some countries, scholars have proposed a closed-loop circular economy system in which building materials are continuously re-used and recycled with no waste created as a by-product. For instance, German engineers have successfully developed a closed-loop recycling system for structural components, thus, altogether avoiding disposal in a landfill (Weil, Jeske, & Schebek, 2006). Unfortunately, the Malaysian construction industry is still far from implementing these practices. Nevertheless, a journey of a thousand miles begins with a single step.

Previous literature has not established the extent to which waste is sorted on construction sites in Malaysia. Hence, there is a need to look into the current waste sorting systems on-site as well as explore the possibilities of improving the waste sorting system. This study aims to propose a pragmatic framework for on-site sorting of construction waste to facilitate the recovery of reusable and recyclable materials present in mixed construction waste streams in an effort to divert the substantial amount of waste sent to landfills. To achieve the aim of the research, it is significant to identify current construction waste management practices and factors influencing waste management practices on-site in order to propose a pragmatic framework for the on-site sorting of construction waste.

LITERATURE REVIEW

Construction Waste Stream

The construction waste stream generated on-site is often a mixture of inert, non-inert, and hazardous waste (Yuan et al., 2013). Merino et al. (2010) noted that the majority of construction waste is inert, which means it does not undergo a significant physical, chemical or biological transformation when in contact with the natural environment, thus, rendering these materials to be easily processed for re-use and recycling. Hence, it can be said that the waste stream loses its value when mixed with non-inert or hazardous materials. Examples of inert materials include concrete, bricks, sand, stone and aggregates, asphalt, and soil (Poon et al., 2004).

On the other hand, the non-inert waste stream includes metals, timber, plastics, glass, and paper, which are essentially biodegradable materials that decompose and leach chemicals into the environment (Merino et al., 2010; Bhagwat, 2008). Lastly, hazardous waste, also known as, scheduled waste is dangerous because they contribute to the emission of hydrogen sulphide as a fraction of landfill gas (Merino et al., 2010). The hazardous waste stream includes additives, adhesives, bonding agents and sealants, asbestos-based materials, lead-based paint, a solvent such as acetone, wood-treated with pesticide, and gypsum boards which would contaminate the waste stream if not separated (Kourmpanis et al., 2008).

Material Recovery

Huang et al. (2018) noted that a mixed waste stream hinders the re-use and recycling rate of construction waste. Shen et al. (2004) agreed that a mixed contaminated stream would not be suitable for re-use or recycle and would inevitably be disposed of at landfills. The construction waste stream comprises of many recoverable materials. Merino et al. (2010) noted that construction waste arising from construction works has a higher potential of recovery as it can be easily sorted on-site compared to demolition waste. Material recovery can imply the re-use of construction waste, which includes re-using the material as its original function or re-using for a different function (Huang et al., 2018), or the recycling of construction waste, which refers to the waste processed to produce a secondary product (Eusuf et al., 2012).

Reusable Waste

Reusable construction waste includes timber, concrete, masonry, and stones. It is common for timber formwork to be re-used several times before it is disposed due to deterioration (Yuan et al., 2011). Nagapan et al. (2013) noted that timber formwork could be re-used approximately 4-5 times on-site. This is supported by Eusuf et al. (2012) and Kofoworola & Gheewala (2009). Furthermore, concrete and masonry waste can be crushed on-site to be re-used as backfill or sub-grade road for temporary access to construction sites (Nagapan, Rahman, & Asmi, 2012).

Recyclable Waste

Conversely, the larger portion of the construction waste stream is non-reusable. Non-reusable materials are materials that have no more function on-site and will essentially be transported away to landfills. This waste stream generally includes end-of-life timber, metal, packaging, plastics, and other waste generated on-site. According to the waste management hierarchy, non-reusable waste should be considered for recycling (Peng et al., 1997). Tam & Tam (2006) established that metal waste has the highest residual value; thus, it can be resold to scrap metal recycling facilities.

Recycling centres for construction waste are equipped with heavy mechanical equipment and high-level technology. These facilities normally include a metal removal unit, equipment for sorting and sieving, and facilities for other waste streams such as wood (Kourmpanis et al., 2008). Vcasey (1997) noted that it is costly to sort waste at a recycling facility if the waste is delivered from different sources and have different compositions. Tam & Tam (2006) added that many recycling companies encourage contractors to sort out their waste as the profit made from secondary products cannot cover the additional cost of sorting various types of materials. Thus, it is important to segregate waste produced on-site for material recovery as recycling facilities are very specialised and would selectively accept the construction waste for specific materials (Tam & Tam, 2006).

Segregation of Waste

Construction waste generated on-site should be segregated according to its ideal destination. According to Yuan, Lu, & Hao (2013), construction waste is generally segregated into inert and non-inert streams in Hong Kong. There, the non-inert waste stream is designated to be disposed of at landfills, while the inert waste stream can be transported to open dumpsites coined for land reclamation. Unfortunately, these practices are not commonly found in Malaysia. Nevertheless, the material recovery facility to be constructed in Selangor by 2023 will essentially recover recyclables such as metal, paper, plastics, and wood. Thus, to facilitate this process, bulky inert waste should be separated at its source, thereby rendering the recovery process more economical. Additionally, non-inert waste such as metals, plastic, paper, and wood are more commonly accepted by recycling facilities (Tam & Tam, 2006).

Inert waste has a higher value when it is left uncontaminated. It is most ideal for inert construction waste to be separated because the inert fraction of construction waste is considered ‘clean’ and can be recycled with minimal processing (Kourmpanis et al., 2008). According to Gálvez-Martos et al. (2018), clean recycled aggregates can be produced from inert construction waste. Huang et al. (2002) noted that the use of recycled aggregates could be feasible if the impurities are removed beforehand. Thus, it is concluded that a higher quality of aggregate can be produced from well-sorted waste. Unfortunately, concrete waste is commonly contaminated with impurities such as metals, glass, bitumen, and other organic materials (Merino et al., 2010). Segregation of inert waste can essentially lead to a solution for landfilling as bulky inert waste can be sent to inert landfills that do not require protective lining as compared to sanitary landfills.

Thus, it can be observed that it is ideal for inert waste to be sorted from non-inert waste for two reasons: to facilitate the material recovery of construction waste and to divert waste away from sanitary landfills or solid waste disposal sites. Apart from that, it is also vital that hazardous materials are separated from the waste stream as it consists of dangerous substances, which may be released into the environment, causing anthropogenic impacts. Thus, if not handled properly, the recycled products will be deemed contaminated as their utilisation will potentially release leachates into the environment (Gálvez-Martos et al., 2018).

Based on the literature mentioned above, a preliminary framework for on-site sorting based on ideal destinations of construction waste was formulated as depicted in Figure 1.

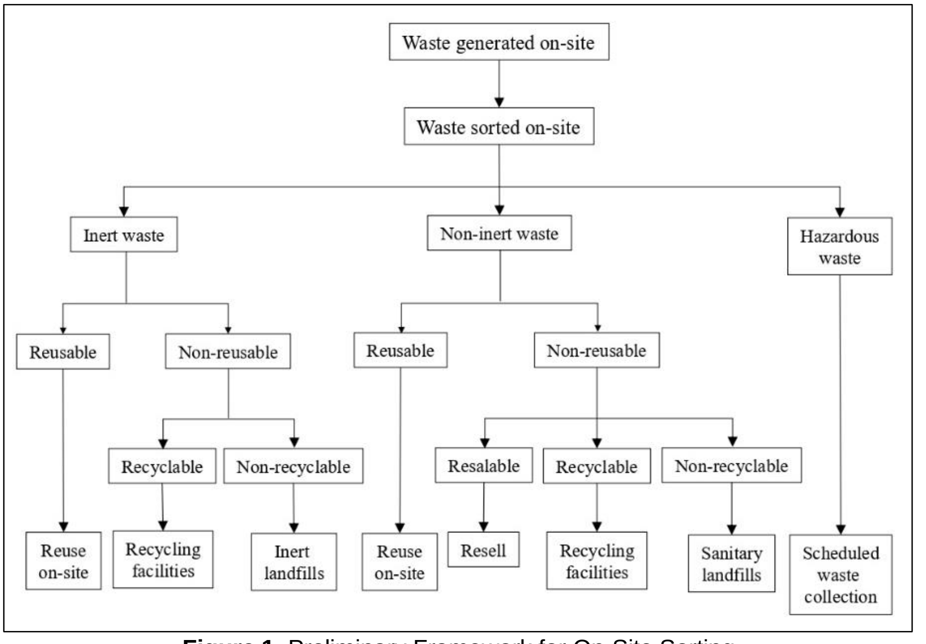

Figure 1. Preliminary Framework for On-Site Sorting

RESEARCH METHODOLOGY

A framework can sometimes be referred to as a paradigm that influences the way knowledge is studied (Mackenzie & Knipe, 2006). The preliminary framework depicted in Figure 1 was formed by reviewing the literature on construction waste management based on the research workflow mentioned in Figure 2.

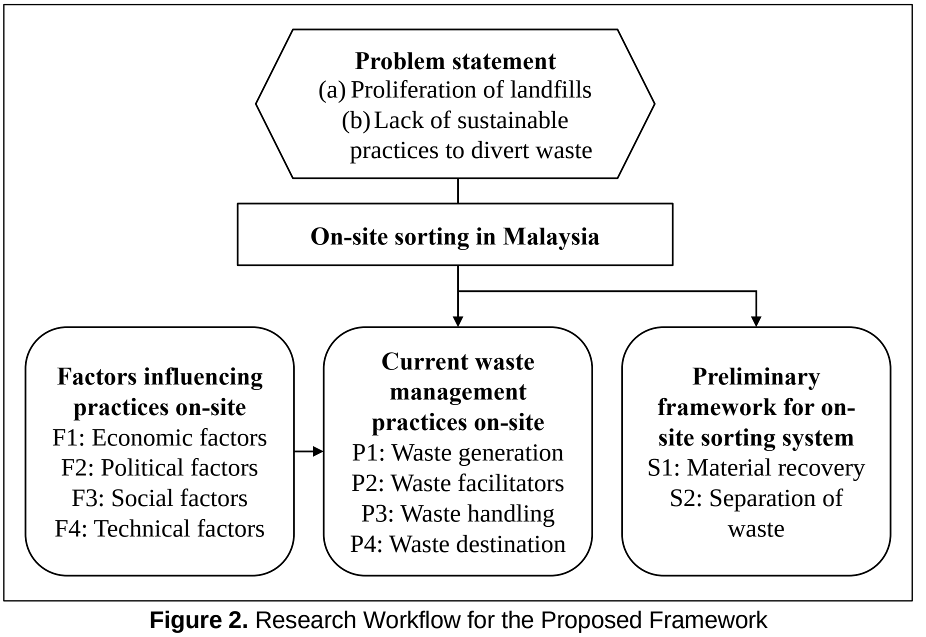

Figure 2. Research Workflow for the Proposed Framework

A qualitative approach was selected for this study because the research questions required an inductive approach, which can only be fulfilled by qualitative methods. In this study, semi-structured in-depth interview questions were designed to obtain data on the current waste management practices as well as the factors affecting such practices. Data required on practices on-site and its components required detailed elaboration for a comprehensive understanding of the procedure. Furthermore, this research technique provided a platform to obtain both implicit and explicit data.

The semi-structured in-depth interviews continue until the collected feedback has reached saturation. The point of saturation was achieved when the collected samples do not provide new emerging themes (Krueger & Casey, 2000). In this study, in-depth interviews were conducted with five industry practitioners. The respondents of this study were directors who are currently working in Grade G6 or G7 contractor companies with more than 29 years of experience in the construction industry. They were selected based on a stratified purposive sampling method. Purposive sampling is a non-probability form of sampling, which means that participants were selected based on their ability to contribute to the research aim and objectives (Bryman, 2012). As such, experienced contractors were selected as they are directly involved with the handling of construction waste. The criteria also select respondents who have both technical and managerial knowledge.

The interviews were conducted in person at an agreed-upon location. The basis for the interview consisted of 6 questions. As each respondent had different procedures, different questions were raised where necessary to gain a deep understanding of their procedure. The data collection is stopped when there is no new ideas or additional sub-themes for the proposed on-site waste management framework. The data collected was converted to textual form by transcription. Subsequently, the data is analysed via the thematic analysis method, which focuses on identifying dominant themes through coding. The data obtained on waste management practices were mapped into a flow diagram according to their respective waste destinations to represent the construction waste streams generated on-site and the waste handling processes involved. It was then incorporated into the preliminary framework formed from the literature review to propose a framework to encourage construction waste recovery in Malaysia.

FINDINGS AND DISCUSSION

With the aim of postulating a pragmatic framework for the on-site sorting of construction waste, it is essential to identify the common types of waste generated. Table 1 summarises the types of waste identified by the respondents. Many researchers including Nagapan et al. (2013) have mentioned that timber contributes the most waste on-site. As such, all the respondents established that timber and plywood used as formwork are the main types of waste generated on-site. As presented in Table 1, other types of waste generated on-site include metal, concrete, bricks, and soil. It is important to note that the waste generated on-site is included but not limited to the data presented below.

Table 1. Summary of Types of Waste Generated

Category A: Types of construction waste generated					
	R1	**R2**	**R3**	**R4**	**R5**
Timber	✓	✓	✓	✓	✓
Steel bar	✓	✓	✓	✓	✓
Aluminium	✓				
Bricks	✓	✓	✓	✓	✓
Concrete	✓	✓	✓	✓	✓
Soil	✓	✓	✓		✓
Cement plaster					✓
Packaging		✓	✓	✓	✓
Scheduled waste		✓			
Stones and aggregates				✓	✓

Current Waste Management Practices

Upon organising the data obtained, it was identified that waste management practices could be divided into four sub-themes, which are waste generation, waste facilitators, waste handling, and waste destination. The generation of waste signifies the sources of generation of waste such as stockpile, cut, and handling waste but was not elaborated in detail as this study aims to focus on the sorting and disposal process. Waste facilitators represent the tools and machinery used to facilitate handling waste, which are the essential components of the waste disposal process. Finally, the waste destination will indicate the method of disposal, in other words, where the waste stream would end. These processes are recognised as the predominant stages in managing waste by Ogunmakinde et al. (2019).

The current waste management practices were illustrated based on five responses from contractors are presented in the form of a flow diagram. A flow diagram provides a visual representation of the transcript, which would depict the waste streams more clearly (Tran, 2017). In this study, the waste handling and waste destinations are symbolised by nodes, while the facilitators are represented by the arrows connecting them. Figure 3 below shows the mapping symbols used in the diagrams.

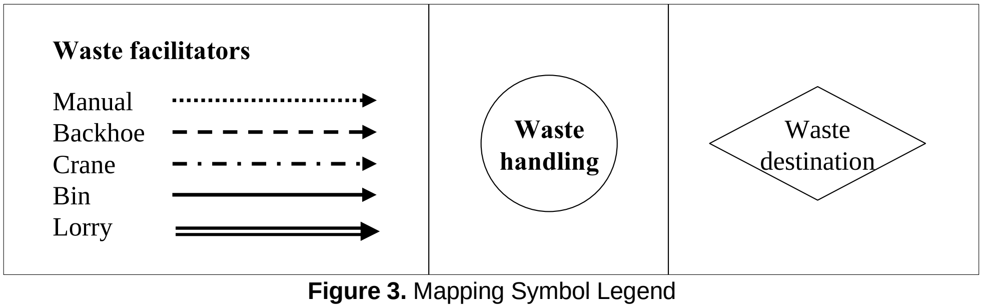

Figure 3. Mapping Symbol Legend

Although the nature of the construction industry is heterogenous as each project has different characteristics and specifications, there are a lot of similarities in waste management practices adopted by Malaysian contractors. The trend that emerged among the responses was summarised in Figure 4. The diagram illustrates how the waste is managed and focuses on the construction waste streams that emerge during the construction process. The flow chart was formulated by identifying the overlap in procedures among all the respondents.

The process of handling waste generated during construction is commonly carried out by general workers on-site. These labourers are under the supervision of the sub-contractors hired by the main contractor to carry out trade works. As highlighted by R3, the sub-contractors that are contracted for trades such as concreting, masonry, and tiling are responsible for handling the waste that they generate. The main contractor is generally responsible for coordinating the site activities to ensure that waste is collected correctly and progressively transported away from the site, as emphasised by R2. It is understood that the main contractors will prepare the necessary bins and arrange for a collection that arises from the trade works. These procedures are communicated verbally down the supply chain. Additionally, it was found that contractors do not usually have a documented site waste management plan. This may be attributed to the fact that it requires additional resources. R2 mentioned that their organisations have specific standard procedures for the handling of waste on-site, which prescribes what should be re-used but is implemented through their site managers.

As previously mentioned, this study found that the waste handling practices generated on-site are consistent among all the respondents. Waste generated that are not resold or re-used are disposed of at landfills. It can be deduced from Figure 4 that soil, bricks, timber, and metals are commonly diverted away from landfills. Subsequently, a large portion of the construction waste stream produced on-site is sent to landfills as a mixed stream. This includes bricks, concrete, timber, cement plaster, packaging, stones and aggregates, and other miscellaneous damaged or unwanted items. As explained by the respondents, there will be several designated areas on-site for waste to be compiled. These piles are strategically located to accommodate the collection process. R3 elaborated that the labourers will manually set aside waste generated during construction, which is then collected with pieces of machinery such as backhoes, bobcat, or case machines, adding that "as long as the waste is piled up, the excavator will come and collect". The waste is loaded into construction waste bins and transported away via lorries on a regular basis. It is common for contractors to use Roll-on Roll-off (RORO) bins as it is convenient for loading. It is also common for bulky waste to be directly loaded onto jumbo lorries, as noted by R2 and R4. According to R5, this procedure of collecting waste is commonly practised by contractors because there is a lot of free space on site available to be utilised.

It is also a norm in the industry for contractors to hire private waste transporters to transport the waste to landfills. The frequency at which waste is transported away depends on the scale of the project, which can range from 4-7 times a week. The private companies essentially provide transportation service from the site to the landfill and are paid on a per-trip basis. R2 and R4 revealed that these waste removal companies are monitored through waste tracking dockets. These dockets are issued by the landfills and acts as evidence that a load of waste is disposed at a government-certified location. However, R1 and R3 admit that they do not monitor the waste disposal to that extent; thus, they do not insist on dockets from their hired waste transporters.

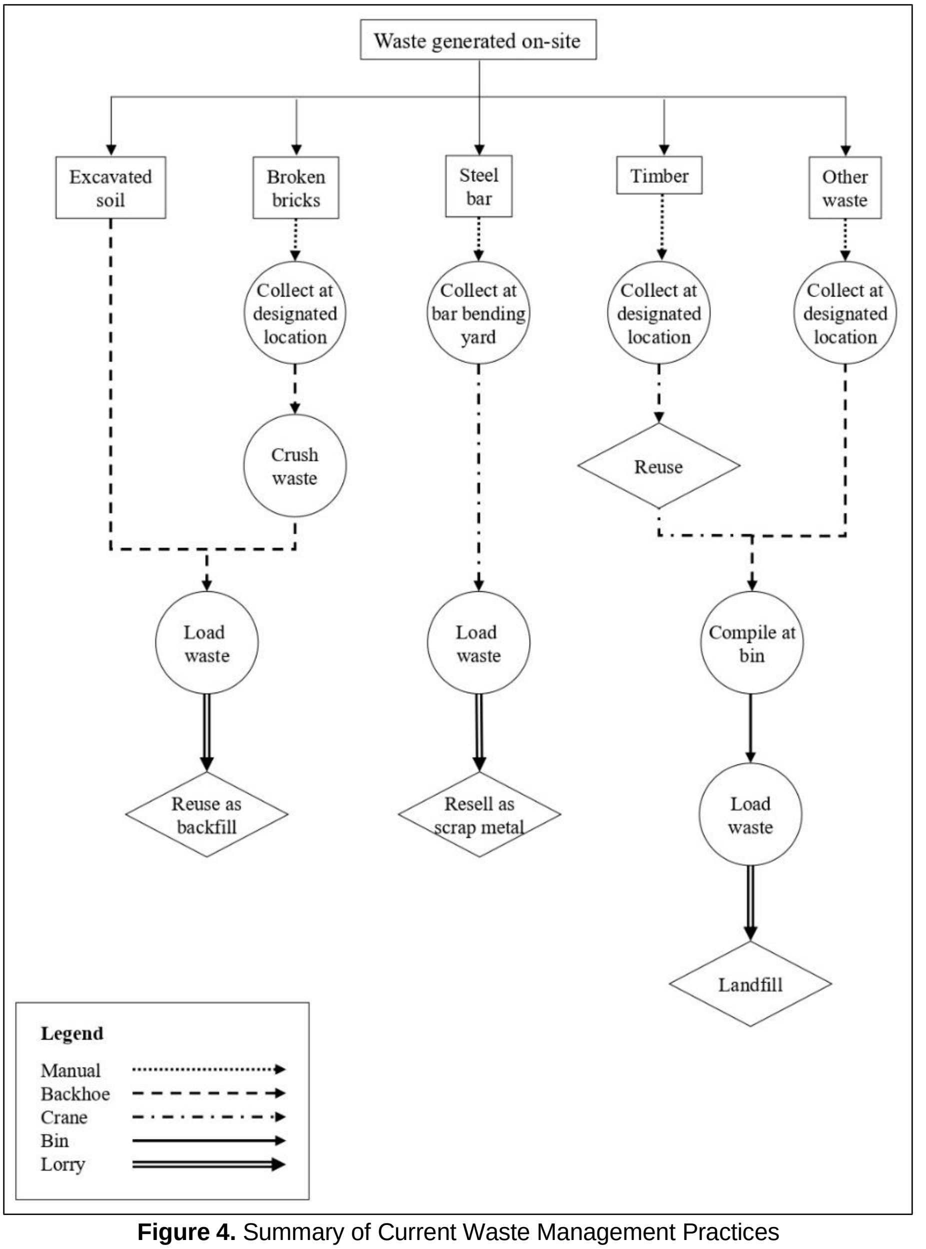

Figure 4. Summary of Current Waste Management Practices

Timber Waste Stream

All the respondents acknowledge timber as the most generated waste on-site, especially during the stages of the project when the frame is being constructed. This can be attributed to the fact that timber is used as formwork which is required to cast concrete elements of the building structure such as concrete beams, columns, and slabs. R2 explained that after curing, the timber formwork would be manually disassembled and collected at a designated location before it is transported across the site via material hoists or cranes for re-use. Although timber formwork can be re-used, high-quality formwork can only be re-used approximately 4-5 times as the material deteriorates reasonably quickly. Alternatively, contractors often buy cheaper quality or second-hand plywood to save cost but will only be able to be re-use the formwork 2-3 times, as emphasised by R3. As such, once the timber has served its purpose, it is discarded into the bin, mixed with other waste, and sent to landfills.

Metal Waste Stream

The findings of this study can confirm that the majority of Malaysian contractors resell metal waste produced on-site. There was a consensus among the respondents that metal is deemed to be the most valuable waste as it possesses a resale value. It is common practice for contractors to set aside any metal waste generated on-site to be sold as scrap metal. Due to the residual value of the metal, buyers are willing to collect metal waste from the site. According to R1 and R2, the generation of metal waste arises when reinforcement bars are cut at designated spaces known as a bar bending yard. Typically, the scrap pieces which arise from cutting the bars will be compiled at the yard in a bin provided by the scrap metal buyers. As the virgin materials are delivered directly to the yard, it can be said that a large portion of metal waste does not mix with the other waste.

Excavated Soil Waste Stream

According to R5, excavated soil is generated in tonnes during the site clearance stages of the project. This study found that it is common for contractors to re-use soil as backfill or as to level the ground. According to R1, contractors do not dispose of soil unless it is found to be too clayey for support. Soil with low bearing capacity would lead to a settlement. Conventionally, the soil excavated would be directly loaded onto lorries to transport across a site where it is used as backfill. In cases where backfill is not required on-site, the excavated soil will be transferred to other sites, as mentioned by R1. R3 also noted that soil is seldom disposed at landfills as it has a resale value and can be resold as earth.

Broken Bricks Waste Stream

As shown in Table 1, all the contractors had listed broken bricks as a type of waste generated on-site. The generation of masonry waste may include clay bricks and concrete bricks, as explained by R5. It was found that R1 and R3 practice the re-use of broken bricks as backfill or sub-grade roads. The process involves collecting the broken bricks at a designated location until the amount is substantial. The bricks are then crushed with the use of machinery available and transported across the site where required. The fact that other contractors do not practice the re-use of broken bricks may be due to project specifications set by consultants, as highlighted by R3. Bricks lose their value once broken as walls cannot be constructed with broken bricks. Additionally, bricks are extremely brittle, thereby generating a lot of waste in their use.

Concrete Waste Stream

R2 noted that wet trades tend to generate more waste as compared to dry trades. This can be attributed to the fact that wet trades such as concreting are highly reactive to the environment, thereby, can seldom be stored for re-use. According to R4, concrete waste generated on-site is caused by ready-mixed concrete ordered in excess. Concrete waste can be re-used by casting lintels or slabs, as practised by R2. The process simply involves pouring the excess concrete to cure at a designated location before transporting it where needed. The study found that concrete waste is commonly found on-site and is often dumped in landfills. As explained by R1 and R4, the excess concrete is left to sit at a designated location before hacking into smaller pieces to ease transportation to landfills. This may be because the quantity of concrete remaining is insufficient to be efficiently re-used, as perceived by R3.

Scheduled Waste

Scheduled waste generated on-site may include diesel, engine oil, lead-based paint, and wood treated with anti-termite, as held by R2 and R4. The waste is dealt with care and stored at a designated storage yard on-site. R2 highlighted that this procedure complies with the International Standards Organisation (ISO) as they have to maintain their ISO-14001 certification. The procedure for the disposal of scheduled waste is also regulated by DOE. Additionally, R4 explains that it is not uncommon for the client to instruct contractors to dispose of construction waste at an empty freehold land to save the cost of disposal. This is legal as approval is obtained from the government to utilise it as a dumping site with the condition no hazardous waste is dumped there.

Ultimately, this study has found that Malaysian contractors generally do not practice any specific procedure for on-site sorting of construction waste. Apart from metals, timber, and in some cases bricks, a large portion of the waste stream produced is collected together and disposed of progressively as a mixed stream. This is consistent with Nagapan et al. (2013)'s findings, which identified Malaysian contractors implement partial waste management by re-using timber and recycling metal. Moreover, although materials such as broken bricks and timber are re-used, the number of times they can be re-used is limited and will eventually be disposed to landfills. While contractors indirectly practice recycling by selling their scrap metal, it can be observed that it is generally uncommon for contractors to recycle their waste. It appears that sustainable waste management practices in the Malaysian construction industry are still very minimal.

Factors Influencing Current Waste Management Practices On-Site

All the respondents perceive the cost as the major contributing factor influencing construction waste management practices as presented in Table 2. Upon analysing the research data obtained from five semi-structured interviews with contractors, the two themes that stood out were profitability and budget constraints. The findings are discussed in detail in this section.

Table 2. Summary of Factors Influencing Practices On-Site

Sub-themes	R1	R2	R3	R4	R5
Profitability	✓	✓	✓	✓	✓
Budget constraints	✓	✓	✓	✓	✓
Tender considerations	✓			✓	
Regulatory compliance	✓	✓	✓		✓
Government requirement	✓	✓			✓
Government initiative	✓		✓		
Managerial influence	✓			✓	✓
Site supervision		✓	✓	✓	✓
Contractor's willingness			✓		✓
Waste recycling facilities			✓		
Project constraints	✓	✓		✓	✓
Project specifications		✓	✓		

F1: Profitability

The cost can heavily influence the practices from various aspects (B. Huang et al., 2018; Mak et al., 2019; Tey et al., 2012). This study found that the respondents unanimously perceive economic incentives as a major factor influencing construction practices on-site. It is found that contractors often weigh the monetary benefits that might accrue against the cost of their actions. R2 explained each decision made by contractors must be justifiable by its end-product as they are essentially running a commercial operation. It can be said that the economic benefits of selling specific waste materials or saving construction costs encourage contractors to practice waste management. The findings agree with Formoso et al. (2003), who noted that contractors view the concept of construction waste as the use of resources that do not add value to the work. Shari & Soebarto (2014) also revealed that it is common for contractors to prioritise cost since the construction industry has been emphasising mostly on providing buildings with the best possible lowest cost, often at the expense of quality.

F2: Budget Constraints

Another prevalent theme that emerged as a primary concern is the constraint of the project budget. R1 explained that the budget allowed for disposal of waste on-site is generally dictated by the price included in the preliminaries bill. Hence, it can be said that most contractors endeavour to abide by their budget and are reluctant to implement practices that exceed the allocated amount. R3 stressed that contractors are generally very cautious with construction cost, which is usually controlled by managing the resources expended on-site. R4 added that implementing sustainable procedures on-site will render additional labour, machinery, space, and cost. Likewise, R5 noted that the budget constraint hinders the re-use of materials on different projects as the transportation and storage cost would outweigh the cost for virgin materials. Thus, it can be concluded that contractors are generally cautious of the operational budget on-site to minimise their financial risks in a project.

Additionally, the study also found that the common percentage for waste disposal allowed for in the preliminaries bill ranged from 0.1% to 0.3% of the contract sum as shown in Table 3. It is important to note that different contractors have different pricing strategies. For instance, R2 considers the cost of waste disposal in minute detail. Thus, it does not perform a detailed breakdown. Conversely, R3, and R4 do not particularly rely on a standard percentage and would always work out the cost of waste disposal by the first principle. It is important to note that this lump sum is highly dependent on the scale and duration of the project as it is based on the estimated number of loads generated.

Table 3. Summary of Data Related to the Waste Disposal Cost

	R1	R2	R3	R4	R5
Allowance preliminaries	0.3% of contract	<0.5% of contract	N/A	N/A	0.1% of contract
Estimated cost per load of waste	RM150/ load	N/A	RM200-300/load.	RM150/ load.	RM200-300/load

F3: Tender Considerations

As previously mentioned, the disposal cost is priced for in the preliminaries bill, which would form the tender sum during the tender stage. As explained by R4, any new implementations to current procedures on-site must not negatively impact the tender unit rate. This may be because it is in the contractor's best interest to have the lowest tender sum to secure his employment during competitive bidding. R1 also emphasised that "If my cost of waste disposal is too high, I will price myself out from the market and would not be able to get projects". Thus, practices on-site that are not common in the industry and are perceived to increase the use of resources such as labour, machinery would not be included to ensure the bid is within market acceptability. R1 added that environmental practices must be aligned with the client's intentions as the increased allowance for waste disposal will raise questions during the tender interview as the clients are the ones who ultimately bear the additional cost.

F4: Regulatory Compliance

This study found that the construction practices on-site are controlled by the government to a certain extent as the respondents had a tendency to justify their current practices with regulatory compliance. It is observed that waste management practices are influenced by the mandatory requirements due to contractors' obligation to abide by the law. According to R1, R3, and R5, their methods of waste disposal are dependent on the regulations set by local authorities. This is consistent with Poon et al. (2001) and Merino et al. (2010), who demonstrated that public administrators are in the position to directly influence waste management stakeholders. Additionally, R2 revealed that waste management compliances for their organisation are based on regulations set by the DOE, adding "…we only enforce whatever is required by DOE". R5 expressed that DOE plays a distinct role in which it is required for contractors to obtain approval for certain procedures. Lastly, R1, R2, and R3 consider CIDB to have little impact on contractors', concluding that the guidelines published are merely suggestions or site practices and are commonly disregarded by contractors.

F5: Site Supervision

Site supervision stands out as another theme that was frequently mentioned among the contractors. The study found that the handling of waste of re-use or disposal is very dependent on the capability of the site manager in directing operatives on-site. R2, R3, R4, and R5 agreed that the handling and disposal of waste might differ for each project due to the site management team. With poor supervision, timber formwork is not utilised to its maximum capacity, as expressed by R4. R2 added that materials to be re-used would be damaged when mixed with other waste. Additionally, most contractors do not have a written waste management plan, which means instructions haven to be relayed to labourers on-site verbally by site managers. Thus, R2 and R3 expressed that it is challenging to ensure waste is properly handled on-site. This is consistent with the findings of Nagapan et al. (2013), Shen & Tam (2002), and Forster (2014), who suggested that the supervision of operatives on site hindered the implementation of effective waste management.

Developing an Effective On-Site Sorting System

This research aims to address the gap in knowledge on the topic of on-site sorting in Malaysia by proposing a pragmatic framework for the separation of waste based on the current waste management practices and factors affecting their practices. The data obtained from interviews are used as a basis to develop a pragmatic framework that would illustrate an ideal method for the segregation of waste generated on-site. The rationale behind developing an on-site sorting framework is that the segregation of waste will facilitate material recovery from the construction waste stream, thus, reduce the amount of waste disposed at landfills.

Upon studying the data collected, the first out of the three alternative procedures proposed by Poon et al. (2004) is deemed most suitable in which the waste streams are handled and collected separately. Applying this concept and incorporating the findings from the literature review with the findings of this study, the framework for on-site sorting is formulated and illustrated in Figure 5.

The on-site sorting procedure beings with the separation of construction waste at its source. Shen et al. (2004) noted that it is easier to sort waste as it is generated and delivered to specific locations than to sort them at later stages. As Malaysian contractors would conventionally collect their waste at several designated areas located to increase work efficiency, the framework proposes for inert waste and non-inert waste to be piled separately. Subsequently, separate bins for inert and non-inert waste shall be provided on-site. Thus, the waste streams collected separately will be loaded into their respective bins. It can be implied that no additional cost or labour is incurred as the waste collection frequency remains the same apart from it being selectively picked-up from its temporary collection points.

From separate bins, the waste can be delivered to their respective destinations. The framework shows the target waste destinations that can be achieved if on-site sorting is implemented. Currently, the most feasible step forward in dealing with inert waste is to send it to inert landfills. Ideally, inert waste could be used in land reclamation or sent to recycling facilities for material recovery to produce recycled aggregates. Conversely, the non-inert waste stream would be disposed of in sanitary landfills in which the Minister of Housing and Local Development, YB Zuraida has proposed to implement. Ideally, non-inert waste can also be separated into recyclables and non-recyclables to further reduce the amount of waste sent to landfills. This can be done mechanically via the material recovery plant currently set to be constructed in Selangor by 2023.

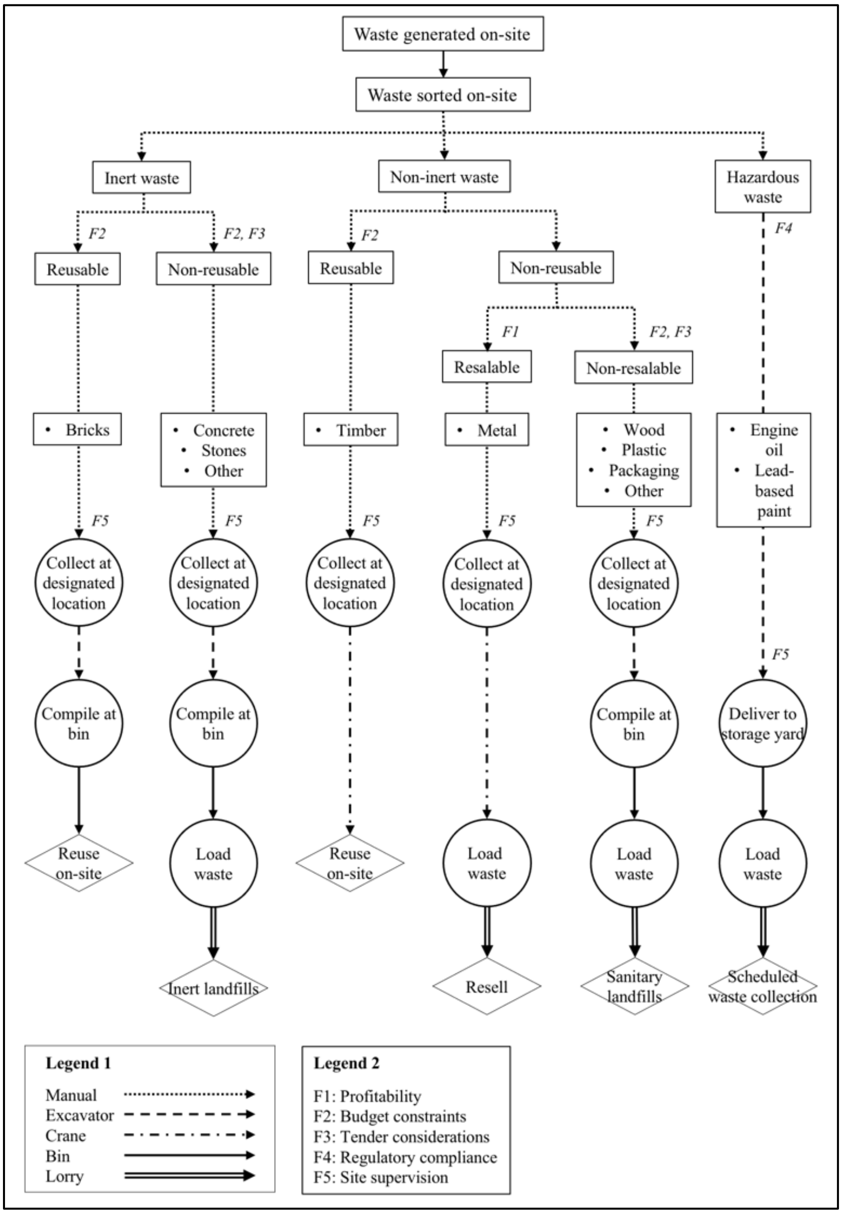

Figure 5. Proposed Pragmatic Framework for On-Site Sorting of Construction Waste

For materials to be re-used on-site, it is already a common practice for materials such as bricks to be separated from the general waste stream in a separate bin. On the other hand, timber to be re-used is often utilised immediately after its generated. Hence, materials to be re-used are also separated into their individual streams and are not mixed with general waste. Similarly, as previously mentioned, a majority of metal waste to be resold is generated at the bar bending yard; thus, it is an independent stream of its own. It is also vital for scheduled waste to be properly handled to ensure it does not contaminate the environment.

This on-site sorting framework is formulated to ideally guide the operatives on-site to perform correctly. The factors influencing waste management practices on site are included in Figure 5 to illustrate the feasibility of the implementation plan. Materials such as timber are commonly re-used to fully utilise the budget allocated for construction. On the other hand, non-reusable and non-resalable materials are affected by the tender consideration factor as they are deemed to lack value; thus, are not allocated for in the contract preliminaries. It is assumed by the author that the proposed system does not significantly affect the normal practices on-site as the contractor's main concern on construction cost is taken into account. However, it cannot be denied that this framework would require more supervision and training that it would originally take, underscoring contractors' lack of motivation to implement additional practices if it does not add value to the work.

Therefore, the government plays a significant role in the implementation of on-site sorting. This is also supported by the findings of this study, which confirms that local authority is in a position to regulate the obligations and responsibilities of contractors. Contractors are highly influenced by mandatory requirements as breaking the law would imply penalty charges. Alternatively, the government can approach the implementation through the use of incentives. In recent years, the Hong Kong government has successfully implemented the waste disposal charging scheme in which the contractors are rewarded with reduced levy charges for inert wastes sent to public fill receptions. It has been proven that the savings in landfill charges have successfully changed the culture of waste disposal in Hong Kong.

Ultimately, it is important to note that the data on current waste management practices on-site were collected from in-depth interviews. Current waste management practices were mapped based on verbal descriptions and not by observation. As such, the findings may have only focused on generic practices and may not have been able to reflect on minute details of the procedure. Furthermore, the framework proposed was formulated based on the data collected on the current waste management practices and previous literature on on-site sorting systems. Thus, the feasibility of this system in the Malaysian construction industry is still uncertain.

CONCLUSION AND RECOMMENDATIONS

Many researchers have previously highlighted the need for on-site sorting, underscoring the importance of waste segregation in material recovery. It was found that by separating waste at the source, the waste streams have more potential to be recycled or repurposed. It is important to highlight that Malaysia is not up to date on the construction waste technology that is used by other countries. Material recovery facilities are uncommon, which hinders the development of a recycling culture among contractors. Nevertheless, the separation of inert and non-inert streams is beneficial as it would divert the amount of waste sent to sanitary landfills. Thus, a pragmatic framework was developed based on the current practices in the industry and the factors influencing these practices.

The findings of this research have increased the understanding of the current waste management status in the Malaysian construction industry. Hence, the output of this study can serve as a foundation for other researchers to explore the implementation of on-site sorting in Malaysia. In light of the limitations mentioned, the practices should be studied in more detail via case studies or simulations to forecast the feasibility of on-site sorting. It is also pertinent that more research should be done on the profitability of recycling facilities in Malaysia. This is vital to promote the recycling culture in our society.

It has become increasingly essential to battle climate change caused by human activities. With an increasing contribution to global pollution and the consumption of resources, the success of the construction industry will never be truly appreciated unless its carbon footprint is minimised. The development of our society should not come at the expense of the earth. Thus, further research is required to ensure the ultimate aim of reducing the dependency on landfills can be achieved. The stakeholders of construction waste must realise their responsibility towards the environment and the importance of sustainability in order to progress towards a cleaner planet.

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SURVIVAL STRATEGIES AND CHALLENGES FACED BY SUBCONTRACTORS IN MALAYSIAN CONSTRUCTION INDUSTRY

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Abstract
The construction industry is one of the biggest sectors in Malaysia's economic productivity. Due to the declining Gross Domestic Product (GDP) growth rate in Malaysia in the past five years, the construction industry is going through a slow growth of development. This phenomenon is currently creating problems to the contractors, and especially to the subcontractors. Hence, it is important to investigate how subcontractors survive the economic downturn- where the market conditions are available only for limited projects, and what are the strategies undertaken for business survival to sustain themselves in the competitive environment. The purpose of this paper is to identify the survival strategies and common challenges that subcontractors faced in the construction industry. The findings identified the common challenges, and the survival strategy actions that could be considered by the subcontractors as a reference, especially when faced with situations that threaten their business survival and prepare themselves before the economic downturn. A detailed literature review is conducted to sort out the common survival strategies and challenges that have been discussed in previous research. Questionnaires were designed and distributed accordingly to the target local contractors which are registered under CIDB located in Klang Valley as respondents of this study. The collected data was analysed by using the Relative Importance Index (RII) for ranking to determine the common adoption discussed by the respondents during the downturn period. The findings discovered that majority contractors are aware of the type of survival strategies can be take in action during prolonged downturn.

Keywords: *Construction industry; subcontractors; economic downturn; survival strategies; challenges.*

INTRODUCTION

In Malaysia, the construction industry is the third-biggest sector in terms of productivity after manufacturing and agriculture, according to Construction Industry Development Board of Malaysia (CIDB). The construction industry has a strong influence on growth because of its extensive backward and forward linkages with the rest of the economy. However, despite the construction sector being known as one of the most productive sectors to the country's economy, development support to the industry and to contractors remains minimal.

According to the statistics provided by Department of Statistics Malaysia, it shows that the Gross Domestic Product (GDP) growth of Malaysia has been a sharp plunge in the past five years, from rate of 6.0 percent in year 2014 to the rate of 4.2 percent in the year 2018. As the Malaysian economic environment is sluggish, the construction sector also experienced a decline in growth in the past five years, which showed in the significant drop of the Construction GDP rate from 11.7 percent in year 2014 to 4.2 per cent in year 2018.

Construction organizations need a contingency plan of survival in relation to uncertainties in the environment. What will keep them alive is innovation and change that is faster than those by the toughest competitors and of the external environment (Welch and

Byrne, 2001). Financial consultant, John Gillespie described survival strategy as a state of being familiar to most start-ups that have weathered the recession and to entrepreneurs who kept their companies afloat by postponing spending, hiring and long-term goal-making to focus on staying alive another day (Reinink, 2010).

Even in the best of times, subcontractor firms struggle to expand. For such companies, if the economic situation is sluggish and unpredictable, these firms find it difficult to sustain. In the worst of times, these subcontractors may face more unexpected challenges and problems and this will ultimately have an impact on their business survival. However, if the subcontractor firms are prepared with strategies such as having broader access to capital, and heightened bargaining power, this enables them to pursue growth strategies despite economic downturns. Hence, it is important for the players in construction sector to implement suitable survival strategies for their business to not only survive, but to also thrive.

This study is focusing on the subcontractors' perspective on how their business survived in the recession period, such as the different types of business strategies adopted to stand out from the competitive environment. There is a lack of research into the adaption of subcontractors in the comparative market in Malaysia. In addition, the study also highlights if there is any difference in the survival strategy implemented between subcontractors who often specialised in one specific of construction work and those who work for the project and main contractors.

RESEARCH OBJECTIVES

This study is expected to achieve the objectives as follows:

i. To identify the prevalent challenges faced by subcontractors in the industry.
ii. To determine the common survival strategies adopted by subcontractors in response to survive in the construction industry.

LITERATURE REVIEW

Types of Challenges Faced in the Construction Industry

Labour Shortages

The Malaysian construction industry has been experiencing a critical shortage of workforce. Nowadays, the local workers are unable to fulfil the demand of the construction market for time being. This reason causes the contractor to be willing enough to import foreign workers from overseas to meet the needs of the labour market in construction sector. According to Kwan Foh Kwai, the President of MBAM (Master Builder Association of Malaysia), he mentioned that shortage of skilled construction workers is a very crucial issue in construction industry (The Star Malaysia, 2010). Besides, MBAM also stated that, the acute shortage of skilled workers in the construction industry will give a negative impact towards the projects under the Malaysian Plan (10MP) and Economic Transformation Programme.

A current topical issue relevant to the Malaysian construction industry is the quality of workmanship. According to REHDA (Real Estate Housing Developers' Association Malaysia, the quality of products including housing and buildings are related directly to manpower and their skill. It seems that the construction industry has failed to attract workers in the skilled and semi-skilled trades. The 3D (Dangers, Dirty, Difficult) perception has discouraged skilled local workers from joining the construction sector locally. This results in a lot of jobs available are currently executed by untrained construction workers. REHDA stated that, the important issue from the shortage of skilled labour is one of the factors that contributed to the increase of property prices (The Star, 2011).

Financial Constraints

Financial constraints are a limiting factor to building activity – the joint highest reading in five years. Researchers often cite financial constraints to be cause difficulties in recent financial reports, and more specifically they are bank finance and credit, cash flow, liquidity challenges or less favourable cyclical market conditions (Aghimien et al., 2018).

According to a survey conducted by TSheets (2018) and Levelset (2019), the findings show that most of the construction firms are struggles with the cash flow problem due to the delayed payments from clients. The survey reported that most of the construction firms do not received payments on time and this leads to cash-flow problems, incomplete work and even liquidation of assets. Generally, these are the financial constraints facing emerging contractors.

Technology Adoption

It is necessary for contractors to catch up to the recent technology. They will need to use more and better cloud-based software, and integrated collaboration tools. The use of Building Information Modelling (BIM), drones and laser scanning are some of the cutting edge technology that will continue to grow in the industry. However, technology has come later and more sporadically to the construction industry, there is less uniformity, as general contractors use a wide variety of technology. This can be overwhelming for subcontractors, architects and owners who try to work with general contractors. It is leads to increased costs and delays if subcontractors are in the midst of learning the new technology.

Competitive Rivalry within the Industry

Economic recessions will cause contractor credit conditions to become tighter and increased difficulty in obtaining credit insurance (University of Craivora, 2010). However, in an economy downturn, there is also a possibility that developers have lesser credit or capital to start a new projects or construction processes. It will cause lesser demand since the number of contractor firms remain the same, and larger projects are potentially obtained by the more established firms, as a result, competition between contractor firms will increase. Many contractor firms may find it difficult to obtain projects in order to sustain their company. Meanwhile, most contractor firms are forced to lower their tender price in order to compete and obtain projects.

Types of Survival Strategies taken by Construction Firms

Contract Marketing

Constructing-related actions are those approaches adopted by contractors in exploring every possible way of obtaining work to maintain their turnover (Hillebrandt, Cannon and Lansley, 1995). The study in UK by Tansey and associates found that the importance of bidding or taking on small contracts was the way they were able to survive during economic turmoil (Tansey, Meng and Cleland, 2013). The surveyed contractors supported that even smaller contracts were vital part to their business as the practise adopted enabled them to survive and create competitiveness among their peers.

In the studies by Hillebrandt and associates and Lim and associates, some of the contracting-related actions were during the economic recession, the contractors carefully considered the payment conditions before entering a project and also considered the client's ability to make payment (Hillebrandt, Cannon and Lansley, 1995). This was practiced due to the fact that surveyed contractors faced the problem during the recession period like not being able to receive payments even after the projects have been completed and assessed months ago (Lim, Oo and Ling, 2010). Hence, these contractors considered the payment conditions and client's reputation, and also financial stability before entering contracts to prevent disputes and problems of cash flow (Lim, Oo and Ling, 2010).

Human Resource Management

A number of studies on the construction industry's response to the recession have noted changes to employment patterns. Hillebrandt and associates explained this strategy is commonly implemented during economic recession for the need of cutting down overhead costs (Hillebrandt, Cannon and Lansley, 1995). Lim and associates studied that the contractors surveyed adopted actions of laying off employees for cost control during the recession (Oke, Aghimien and Adedoyin, 2018). Based on the research by Hillebrandt and associates and Lim and associates, both studies have shown the negative trends actions that were taken by the companies during recession; for example, freezing of employees' salary, cutting of bonuses and overtime, decreasing the pay to employees, delaying of employees' salary and others (Lim, Oo and Ling, 2010).

However, another finding from Lim and associates showed that the surveyed contractors from their study did not apply the actions of laying off the employees instead they maintained their employees during recession as the employees was one of the company's assets (Teo, 2019). Another action taken in Hillebrandt's study was some of the companies acted on converting their permanent employees into temporary placements, hence, it able to lay off unnecessary workers and achieved more financial control (Hillebrandt, Cannon and Lansley, 1995).

Diversification of Work

Hillebrandt and associates mentioned that diversification can include backward integration (diversification into business with inputs into the main operations), forward integration (expansion into the business activities of those firms who would typically purchase the outputs of the main operation) and horizontal integration (integration into other markets not linked with the existing business) (Hillebrandt, Cannon and Lansley, 1995).

Differentiation is to change the appearance of what the firm is providing to create a point of difference from its competitors (McCabe, 2010). In the construction industry this could involve offering innovative services, such as design and build packages or capitalizing on niche markets such as sustainable buildings.

Financial Management and Investment

Correct Financial Management is an important contributor to the success of any company. An interesting study had conducted a research which focused on studying the reasons for company failures in the construction industry- which included budgetary problems including insufficient profits, heavy operating expenses, insufficient capital & institutional debt accounted for over 40% of all failures (Arditi, Koksal and Kale, 2000). These budgetary issues are noted as internally controlled by the companies (Arditi, Koksal and Kale, 2000). Mutti and Hughes (2002) highlight that their research noted the main causes of insolvency in construction is inadequate management as the most common reason, followed by a lack of financial control.

Other studies have noted the importance of reducing operating costs for survival. Hillebrandt and associates study found that reducing both employment costs and head office costs is another strategy adopted by majority of firms to survive (Hillebrandt, Cannon and Lansley, 1995). Meanwhile, Lim and associates state that other than reducing employment costs, 100% of firms attempted to control costs by implementing stricter site management, reducing material wastage and implementing stricter procurement procedures (Lim, Oo and Ling, 2010). The lack of cash flow management and budgetary control is a major cause of business failure within the construction industry (Boateng et al., 2019). Information on cash flow modelling and forecasting is relatively easy to find, and being such a major cause for company failure, it seems construction firms simply need to take the concept more seriously. Furthermore, Lim and associates' research recorded that most firms chose to implement stricter financial management on company cash flow during recession (Boateng et al., 2019).

RESEARCH METHODOLOGY

A questionnaire survey was adapted and conducted for the research to obtain data from the targeted population. A five-point Likert scale was incorporated into the questionnaire survey.

The questionnaire was distributed via email using Google Form survey due to its effectiveness and anonymity for the respondents. This was complemented with a follow up call to each respondent after the emails have been sent out to ensure a better response rate.

The scope of the study is limited to the contractor firms which mainly specialized in building works registered under Construction Industry Development Board (CIDB) Malaysia; ranged from Grade 1 to 7; the geographical location focused on Klang Valley, Malaysia, only for reason to understand the impacts towards the subcontractors who are trying to survive in Malaysia's most crowded city. The suggested reliable target sample size of Klang Valley respondents is to be at least 50 numbers to run the Relative Important Index analysis (Pallant, 2007).

Descriptive analysis was used in analysing the data of this study by using mean analysis. Relative Important Index was then used to arrange the variables for discussion.

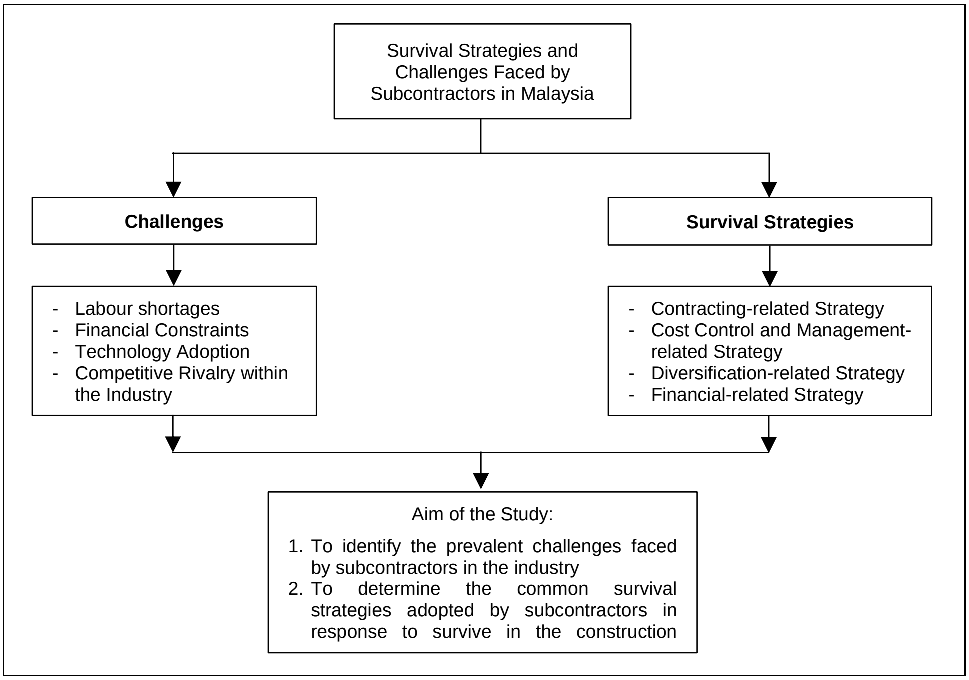

Figure 1. Research Framework

DISCUSSION & FINDINGS

Respondent's Background

The figure below shows the location of the subcontractor's firm where the respondent is located. Based on the data collection, majority of the respondents' firm is located in Selangor with a total number of 44 (70.97%) whereas the respondents' firm located in Kuala Lumpur has a total number of 18 (29.03%).

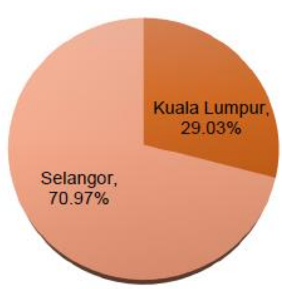

Figure 2. Location of Respondent's Firms

Figure 3 illustrates the number of respondents on their firm's Contractor Registration Grade under CIDB Malaysia. Based on the graph analysis, the highest firm grade is the respondents from Grade 6 with a percentage of 27.4% and this is followed by Grade 5, with a percentage of 25.8%. Surprisingly, the response of Grade 7 achieved a slightly low target compared to responses from Grade 6 and Grade 5, which consists a total of 14.5%. This is followed up by the responses from Grade 3 and Grade 4 with at a percentage of 11.3% . The lowest rate for this survey is from Grade 1 (3.2%) and Grade 2 (6.5%) respectively.

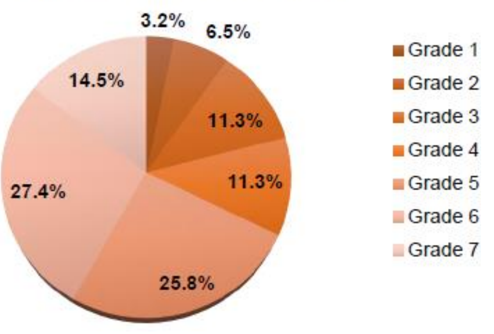

Figure 3. Respondent's Contractor Grades

Challenges Faced by Subcontractors in the Industry

Table 1 shows the 15 common problems faced in the construction arena that is further categorised into four main challenges: Labour Shortages, Financial Constraints, Technology Adoption and Competitive Rivalry within the industry.

The top challenge facing in the industry is low demand for construction projects due to the economic downturn (RII 0.835). Due to the low demand for projects in the industry, it then derives another challenge to subcontractors that is intense competition for bidding limited projects (RII 0.781). These problems can cause difficulties to the subcontractors in bidding projects to sustain their company as they are forced to bid lower tender price and with tiny or zero profits to secure projects.

The second highest rated challenge by respondents are facing a shortage of local workers due to 3D (Dirty, Difficult, Dangerous) factors. Few of the respondents commented that there are increased difficulties in applying for local workers and especially in recent years less members of the younger generation choose to work in the industry. Shortage of foreign labours is another problem facing the industry. This problem is due to the renewal of foreign worker's permit (RII 0.765) and unattractiveness exchange rate conversion (RII 0.732). With the prolonged downturn and the issues of changes in the government, the foreign labours had an issue on a period of invalidity for their working permit that caused the construction industry some major issues on recruiting foreign workers to work on-site.

The next challenge that was agreed by the majority of respondents is the inflation (RII 0.803), for example, an increase of material price, equipment, machinery as well as wages for labourers. The inflation is the cost escalation for the subcontractors that are working in a project, and mostly the project has tiny or zero profits that were caused by the bid during the downturn for work security. The challenge causes the subcontractors to earn less interest and indeed causes an extra payment for the inflation costs.

The fourth common challenge by subcontractors is that the majority of them had problems with cash flow (RII 0.781). This challenging issue is faced by subcontractors who usually have an insufficient cash flow due to delays of claim payments and this impacts their inability to pay for debts such as purchases and wages. The respondents had commented that their insufficient cash flow problem is caused by the withholding of progress payment by the client (RII 0.735), especially during the downturn period. Some of the respondents facing issues on their client's poor financial management and thus causing payment delays (RII 0.706).

Table 1. Analysis of Respondents on Identified Types of Challenges Faced in the Industry

Challenges Identified		Likert Scale					Mean	RII	Rank
		1	2	3	4	5			
A13	Low demand of construction projects due to economic downturn	0	2	11	23	26	4.177	0.835	1
A12	Shortage of local workers due to 3D factors (Dirty, Difficult, Dangerous)	0	6	12	16	28	4.065	0.813	2
A6	Inflation (e.g.: increase of material/equipment/wages)	0	6	12	20	25	4.016	0.803	3
A5	Problems of Cash flow (e.g.: delays of claim payment, unable to pay for materials and wages)	2	4	13	22	21	3.903	0.781	4
A14	Intense competition for bidding limited projects	0	7	11	25	19	3.903	0.781	5
A9	Shortage of foreign labours (e.g.: due to renewal of foreign workers' permit)	1	6	13	25	17	3.823	0.765	6
A2	Withholding of progress payment by client	0	5	20	27	10	3.677	0.735	7
A10	Shortage of foreign labours (e.g.: unattractive exchange rate conversion/ low wages)	0	8	11	37	6	3.661	0.732	8
A15	Modernizing of the construction sector (e.g.: using of IBS/technology for fasten the project)	1	3	20	30	8	3.661	0.732	9
A1	Client's poor financial management causing payment delays to contractors	1	11	13	28	9	3.532	0.706	10
A11	Insufficiency of skilled workers	2	2	36	12	10	3.419	0.684	11
A8	Changes of Government Policy/High taxes rate	1	15	14	27	5	3.323	0.665	12
A3	Invalid claim submitted by contractor causing delay of payment received	6	16	20	19	1	2.887	0.577	13
A7	Fluctuation of interest rate	11	8	23	17	3	2.887	0.577	14
A4	Conflict/ Disputes between client and contractor	10	22	10	12	8	2.774	0.555	15

Types of Survival Strategies Adopted by Subcontractors in Response to Survive in the Construction Industry

A total of 28 actions taken were organized into four categories of construct by using validity analysis as per shown in Table 2 to predetermine the models grouping before the final RII analysis as following:

(1) contracting-related strategy;
(2) cost control and management-related strategy;
(3) diversification-related strategy;
(4) financial-related strategy.

Table 2. Total Variance Explained Table from Validity Analysis

Total Variance Explained									
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	14.200	48.966	48.966	14.200	48.966	48.966	9.434	32.530	32.530
2	5.254	18.118	67.084	5.254	18.118	67.084	8.841	30.487	63.018
3	4.687	16.161	83.245	4.687	16.161	83.245	5.866	20.227	83.245
4	3.958	14.304	83.549	4.245	15.345	78.469	5.129	19.786	78.569
5	.760	2.619	89.168						
6	.531	1.830	90.998						
7	.360	1.241	92.239						
8	.305	1.051	93.290						
9	.244	.843	94.133						
10	.222	.765	94.898						
11	.197	.679	95.577						
12	.188	.647	96.224						
13	.155	.535	96.759						
14	.124	.427	97.186						
15	.116	.399	97.585						
16	.103	.356	97.941						
17	.095	.328	98.269						
18	.093	.322	98.591						
19	.079	.271	98.862						
20	.070	.242	99.105						
21	.059	.204	99.309						
22	.048	.166	99.475						
23	.041	.143	99.617						
24	.034	.117	99.734						
25	.024	.084	99.818						
26	.022	.077	99.895						
27	.013	.045	99.940						
28	.010	.035	99.975						

Extraction Method: Principal Component Analysis.

The following is a detailed analysis of the research findings. Each category is analysed and summarized in descending order according to RII value.

Table 3 shows the 12 contracting-related actions adopted by contractors. The top contracting-related actions that considered the most (RII 0.758) based on the responses are considering the payment terms carefully before entering the projects. This means that the respondents were attentive on their interest and made sure they are getting payments, especially during the economic downturn due to limited capital available. This top ranked action is supported by the second rank action at RII 0.755, which is considering the client's ability to make payment. Due to the economic downturn, the contractor firms are usually in a tight situation on financial aspects; hence, it is vital for the contractors to considered client's ability to prevent no payment received or late-payment issues.

Table 3. Contracting-Related Strategy Actions

	Actions Identified	Likert Scale					Mean	RII	Rank
		1	2	3	4	5			
B12	Considered carefully the payment terms before entering the projects	1	2	13	29	17	3.952	0.790	1
B11	Considered the client's ability to make payment	1	2	17	28	14	3.839	0.768	2
B5	Undertaking smaller contracts	0	3	20	26	13	3.790	0.758	3
B1	Bidding more projects that are within company's resources and ability	2	3	13	41	3	3.645	0.729	4
B4	Undertaking short-term and fast track projects	0	11	17	19	15	3.613	0.723	5
B7	Subcontracting work from other contractors	0	5	20	31	6	3.613	0.723	6
B10	Maintain a good long- term relationship with existing clients and suppliers	0	5	24	24	9	3.597	0.719	7
B9	Bidding a low tender price to secure projects	2	8	16	31	5	3.468	0.694	8
B8	Forming partnership/ contract with clients	1	13	22	20	5	3.246	0.649	9
B2	Entering contracts with suppliers and subcontractors to protect firm's cost escalation	6	6	23	24	3	3.194	0.639	10
B3	Bidding projects with tiny or zero profits	5	15	25	17	0	2.871	0.574	11
B6	Joint venture with other firms to explore business opportunities	10	13	20	15	4	2.839	0.568	12

The next action that was considered by the respondents during the economic downturn is undertaking on smaller contracts (RII 0.755) and short-term and fast track projects (RII 0.742). This action is suggested by reference [5] for the companies to bid for more smaller contracts in recession. It also agreed by reference [7] survey, that taking on short-term projects are less stressful and importantly since the clients are concerned more on the speed of work and they can pay for the works in a shorter period, hence this can improve the contractor's cash flow.

Where there are fewer projects available during the economic downturn, the competition in the construction industry then arise. The respondents had taken actions to bid a lower tender price to secure projects (RII 0.32) and bid projects in tiny or zero profits (RII 0.684). The action was to win for bidding projects that enable their companies to maintain cash flow and their business survival in the industry. This action is similar to the findings of reference [5] and reference [11] that the strategy of bidding projects at a low tender price with tiny or zero profits is common during a recession. The action can reduce the possibility of loss that is projected by negotiating with suppliers and subcontractors for the lowest prices.

Other actions such as maintaining a good long-term relationship with existing clients and suppliers (RII 0.735), so the contractors can enter contracts with suppliers and subcontractors to protect their business from cost escalation (RII 0.706). The results show some of the surveyed respondents do consider forming a partnership with clients (RII 0.732) in order to secure projects.

Table 4. Cost Control & Management-Related Strategy Actions

	Actions Identified	Likert Scale					Mean	RII	Rank
		1	2	3	4	5			
C6	Converting permanent employees into temporary placements (e.g.: contract-based)	3	12	18	19	10	3.339	0.668	1
C2	Delaying salary of employees	3	17	16	25	1	3.065	0.613	2
C3	Laying off employees	9	17	16	20	0	2.758	0.552	3
C5	Cutting employees bonuses/overtime	10	18	13	19	2	2.758	0.552	4
C4	Cutting employees' salaries	11	19	20	11	1	2.548	0.510	5
C1	Freezing salaries of employees	23	30	4	5	0	1.855	0.371	6

Table 4 shows the six cost-control and management related actions adopted by respondents. The findings show the respondents prefer to convert permanent employees into temporary placement, for example, a renewable contract basis that usually for two to three years. One of the respondents commented that their company had converted few permanent employees into contract basis that work only for a particular project for a period of three to five years. This contract basis action can fix the company's financial control as the salary is usually an agreed amount in the contract years without increasing the salary.

The next common action by respondents is their company delays employees' salary (RII 0.613). In contrast, the majority of the respondent's company did not practice freezing employees' salary (RII 0.371). This means that the majority of the companies rather pay late for their employees but they do not practice not paying the salary even during the economic downturn. This agrees with reference [12], reference [13] and reference [7] findings on the contractors explaining the difficulties and stating that the delaying of salary payments to their employees in the hard times.

The two actions in the findings shared the same RII (0.552), the respondent's company taken practice for laying off employees and cutting overtime, including bonuses as a cost saving measure. This action is taken to reduce the company's overhead cost. However, it is crucial to notify the employees before doing this exercise.

Table 5. Diversification-Related Strategy Actions

	Actions Identified	Likert Scale					Mean	RII	Rank
		1	2	3	4	5			
D3	Focusing in a particular expertise	2	3	26	26	5	3.468	0.694	1
D1	Diversifying into other construction-relation business (e.g.: renovation works for residential)	4	16	19	21	2	3.016	0.603	2
D2	Diversifying into any non-construction related business	4	21	26	11	0	2.710	0.542	3

Table 5 above shows in diversifying category that majority of contractors agreed on the action of focusing in particular expertise (RII 0.694), for example, painting works, tiling works as the bargaining of entry-level is comparatively low than other expertise. The next action that considered by respondents that had diversified into other construction-related business (RII 0.603), for example, renovation works, property maintenance, road and infrastructure work [7]. The preferences of this action can be in order to obtain turnover and maintain their company during the intense competition in the economic downturn. The least preference action by respondents is diversifying into non-construction related business.

Table 6. Financial-Related Strategy Actions

	Actions Identified	Likert Scale					Mean	RII	Rank
		1	2	3	4	5			
E7	Trying new methods and technologies for improved productivity that save money	2	4	20	22	14	3.677	0.735	1
E4	Implementing stricter financial control to ensure positive cash flow	1	11	16	18	16	3.597	0.719	2
E1	Sourcing for alternative loan services (e.g.: long term/ short term bank loan)	2	9	16	31	4	3.419	0.684	3
E5	Sourcing alternative funds by selling assets (e.g.: property/ machine/equipment, etc)	2	6	29	23	2	3.274	0.655	4
E2	Investing machine with high liquidity value	3	20	22	15	2	2.887	0.577	5
E3	Investing surplus funds in financial investment	10	21	18	10	3	2.597	0.519	6

Table 6 shows the top action that agreed by respondents in financial-related strategy is trying new methods and technologies for improved productivity, so that enables to save money (RII 0.735). This means the respondents find the importance of technology adoption in construction works was able to improve productivity and mitigate cost wastage.

The second common financial related practice by the contractors is implementing stricter financial control to ensure positive cash flow (RII 0.719). The action is supported by Lim et al. (2010) that by adopting stricter financial control, it is seen as one of the keys to survival during the economic downturn. Other than that, the contractors do take action in sourcing for alternative loan services (RII 0.684); for example, long-term or short-term bank loan, to finance for the capital and debts. The action is in agreement with the reference Hillebrandt, Cannon and Lansley (1995), Abu Hassan et al. (2008) and Tsheets (2018) findings that it is a common strategy that implements to source for finance debts and expenses during the economic recession.

Some respondents had to source alternative funds by selling company' assets (RII 0.655), for example, property and machinery as well as equipment in order to obtain alternative money. One of the respondents mentioned that funds from assets selling which can only support the financing for a short period due to its amount limit and availability of debts.

The two least actions practice by subcontractors are investing machine with high liquidity value (RII 0.577) and investing surplus funds in financial investment (RII 0.519). The low adopted actions may be due to limitation of capital, and the contractors may do not want to invest in machinery.

The findings drawn from this research has shown how Malaysian subcontractors survive in the present turmoil, in which the findings is comparably exceptional when compared to other countries as each country has their own unique operational matter, law and regulations which are non-identical.

CONCLUSIONS

This research has identified the typical challenges faced and the type of survival strategies action taken by local subcontractors. This research findings may not able to represent overall of the subcontractors in the industry, however, it provides a perspective from surveyed respondents towards actions taken to during economic downturn (Levelset, 2019). From the analysis, the findings discovered that majority of the respondents are aware of the type of survival strategies that can be taken into action during prolonged downturn. The study findings RII ranking shown majority of subcontractors' preference adopted in contracting-related actions and financial-related actions as their survival strategies from the tested model of 4 constructed generated on this study (Ogbu and Olatunde, 2019). Despite that the challenges and strategies may differ over the time, this study providing insights on how the subcontractors company respond during the economic downturn and the actions suggested as referencing idea for subcontractors in order to survive in the competitive industry. Moreover, this study has developed a framework that could reflect a significant effect and implication of the contractor survival strategies in which mainly for Malaysian context (Mengistu and Mahesh, 2019).

LIMITATIONS OF STUDY

There are a few limitations in this study which to be taken into consideration. The first limitation of this study is the low response rate. No doubt that the email survey is one of the efficient data collection methods to collect quantitative data that are sent to target respondents; however, it is acknowledged that there is a factor of the low return of responses and it limits the survey's ability to reach all demographics. Besides, even if the sampling size is widened to all contractors' grade to improve the response of findings, however, only low numbers of contractors are returning the survey, and the survey time-frame is only for three weeks, possibly resulting in the low response rate of survey.

The second limitation carrying out this study, despite being able to get the contractor's listing from the CIDB registration website, it faces an issue on identifying the identity of the contractor firm ranged in Grade 7, whether as a developer, main contractor or subcontractor. Therefore, it takes extra timing to search if the randomly selected companies have fulfilled the requirements as a target respondent.

Furthermore, the study is only expected to serve as a framework idea for the subcontractors on the types of common strategy that can be taken for business survival in the construction industry. It may not be able to draw the best recommend strategy and conclusion; however, it expected as a general guide for the subcontractor's company. Also, this study findings may not be applicable for all subcontractors in Malaysia as the study only focused results in Klang Valley, where the other locations might adopt a different type of survival strategies and faced different construction challenges.

Moreover, it is difficult to restrict the position of each respondent in return the survey to achieve the reliability and validity of the findings. The findings of this study may be varying due to the respondents' position in the company and working experience in the industry.

RECOMMENDATIONS

This study can further explore and expand more in-depth from the limitation findings as below:

1. Expand the research's geographical area instead of limited only in Klang Valley. The different geographical area might result in different on the common challenges faced and the types of survival strategy taken, in relation to the location's culture, population and political factors. Hence, it might be useful and interesting if an in-depth study can be further carried out.
2. Extend the survey time frame on data collection for more responses. Due to this research survey's low response rate, it is recommended to lengthen the data collection up from four to eight weeks for a better response rate.
3. Carry out analysis integrated into a structural questionnaire or interview questionnaire to quantify the frequency ranking of challenges and survival strategies adopted among the subcontractors for the validity of results. Besides, the selection of interviewees should be restricted to senior management to maintain the reliability of the data obtained.

4. Further studies can also be considered in a comparative analysis between main contractors and subcontractors in adopting different survival strategies and common challenges faced in the industry.

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STATUS OF SUSTAINABLE CONSTRUCTION PRACTICE IN MALAYSIA : A REVIEW PAPER

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Abstract
Implementing sustainable construction is very important in all developing countries. Malaysia suffers from many serious environmental issues due to irresponsible actions, which include the involvement of construction activities. All parties in the construction industry need to take responsive actions to implement sustainable construction. Previous research has revealed that the implementation of sustainable construction still needs all parties in the construction industry to make improvements. The aim of this paper is to attempt to report on the current status of sustainable construction practice in Malaysia. This paper contains two (2) objectives which are to explore current developments in Malaysia and to determine the status of sustainable construction practice in Malaysia which covers government support, regulation enforcement, a rating system and the consciousness of both developer and consultant in terms of implementation. This article employs a theoretical review of the literature on the status of sustainable construction practice in Malaysia. From the review, it can be concluded that Malaysia is still progressing towards sustainable construction but needs further improvement.

Keywords: *Sustainable construction; sustainable development; consciousness.*

INTRODUCTION

Due to the many possibilities of building ventures and renovation, the material demands of the construction industry are growing. As a resource-intensive industry that contributes to the national economy, it requires substantial natural resources, which has led to adverse environmental and human health effects (Kibert, 2013). The construction industry is one of the main causes of environmental degradation due to human greed (Abidin, 2010a). Therefore, all parties involved in the construction industry need to work together through sustainable construction to reduce the environmental impact problem. In Malaysia, this idea was applied and proposed by the government of Malaysia in 2000 to prevent this issue from becoming ever more prevalent (Abidin, 2010b). Since then, several discretionary government initiatives, projects, and activities have been implemented to incorporate the idea of sustainable construction, but the status needs to be kept up-to-date and reviewed in order to see the success of sustainable construction in Malaysia.

ORIGIN OF SUSTAINABLE CONSTRUCTION

Many countries have long recognized the importance of sustainable construction and implemented it. The root of the acts and promises started with a debate that took place in Rome in 1968 called the Club of Rome-Limits to Growth, 1968. The topics addressed included the interaction of political aspects in technological, social, and economic terms. Following these discussions, the so-called Meadows-Meadows theory report was released. This claimed that in order to obtain more oil, investment was needed at an early stage and this in return would enable energy costs to be cut. In a continuation from that, the UN

Conference on the Human Environment (UNCHE) in 1972 committed itself to fostering sustainable development. The conference was responsible for making the topic of the environment relevant, and involved in political issues. Then, in 1981, the World Conservation Union was established, which took sustainable development into account. It then became the subject of the Brundtland Commission, formerly the World Environment and Development Commission (WCED), created in 1987. In this context, the United Nations Conference on Environment and Development (UNCED) was formed in 1992 to discuss the conditions of sustainable development and to consider actions across the world. Starting from this, many more initiatives or events have been set up to promote a sustainable response to this growth (Halliday, 2008). The importance of sustainable building in promoting sustainable development can be seen through the presence of these efforts.

PROBLEM STATEMENT

The philosophy of sustainability consists of three main pillars: conservation of the environment, economic prosperity and social well-being (Addis & Talbot, 2001). It is a demanding task due to its complexity, renewable energy generation and distribution infrastructure programs, which are affected by several existing building problems (Pietrosemoli & Rodríguez, 2013). In Malaysia, many efforts have been made by all parties to introduce sustainable construction, such as the Construction Industry Development Board (CIDB), which has been proposing sustainable infrastructure to improve local activities and increase capacity from 2015 (CIDB, 2015). It was developed because of the country's problem of catastrophic year-end floods. However, since sustainable building was introduced in 2000 (Abidin, 2008), Malaysia has still faced challenges in shifting the mindsets of real estate developers to turn to sustainable methods of construction, because of the growing concern that sustainability is relatively expensive (Asia Green Building, 2015). Therefore, other building professionals also lack an understanding of sustainable construction and need to be motivated to deepen their knowledge of the subject (Hock, 2015).

RESEARCH QUESTION

This article therefore seeks to answer the following research questions in light of the above:

i. What is the current development in Malaysia?
ii. What is the status of sustainable construction practice in Malaysia?

RESEARCH METHOD

An attempt was made to present a general overview of sustainable construction in Malaysia based on the available literature on the subject. The approach of this study was to use ScienceDirect, Google Scholar, electronic scientific databases, and the analysis gate and website. The selection of the scientific papers was easy to find, and most of them were reviewed. To present Malaysia's status on sustainable construction, it seemed appropriate to divide the article into the following subchapters:

1. Current development in Malaysia
2. Compliance of Government support and control
3. Sustainable rating system
4. Consciousness in sustainable construction practice
5. Findings and discussion
6. Conclusion

STATUS OF SUSTAINABLE CONSTRUCTION PRACTICE IN MALAYSIA

Current Development in Malaysia

By contributing revenue sources, the construction industry in Malaysia is an important sector of the national economy. Statistics collected from 1991 to 2010 indicate a clear association between the building sector and economic growth (Ali et al., 2014). In national economic aggregates, the construction sector has played an important role in contributing to revenue generation, capital growth, and employment creation that ultimately supports Malaysia's gross domestic product (GDP), and socio-economic development (Ali et al., 2014). As the construction sector has significantly contributed to the national economy, the government needs to pay attention to and concentrate on the construction sector in order to qualify as a developed country (Ali et al., 2014). Not only does the sector contribute to industrial growth, but it is also a gateway to other industries (Halliday, 2008; Grovera & Froesea, 2016).

Today, the field of construction and development is highly attractive to investors from the foreign market economy (Addis & Talbot, 2001). The needs for technical and engineering advancement has become a phenomenon in the industry as regards the management of construction projects (Addis & Talbot, 2001). Additionally, new relationships have been established in the construction sector. Therefore, the Malaysian construction industry needs to invest in research and development (R&D) to create incentives for the construction industry (Grovera & Froesea, 2016). Support for public education to conduct research and find new ways of enhancing construction operational efficiency is also necessary (Bahaudin et al., 2014).

Nowadays, the construction industry in Malaysia definitely lacks proper standards in terms of the construction process, such as the control of pollution due to CO_2 emissions, dust and other contaminants which have a negative effect on the surrounding environment (Bahaudin et al., 2014). The government is incessantly seeking to resolve the situation (Omardin et al., 2015). In all such aspects, Malaysia has set the following goals to achieve more sustainable development (Omardin et al., 2015):

- Enable green growth of the environment
- Take on the idea of sustainable consumption and development
- Conservation of natural resources for current and future generations
- Fortify resistance to climate change and natural disasters

The above mission shows that Malaysia is still moving towards sustainability in construction and towards achieving sustainable development in conjunction with other countries (Omardin et al., 2015). However, sustainable construction is still in its infancy according to Shari (2012) (Soebarto, 2012). Many people are worried about the high cost of green technology, while long-term cost-cutting energy consumption is still ignored (Shari & Soebarto, 2012).

As a result of demands for progress in leadership, poverty, inequality, and climate change, the 2030 Agenda for Sustainable Development was adopted in New York on 25 September 2015 after a United Nations debate which included Malaysia (Yiing et al., 2013). The United Nations Development Program (UNDP) has worked to help promote poverty eradication and the elimination of deprivation and exclusion in over 170 countries and regions.

Support and Monitoring of Policy Enforcement

It is very important to promote the idea of sustainable construction. This involves making extensive and effective recommendations for regulatory requirements, as well as securing clear support for sustainable construction (Malaysia, 2016). The Minimum Energy Performance Standards (MEPS), which implement the minimum level of energy efficiency of electrical equipment and lighting, are among the programs developed by the government. For commercial purposes, the amount must meet or exceed the criteria or basic capability (JKR, 2019). A Feed-in Tariff (FiT) scheme has also introduced a mechanism to ensure that industrial firms and individuals can invest in renewable energy over the long term (Darus et al., 2009).

Several policy interventions and programs, such as the application of the Environmental Management Plan (EMP), have been initiated to ensure that construction projects are sustainably built during the construction process. Unfortunately, rapid urban growth is still occurring, and this pollutes the atmosphere. The productivity methods of sustainable construction have been found to be very limited. To implement the EMP, many requirements must be considered which especially focus on environmental aspects and social and economic development (Shari & Soebarto, 2012).

Policy agencies such as the Construction Industry Development Board (CIDB) play important roles in the achievement of the construction sector in line with sustainable construction. The goal of the CIBD is to enhance the building industry's capacity and capabilities by integrating quality and productivity through the growth of professionals, creativity and expertise. This involves improving the quality of life (Pietrosemoli & Rodríguez, 2013). International Construction Week 2016 (ICW, 2016) was one of the strategies initiated by the CIDB to support sustainable construction. This took place under the theme of 'Driving Productivity in Construction,' which highlighted state-of-the-art technology. The strategies of this event were to boost productivity and sustainability in construction, specifically Automated Building Systems (IBS) in industrial housing (Pietrosemoli & Rodríguez, 2013).

Malaysia also entered into a major collaboration with the Real Estate and Housing Developers’ Association (REHDA) with the signing of a Memorandum of Collaboration (MoC) to support low-carbon and sustainable practice. With features like MyCREST, it also intends to measure and reduce carbon emissions. By implementing MyCREST, industry players like developers will be driven to implement a greater number of processes within their projects that are environmentally friendly (Pietrosemoli & Rodríguez, 2013). Other than that, the CIDB has also recommended the Center of Excellence (CoE) for Sustainable Infrastructure under the Second Master Plan for the Construction Industry, in a way does not minimize social, economic and ecological processes to sustain human dignity, biodiversity and the resilience of natural systems.

In addition, the CIDB has also identified Construction Industry Transformation Programme (CITP) is to strengthen the current paradigm for continuing the task of sustainable construction. The CITP puts forward five main measures to overcome these challenges (Pietrosemoli & Rodríguez, 2013):

Initiative E1: Fostering Sustainable Construction

Center of Excellence (CoE) for Sustainable Building is to be the "home" of sustainability in construction. The implementation is to be conducted through a variety of programs and responsibilities. The CoE also plans to raise awareness of sustainability among industry players and key stakeholders, offering sustainable training and skills courses in Malaysia at an acceptable rate.

Initiative E2: Force Compliance with Environmental Quality Ratings and Criteria

Enforcement will be driven by systems of Environmental Sustainability Ratings and Requirements. Considering the significance of environmental sustainability as a market engine and growth engine, ensuring a robust suite of sustainability rating systems in Malaysia will be crucial. CITP suggests the integration of existing building rating tools or programs (e.g., MyCREST, BCA Green Mark, BREEAM, and the like) and the creation of a Malaysian infrastructure rating tool.

Initiative E3: Focus on Public Projects to Navigate Sustainable Responsibility

Emphasis should be placed on public projects leading the way in sustainable practices. It is suggested that sustainability criteria for main public projects should be implemented under the CITP. The CITP suggests improvements in procurement within the public sector to improve the components of sustainability in its requirements and the Bill of Quantities. This involves setting basic sustainability standards for particular public projects, then using them with high-profile projects to demonstrate the financial and technological potential of sustainable development.

Initiative E4: Encourage the Development of Sustainable Practices in Industry

The CITP suggests adequate frameworks and opportunities to promote the development of environmentally sustainable growth within the private sector. Such initiatives would include both financial and non-financial incentives and encourage progress towards sustainable development.

Initiative E5: Reduce Excess Waste During Construction

Reducing waste during construction activity should improve developers' waste production and waste management policies. This would allow building players to develop material procurement practices to reduce waste while increasing rates of reuse and recycling.

Current Development in Malaysia

In order to quantify changes in the environmental efficiency of buildings that relate to existing standard practices, it is necessary to implement methods of assessment (Shi et al., 2012). To determine the requirements of sustainable construction, stakeholders must understand and learn whether certain elements should be mentioned to strengthen sustainable construction (Mokhtsim & Salleh, 2014). In addition, to decide the extent of the quality of a sustainable construction project, a quality rating system should be provided. Rating systems from other countries include (Malaysia, 2016):

i. BREEAM (Building Research Establishment Environmental Assessment Method). This provides detailed criteria and a grading system for advanced buildings.
ii. LEED - In the United States, the USGBC developed an American building rating system with the acronym LEED (Leadership in Energy and Environmental Design).
iii. CASBEE (Comprehensive Assessment System for Building Environmental Efficiency) in Japan (2004) and Green Star in Australia (2006).
iv. DGNB - In Germany, which has always had a strong tradition of high-performance buildings, the German Green Building Council and the German government collaborated in 2009 to develop a building rating system.

In Malaysia today, many rating systems are used to evaluate the sustainability of buildings, such as the Green Performance Assessment System (GreenPASS), the Green Assessment System in Construction (GASSIC), the Green Real Estate (GreenRE) and the Public Works Department (PWD) Green Rating Scheme. These assessments are among the outcomes of the Low Carbon Cities Framework and Assessment System (LCCF) under the Ministry of Energy, Green Technology and Water of Malaysia. The regional characteristics need to be reflected in any sustainability assessment methodologies in order to encourage sustainable development locally (Shi et al., 2012). However, most assessments focus mainly on environmental aspects, and the other two dimensions of sustainability (social and economic) are not directly considered in the assessment systems. In terms of environmental criteria, almost all assessments adopt similar criteria, for example, energy and water efficiency and site planning. These assessment tools are also still fragmented across the building lifecycle; for example, GBI relates mostly to the design and construction phases, while GreenPASS and GreenRE are focused on the construction and operation phases (Reinhardt et al., 2013). MyCREST, also known as Malaysian Carbon Environmental Sustainability, was established in 2016 and aims to guide, assist, quantify, and hence reduce, the built environment's impact in terms of reduced carbon emissions and impacts on the environment. It also aims to integrate socio-economic considerations relating to the built environment and urban development.

Another rating system in Malaysia is the Green Building Index (GBI). A Green building focuses on increasing the efficiency of its use of resources such as energy, water, and materials. Green Buildings should be designed and operated to reduce the overall impact of the built environment on its surroundings. Beginning in 2009, GBI has achieved success with more than 300 certified projects in the country which fulfill the criteria rated by the Green Building Index (GBI). Malaysia Green Technology Corporation (GreenTech Malaysia) chairman Tan Sri Peter Chin Fah Kui said there was a 50 per cent leap from 100 million square feet gained in 2014 to 150 million square feet of gross floor area in GBI certified buildings, and he also stated: "GBI targets to achieve another 50 million square feet green building in the country by the end of December" (GBI, 2016). This is proof that the commitment by some agencies to achieve sustainable construction is very high. Unfortunately, Malaysian green tax incentives for obtaining GBI certification are significant but not outstanding (Aliagha et al., 2013). They inherently suffer from serious criticism and may not be sufficiently attractive to potential real estate investors.

Consciousness in Sustainable Construction Practice

The construction sector is complex and fragmented (Halliday, 2008). It has the potential to deliver complex infrastructure and skyscraper projects by using highly sophisticated mechanized techniques. It is also the most important sector in contributing to the national economy and as a benchmark of development. The industry is often associated with low levels of productivity due to poor knowledge management (Abidin, 2010a). For that reason, it is very important for construction practitioners to have sufficient knowledge to gain awareness within the construction industry. Likewise, the implementation of sustainable construction creates quality and capable local construction. However, this depends on the awareness, knowledge, and understanding of all the consequences of individual actions. As well as being a viable sector, those are the first obstacles that must be overcome to successfully achieve the concept of sustainable construction (Alia et al., 2015).

In Malaysia, the majority of development companies that implement sustainable construction practices are well-established. For instance, Sime Darby Property are very active and supportive in implementing sustainable construction and recognize themselves as leaders of sustainable communities (Razak et al., 2010). They are committed that their projects are built sustainably, incorporating eco-friendly practices and green design initiatives to minimize the impact on the environment and enhance lifestyle experiences. Other than that, Sime Darby Property has also been awarded Green Building Certification (LEED Silver) for the Focus Peak project. Sime Darby has a number of awards, which proves its progress in the implementation of sustainable construction.

Another development company that supports and enhances sustainable construction is EcoWorld Development Sdn. Bhd. They are a publicly listed Malaysian company involved mainly in property development. They have built eighteen development projects in total that include new townships, integrated commercial developments, luxury high-rise apartments and green business parks. Currently, they are planning to build the Malaysian EcoSky development with the capacity to collect daylight and rainwater, and integrate greener ways of luxury living (S P Setia, 2015). S P Setia has an enviable track record of incorporating sustainability into its developments in line with its corporate responsibility charter (Annuar et al., 2014).

There are other development companies who implement sustainable construction but they are mostly well-established (Asia Green Building, 2015). The higher the level of environmental concern, the higher the level of environmental sustainability practices among practitioners of the project (Rashidi et al., 2014). It has been proven that more than 70% of respondents who were interviewed have a high level of environmental concern but only a moderate level of environmental sustainability practice. A positive view of environmental sustainability is that there have been positive effects and cases of pro-activity concerning the level of anxiety and construction management practices in environmental sustainability. The implications of the study are that coordinated effort and action is needed during pre-construction practices to improve, and make more efficient, environmental sustainability practices throughout the construction project.

FINDINGS AND DISCUSSION

The sustainable construction concept originates from the discussion that was held in 1968 in Rome called the Club of Rome-Limits to Growth 1968 (Halliday, 2008) and which influenced the whole world, including Malaysia, which began to implement the concept in 2000 (Alia et al., 2015). It has been implemented for about one and a half decades. However, Malaysia still in its infancy with this practice and more innovative strategies are needed in its implementation (Ahankoob et al., 2013). Government effort is very important in helping to improve the understanding of sustainable construction (Abidin, 2010b). It is very important to obtain knowledge to use resources strategically. This can improve the results of construction projects by reducing unnecessary cost and implementation time while improving competitiveness. The rating system for sustainable construction in Malaysia is quite progressive, but still in its infancy in terms of sustainable construction implementation. Many people worry about the high cost of green technology in construction. Cost reduction of energy consumption in the long term is often overlooked. In addition, life cycle management and government incentives also have important roles in eliminating these challenges. Government support and regulations are very important in promoting the concept of sustainable construction as part of national development because moving towards sustainable building allows integration between different communities and creates a stable environment.

Construction practitioners, especially developers, also play important roles in sustainable development. Their knowledge is still at a moderate level, and in terms of implementation is lower still. Even though the government has implemented tax exemptions, it still cannot cover the costs contributed by sustainable construction. Developers need to spend substantial amounts of money which sometimes does not bring any benefit to their company. That is why they do not care about the sustainability concept, which is due to the developers’ mindsets. They are only care about profit orientation rather than thinking about sustainable construction processes. These require substantial capital and the cost of such projects is higher than the norm. The developers’ mindsets are such that they do not want to accommodate aspects that are not favorable to them, but mostly think of their companies’ profits. Sustainable construction implementation involves all parties, including the government, taking responsibility to ensure its success.

CONCLUSION AND FURTHER RESEARCH

In conclusion, Malaysia is setting a mission to ensure more sustainable development in all aspects. The mission includes features such as enabling environments for green growth, adopting sustainable consumption and production concepts, conserving natural resources for present and future generations, and strengthening resilience against climate change and natural disaster. This shows that Malaysia keeps moving towards sustainability of construction. This view is supported by Rashidi et al. (2014) who claimed that Malaysia is still to achieve sustainable development concomitant with developed countries and the implementation is still in its infancy (Ahankoob et al., 2013). The knowledge of construction practitioners, especially developers, is still at a moderate level. The effect of this is that the implementation of sustainable construction is very low. This is critical because environmental conditions are becoming increasingly worse and sustainable construction is for long-term needs. All parties involved must play important roles in implementing sustainable construction. This process should start from a feasibility study to drive future sustainable development in economic, social, and political terms. Other than that, actions by the government to provide intensive development within the state must be balanced to achieve a win-win situation between the two sides.

Therefore, further research may be able to, firstly, focus on how to tackle the cost of sustainable practices during construction since the main cause of the lack of the implementation of sustainable construction is an economical issue. Secondly, further research is needed on innovation strategies that can give more ideas for better implementation of sustainable construction; and thirdly, research could focus on the types of win-win situation that can be achieved for all parties.

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A CONCEPTUAL CONSTRUCTABILITY ASSESSMENT MODEL FOR RIVER-CROSSING GIRDER BRIDGE CONSTRUCTION IN SARAWAK

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Abstract
There are numerous research on the constructability concept since its introduction in late 1970. After years of development, the trend of constructability research had moved towards the development of quantitative assessment models. There are many assessment models being developed for building projects but the models for infrastructure projects are still limited. The aim of this study is to propose a conceptual quantitative model for the assessment of constructability of river-crossing girder bridge designs at the design stage in Sarawak, Malaysia. Two stages of questionnaire survey were conducted in order to achieve the aim. At the first stage of survey, 143 responses were collected from professional engineers and G6 & G7 contractors in Sarawak. The collected data was analyzed using factor analysis and descriptive statistics of IBM SPSS Statistics. Subsequently, 7 major criteria of constructability principles and the constructability weightings of different bridge components were determined. At the second stage of survey, another 136 responses were collected from professional engineers and G6 & G7 contractors in Sarawak. The collected data was analyzed using descriptive statistics of IBM SPSS Statistics and Relative Importance Index (RII) method. Subsequently, the weightings of the 7 criteria of constructability principles and the Constructability Indexes (CI) of 119 girder bridge design alternatives were determined. The results of the two stages of survey were then integrated to form a quantitative constructability assessment model. This model is the first in Sarawak that can be used by professional engineers at the design stage to quantify the constructability of river-crossing girder bridge designs. By using this model, the assessment of river-crossing girder bridge constructability can be carried out more efficiently and effectively.

Keywords: *Constructability; buildability; river-crossing girder bridge.*

INTRODUCTION

Applicable to both building and infrastructure projects, implementing constructability principles at the early design stage can help to enhance the project performance. Some benefits of "constructability" include reduced project duration & cost (Jadidoleslami et al., 2018; Samimpey & Saghatforoush, 2020), reduced changes (Saghatforoush et al., 2010), reduced wastes (Jadidoleslami et al., 2019), reduced project risks (Sopic et al., 2019), better design (Khan, 2018), and improved construction efficiency (Sanjaya et al., 2019). There are numerous research on the constructability concept since its introduction in late 1970. After years of development, the trend of constructability research had moved towards the development of quantitative assessment models (Ding et al., 2020). It was discovered that the existing quantitative models are mostly suitable for building projects only. Therefore, more new models which are specifically designed for infrastructure projects are required in order to quantify the constructability of those projects. The present study aims to propose a conceptual constructability assessment model to be used at the design stage to quantify the constructability of river-crossing girder bridge designs. The research process and findings are explained in this paper. The limitations of the model are also discussed.

LITERATURE REVIEW

Definitions of "constructability"

There are many definitions of "constructability", some of which are:

> *Constructability can be defined as the application and integration of construction knowledge and experience to the process of planning, designing, procuring and implementing construction* (Ansyorie, 2019).

> *Constructability is a project management technique, which examines construction logic from beginning to end, in order to identify obstacles, restrictions, and potentials* (Samimpey & Saghatforoush, 2020).

> *Constructability is a project management concept to be considered and adopted before and throughout the project delivery stages so that optimum project outcome can be achieved* (Ding et al., 2021).

Another similar term commonly used is "buildability". Although some researchers mentioned that both terms can be used interchangeably, "constructability" is generally regarded to have covered wider scope than buildability (Alinaitwe et al., 2014; Keerthana & Pradeep, 2019). According to Kifokeris and Xenidis (2017), constructability covers all phases of a project's life cycle whereas buildability is mainly adopted during the design stage.

For the present study, "constructability" is defined as a project management concept that emphasizes on the integration of construction knowledge and experience throughout a project's life cycle with the aim to enhance the project's performance especially in terms of cost, time, quality, safety, sustainability and aesthetics.

Research Trends of Constructability

Based on in-depth literature review, it was discovered that there is a trend for the constructability research in overseas countries to shift from the exploration of theoretical constructability concept to the development of quantitative constructability assessment models (Ding et al., 2020). A quantitative assessment model can be used at the design stage to generate a constructability score that will inform the assessors as to the level of constructability of a design. The advantages of quantitative assessment models include easier to apply (Zin, 2004), more achievable & practical (Wong et al., 2006), more manageable & objective (Lam & Wong, 2011), and that the assessment can be done in a more structured way (JadidAlEslami et al., 2018).

There are a number of quantitative assessment models available to measure the constructability of building projects which include neural network model (Zin et al., 2004), Building Assessment Model (BAM) (Wong, 2007), the conceptual model presented by Nourbakhsh et al. (2012), Buildable Design Appraisal System (BDAS) (Building and Construction Authority [BCA], 2017), Automated constructability rating framework for concrete formwork systems (Kannan & Santhi, 2018), Risk Source-based Constructability

Appraisal (RISCONA) system (Kifokeris & Xenidis, 2019), and BIM-based model for constructability assessment of conceptual design (Fadoul et al., 2020) to name a few.

There is a gap in the current literature because the existing quantitative assessment models are mostly suitable for building projects only. Therefore, more new models which are specifically designed for infrastructure projects are required in order to quantify the constructability of those projects.

River-Crossing Girder Bridge

In Sarawak, bridges are important infrastructure due to the presence of many rivers. There are many bridges to be constructed under the Pan Borneo Highway project (Free Malaysia Today News, 2016) and Coastal Road project (The Star Online, 2019). Constructing more bridges will enhance the connectivity between different places and boost the development of agricultural and commercial projects of the surrounding areas. Considering the need of constructing more bridges and the huge funding required for bridge constructions (Borneo Post Online, 2018; New Sarawak Tribute, 2018), it is important that more research related to bridges constructability in Sarawak should be studied for the benefits of future bridge constructions.

River-crossing girder bridge was chosen as a subject of the present study because it is the most commonly constructed bridge type in Sarawak. For the present study, “bridge components” include (Ding et al., 2021):

1. Foundation
2. Abutment
3. Wing wall
4. Pier
5. Girder
6. Bridge deck
7. Wearing surface
8. Approach slab
9. Expansion joint
10. Bearing
11. Drainage system
12. Railing/parapet wall

“Bridge design alternatives” mean the different designs of each of the component above. For example, the design alternatives of pier include hammerhead pier, wall pier, single column pier, etc. (Wang, 2014; Zhao & Tonias, 2017; Song et al., 2018). The design alternatives of expansion joint are modular joint, steel finger joint and elastomeric strip joint (Niemierko, 2016; Zhao & Tonias, 2017; Simun et al., 2018) to name a few.

RESEARCH METHODOLOGY

Quantitative research technique was adopted in order to collect numerical data. Quantitative method allows researchers to gather data in a way that is quantifiable (Burrell & Gross, 2017; Johnson & Christensen, 2020). This feature allows the researcher to quantify the abstract constructability concepts in order to develop the quantitative constructability assessment model. The present study went through two data collection stages as detailed in Figure 1.

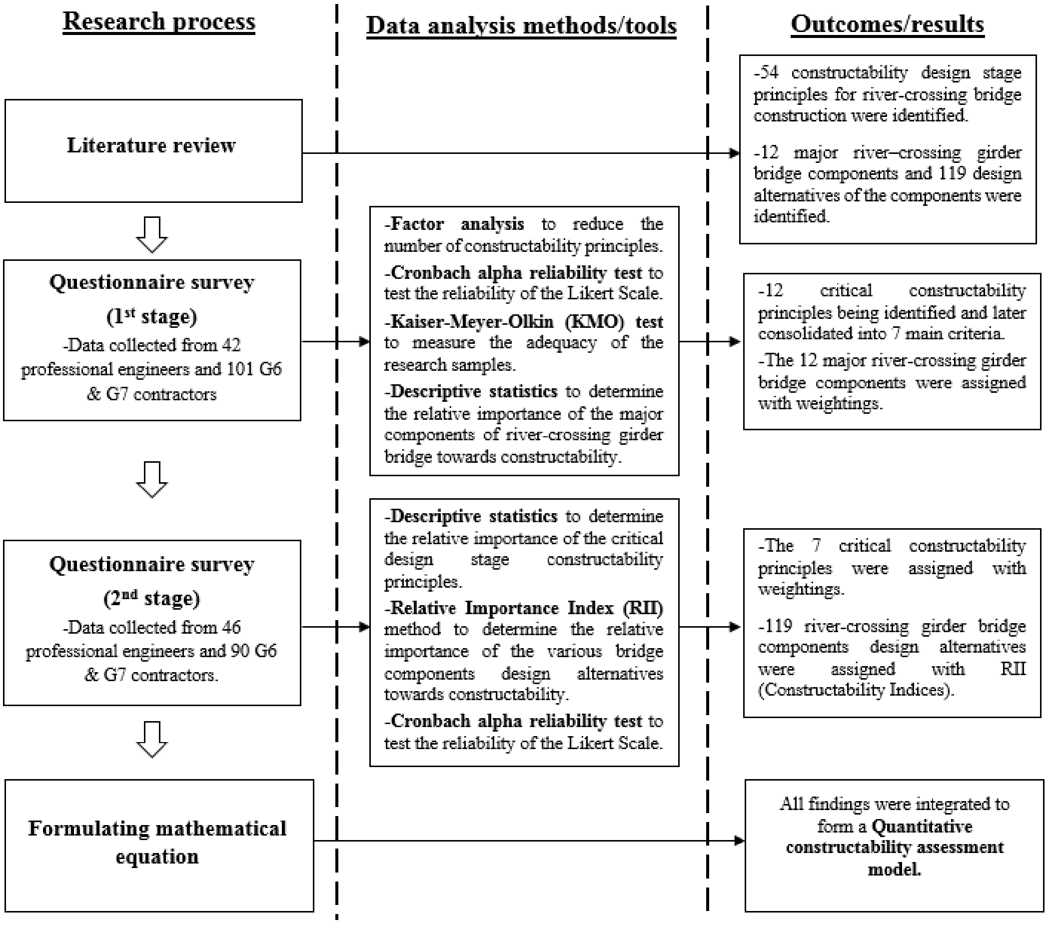

Figure 1. Research Process for the Present Study

The First Stage of Questionnaire Survey

The respondents for the first stage of survey are professional engineers and G6 & G7 contractors in Sarawak because they are designers and builders of bridges respectively. Higher grade contractors were targeted because only they are eligible to tender for long bridge projects which require high cost to be constructed. The data collection period for this stage of survey was from April to June 2019. The majority of questionnaires were sent to the respondents through email, others were distributed by the researchers in person.

The first objective of this stage of survey was to evaluate the most critical constructability principles for river-crossing girder bridge construction. The respondents were invited to rate the 54 constructability principles in term of their importance in enhancing the constructability of bridge construction based on 5-point Likert scale. The second objective of the first stage of survey was to determine the relative importance weightings of the 12 girder bridge components. The respondents had to indicate in percentage the relative importance weightings towards constructability among the various girder bridge components. Components with higher percentages are relative more important towards constructability of a girder bridge project.

The Second Stage of Questionnaire Survey

The respondents for the second stage of questionnaire survey are also professional engineers and G6 & G7 contractors in Sarawak. The data collection period was from February to April 2020. The majority of questionnaires were sent to the respondents through email, others were distributed by the researchers in person. There were two objectives for this stage. The first objective was to determine the relative importance weightings of the critical girder bridge constructability principles (which were identified in the first stage). The respondents had to indicate in percentage the relative importance weightings towards constructability among the 7 constructability criteria (refer Table 3). Principles with higher percentages are relative more important towards constructability of a girder bridge project.

The second objective was to determine the relative importance of various girder bridge design alternatives of the 12 major bridge components in terms of their importance towards the 7 constructability criteria based on 5-point Likert scale. For example, Table 1 shows component 10 bearing and its design alternatives. The respondents had to rate the importance of each design alternative towards all the 7 criteria. The process was repeated for the rest of the 11 components.

Table 1. Bearing and Its Design Alternatives

10. Bearing		**Criteria 1**	**Criteria 2**	**Criteria 3**	**Criteria 4**	**Criteria 5**	**Criteria 6**	**Criteria 7**
10.1	No bearings (integral structure)	3	5	1	2	3	5	1
10.2	Rubber bearing pad/strip (unreinforced)	4	1	3	2	5	5	1
10.3	Steel reinforced elastomeric bearings	1	2	5	4	3	3	5
10.4	Elastomeric sliding bearing	5	4	5	3	3	2	1
10.5	Pot bearing							
10.6	Pin bearing/knuckle bearing				Example Only			
10.7	Rocker bearing							
10.8	Roller bearing							
10.9	Disc bearing							
10.10	Spherical bearing							
	Others, please specify (if any):							

At the end of the study, a model (mathematical equation) was developed by taking into account the data collected through the two stages of questionnaire survey.

Data Analysis Method

Table 2 summarizes the data analysis methods and tools adopted for the present study.

Table 2. Data Analysis Methods and Tools Adopted for the Present Study

Type of Survey	Objective	Data Analysis Method	Data Analysis Tool
Questionnaire survey (1st stage)	Objective 1: - To identify the most important constructability principles	Factor analysis (Principal Component Analysis)	IBM SPSS Statistics Version 21
	Objective 2: - To identify the relative importance weightings of the girder bridge components	Descriptive statistics (mean value)	IBM SPSS Statistics Version 21
Questionnaire survey (2nd stage)	Objective 1: - To identify the relative importance weightings of the 7 criteria of constructability principles (which were identified in the first stage)	Descriptive statistics (mean value)	IBM SPSS Statistics Version 21
	Objective 2: - To rank the various bridge components design alternatives in terms of their importance towards enhancing constructability	Relative Importance Index (RII)	Mathematical formula

Sampling Method

The sampling methods adopted were non-probability judgement sampling (purposive sampling) because it is useful to reach specific population with unique characteristics (Pajo, 2018) to ensure the representativeness of the data collected (Baltes & Ralph, 2020). For both stages of questionnaire surveys, the professional engineers and contractors who have experience in girder bridge construction were first selected to participate in the surveys. Another method adopted was snowball sampling. The researcher used the initial respondents to help to recommend other respondents who have experience in bridge construction (Adams & Lawrence, 2019; Baltes & Ralph, 2020).

Scope of Study

The scope of the present study was limited to Sarawak only. The respondents were asked to provide information by taking into account the construction of 2 lanes single carriageway river-crossing girder bridge that is in between 1 to 2km in length. This is because the existing long bridges in Sarawak and the new bridges that are to be constructed under the coastal road project are mostly within this range.

RESULTS AND DISCUSSIONS

Results of the First Stage of Questionnaire Survey

The data collection period for this stage of survey was from July to September 2019. In total, 560 questionnaires were sent to the targeted respondents. Out of 560 questionnaires distributed (370 G6 & G7 contractors and 190 professional engineers), 152 responses were received, representing a 27.1% response rate. After 153 responses were received, the responses with missing data were dismissed, resulting in 143 valid responses. Out of 143 responses, 101 were G6 & G7 contractors (70.6%), and 42 were professional engineers (29.4%).

In order to achieve the first objective, the 143 valid responses were analyzed using factor analysis which is a data reduction tool of SPSS. Factor analysis helped to generate 12 critical constructability principles. The 12 critical constructability with similar themes were then consolidated into 7 constructability criteria (Table 3) using qualitative content analysis in order to ease the subsequent research. The consolidation process and result were validated by 5 bridge construction experts.

Table 3. Seven Constructability Criteria

7 Constructability Criteria	
Criteria 1 (C1)	Principles related to resources utilization and site accessibility
Criteria 2 (C2)	Principles related to sustainable construction
Criteria 3 (C3)	Principles related to simple design, modularization, standardization, ease of installation, and less storage requirement
Criteria 4 (C4)	Principles related to clear and effective designs, involvement of construction knowledge and efficient construction sequence
Criteria 5 (C5)	Principles related to improved construction safety
Criteria 6 (C6)	Principles related aesthetics
Criteria 7 (C7)	Principles related to time and cost savings

Most of the criteria identified are similar to the previous research except for C6 and C7. Previously, although there are many researchers who emphasized on the importance of considering design aesthetics, construction time and construction cost at the design stage, these considerations were not being formally linked to the constructability concept. This is the first study to include aesthetics, time and cost considerations as important constructability principles under the big umbrella of the constructability concept.

To achieve the second objective, the 143 responses were analyzed using SPSS Descriptive Statistics. The mean statistics generated were rounded up or down to the nearest whole number. The constructability weightings of different bridge components are provided in Table 4.

Table 4. Constructability Weightings of Different Bridge Components

Girder Bridge Components	Constructability Weightings
Foundation	18%
Abutment	13%
Wing wall	6%
Pier	13%
Girder	12%
Bridge deck	8%
Wearing surface	4%
Approach slab	5%
Expansion joint	7%
Bearing	7%
Deck drainage system	4%
Railing/parapet	3%
Total:	100%

Most respondents thought that foundation are the most important component (18%), followed by abutment and pier (13%). The top three most important components are all substructures. A few respondents stated in the questionnaire forms that foundation is the most important component because its main purpose is to hold the structure above it and to support the loads from the top. The constructability and sustainability of a girder bridge depends strongly on its foundation. Abutment and piers are also important in supporting bridge girders. Another respondent categorized foundation as “the most critical structure” and then abutment, pier and girder as “critical structure”. He stated that the design failure of those “critical structures” will directly cause a project failure.

Results of the Second Stage of Questionnaire Survey

In total, 503 questionnaires were sent to the targeted respondents. Out of 503 questionnaires distributed (318 G6 & G7 contractors and 185 professional engineers), 142 responses were received, representing a 28.2% response rate. Out of 136 responses, 90 were G6 & G7 contractors (66.2%), and 46 were professional engineers (33.8%).

To achieve objective 1, the 136 responses were analyzed using SPSS Descriptive Statistics. The mean statistics were rounded up or down to the nearest whole number. The constructability weightings for different constructability criteria were provided in Table 5.

Table 5. Constructability Weightings of the Seven Constructability Criteria

	Constructability Criteria	Constructability Weightings
Criteria 1	Principles related to resources utilization and site accessibility.	13%
Criteria 2	Principles related to sustainable construction.	11%
Criteria 3	Principles related to simple design, modularization, standardization, ease of installation, and less storage requirement.	10%
Criteria 4	Principles related to clear and effective designs, involvement of construction knowledge and efficient construction sequence.	25%
Criteria 5	Principles related to improved construction safety.	15%
Criteria 6	Principles related aesthetics.	9%
Criteria 7	Principles related to time and cost savings.	17%
	Total:	100%

Criteria 4 are deemed by the respondents as the most important (25%). Criteria 7 are the second important (17%), followed by criteria 5 (15%). The weightings of Criteria 1 to 3 are similar, ranging from 10% to 13%. As for criteria 3, a lot of respondents mentioned that modularization is not suitable for long bridge construction. Aesthetics is the least important criteria among the 7 but the weighting is worth noting (9%). Based on the weightings distribution, it can be seen that aesthetics is still an important factor to be considered when designing a bridge.

To achieve objective 2, the responses were analyzed using mathematical formula of RII:

$$\text{RII} = \frac{\sum w}{AN} = \frac{5n_5 + 4n_4 + 3n_3 + 2n_2 + 1n_1}{5N} \tag{1}$$

Where:

W	=	The weight given to each design alternative by the respondent, ranging from 0 to 5.
A	=	The highest weight (5 in this case).
N	=	Total number of respondent.
n_1	=	Number of respondents for "very low contribution".
$n_2 - n_4$	=	Number of respondents for intermediate level between very low and very high contribution.
n_5	=	Number of respondents for "very high contribution".

Table 6. Constructability Indexes (CI) of Foundation Design Alternatives (a)

Foundation	**Constructability Indexes**							
	Criteria 1 (13%)	**Criteria 2 (11%)**	**Criteria 3 (10%)**	**Criteria 4 (25%)**	**Criteria 5 (15%)**	**Criteria 6 (9%)**	**Criteria 7 (17%)**	**Average**
Spun pile	0.900	0.850	0.867	0.908	0.883	0.250	0.867	0.827
Pipe pile	0.750	0.683	0.750	0.308	0.775	0.233	0.533	0.553
H pile	0.750	0.683	0.750	0.292	0.742	0.233	0.550	0.546
Bored pile	0.758	0.792	0.733	0.883	0.792	0.242	0.467	0.700
Caisson method	0.250	0.275	0.375	0.233	0.375	0.233	0.333	0.293

Table 6 shows the RII (or CI for the present study) of foundation design alternatives under each constructability criteria. After CI for all criteria were obtained, an average index for each design alternative was calculated by taken into account the weightings of all 7 criteria (Equation 2).

Average constructability index = [(CI under criteria 1 * 13%) + (CI under Criteria 2 * 11%) + (CI under Criteria 3 * 10%) + (CI under Criteria 4 * 25%) + (CI under Criteria 5 * 15%) + (CI under Criteria 6 * 9%) + (CI under Criteria 7 * 17%)] / 100] (2)

Take bored pile as an example, the formula to calculate its average is as following:

Average constructability index for bored pile = [(0.758 * 13% for criteria 1) + (0.792 * 11% for criteria 2) + (0.733 *10% for criteria 3) + (0.883 * 25% for criteria 4) + (0.792 * 15% for criteria 5) + (0.242 * 9% for criteria 6) + (0.467 * 17% for criteria 7)] / 100 = **0.700**

The process was repeated to calculate the average CI of all the design alternatives. The average CI of all design alternative under all 12 components are shown in Table 7 to 18.

Table 7. Constructability Indexes of Foundation Design Alternatives (b)

1. Foundation	**CI**
Spun pile	0.827
Bored pile	0.700
Steel Pipe pile	0.553
Steel H pile	0.546
Caisson method	0.293

Table 8. Constructability Indexes of Abutment Design Alternatives

2. Abutment	**CI**
Stub abutment (cast-in-place)	0.739
Semi-stub abutment (cast-in-place)	0.656
Mechanically stabilised earth (MSE) abutment (cast-in-place)	0.633
Counterfort abutment (cast-in-place)	0.577
Spill-through abutment (cast-in-place)	0.569
Full height abutment (cast-in-place)	0.549
Gravity abutment (cast-in-place)	0.544
Stub abutment (precast)	0.522
Semi-stub abutment (precast)	0.501
Pile bent abutment (cast-in-place)	0.485
MSE abutment (precast)	0.477
Spill-through abutment (precast)	0.476
Counterfort abutment (precast)	0.462
Full height abutment (precast)	0.439
Pile bent abutment (precast)	0.415

Table 9. Constructability Indexes of Wing Wall Design Alternatives

3. Wing Wall	**CI**
U type wing wall cantilever (cast-in-place)	0.716
Flared wing wall cantilever (cast-in-place)	0.708
U type wing wall independent (cast-in-place)	0.615
Flared wing wall independent (cast-in-place)	0.606
In-line wing wall cantilever (cast-in-place)	0.569
In-line wing wall independent (cast-in-place)	0.537
Flared wing wall cantilever (precast)	0.506
U type wing wall cantilever (precast)	0.493
Flared wing wall independent (precast)	0.490
U-type wing wall independent (precast)	0.468
In-line wing wall cantilever (precast)	0.425
In-line wing wall independent (precast)	0.416

Table 10. Constructability Indexes of Pier Design Alternatives

4. Pier	**CI**
Hammerhead pier (cast-in-place)	0.785
Wall pier (cast-in-place)	0.703
Rigid frame pier (cast-in-place)	0.688
Single column pier (cast-in-place)	0.664
V-shaped pier (cast-in-place)	0.564
Hammerhead pier (precast)	0.531
Wall pier (precast)	0.477
Rigid frame pier (precast)	0.472
Single column pier (precast)	0.468
V-shaped pier (precast)	0.463
Pile bent pier (cast-in-place)	0.439
Pile bent pier (precast)	0.419

Table 11. Constructability Indexes of Girder Design Alternatives

5. Girder	CI
Box girder (cast-in-place)	0.807
I girder (precast)	0.755
T beam (precast)	0.682
Box girder (precast)	0.674
U girder (precast)	0.638
Concrete encased steel beam (precast)	0.570
Steel U girder	0.557
Steel I girder with shear connectors	0.539
Steel I girder without shear connectors	0.535
I girder (cast-in-place)	0.518
T girder (cast-in-place)	0.515
U girder (cast-in-place)	0.512
Concrete encased steel beam (cast-in-place)	0.499

Table 12. Constructability Indexes of Bridge Deck Design Alternatives

6. Bridge Deck	CI
In situ concrete deck	0.766
Precast concrete deck	0.679
Top flange (of box or T girder) as deck	0.646
Precast + in situ deck	0.554
Precast effideck	0.527
Exordemic deck (precast)	0.517
Fibre Reinforced Polymer deck	0.515
Grid reinforced concrete deck (precast)	0.508
Steel trough deck	0.485
Steel orthotropic deck without shear connector	0.484
Steel orthotropic deck with shear connector	0.483
Grid reinforced concrete deck (cast-in-place)	0.478
Exodermic deck (cast-in-place)	0.477
Open steel grid deck	0.459

Table 13. Constructability Indexes of Wearing Surface Design Alternatives

7. Wearing Surface	CI
Dense graded asphalt	0.805
Unmodified concrete	0.696
Integrated wearing surface (the wearing surface is an integral part of the concrete deck)	0.690
Polymer modified asphalt	0.619
Stone mastic asphalt	0.592
Latex modified concrete	0.533
Open graded asphalt	0.522

Table 14. Constructability Indexes of Approach Slab Design Alternatives

8. Approach Slab	**CI**
Concrete slab on embankment soil supported by embankment slab & piles (cast-in-place)	0.673
Concrete slab supported by piles (cast-in-place)	0.605
Concrete slab supported by geogrid (cast-in-place)	0.578
Concrete slab on embankment soil supported by embankment slab & piles (precast)	0.574
Concrete slab supported by piles (precast)	0.559
Concrete slab supported by geogrid (precast)	0.546
Concrete slab on sleeper slab + piles under sleeper slab (cast-in-place)	0.506
Concrete slab on sleeper slab + piles under sleeper slab (precast)	0.493
Concrete slab on sleeper slab (cast-in-place)	0.479
Concrete slab on sleeper slab (precast)	0.473

Table 15. Constructability Indexes of Expansion Joint Design Alternatives

9. Expansion Joint	**CI**
Modular joint	0.736
Steel finger joint	0.719
Elastomeric strip joint	0.705
Bolt down (reinforced rubber) joint	0.647
Sliding steel plate joint	0.560
Compression seal joint	0.538
Asphaltic joint	0.535
Poured sealant joint	0.511
Butt joint	0.507
No expansion joint (integral structure)	0.491

Table 16. Constructability Indexes of Bearing Design Alternatives

10. Bearing	**CI**
Pot bearing	0.771
Disc bearing	0.758
Steel reinforced elastomeric bearing	0.740
Elastomeric sliding bearing	0.681
Spherical bearing	0.604
Roller bearing	0.396
Pin bearing	0.388
Rocker bearing	0.385
Rubber bearing (unreinforced)	0.379
No bearing (integral structure)	0.374

Table 17. Constructability Indexes of Deck Drainage Design Alternatives

11. Deck Drainage	**CI**
Concrete curb	0.821
Composite material curb (e.g. Envirodeck)	0.678
Combination inlets (concrete curb + grate)	0.656
Grate inlets	0.625
Slotted inlets	0.586
Trench inlets	0.571
Ductile steel curb	0.508

Table 18. Constructability Indexes of Railing/Parapet Wall Design Alternatives

12. Railing / Parapet Wall	CI
New Jersey parapet with steel railing	0.806
Concrete parapet	0.720
Steel railing	0.612
Standard curb with steel railing	0.606

The explanations and pictures of all design alternatives can be found from online sources. Generally, most of the respondents preferred cast-in-place method over precast method, especially for abutment, wing wall and pier construction. The researchers are in the opinion that cast-in-place construction method allows for more flexibilities compared to precast concrete construction method. Precast concrete construction method requires high accuracy so that all the elements can be fixed into position and connected properly. It requires more detailed design and higher quality control during the casting process in the factory or near the construction site. Precast elements can be very difficult and costly to be transported to the construction site if they are cast in factories. Furthermore, when a bridge is curved and of greater skew angle, using precast components is not practical. Another consideration is the transportation of big precast segments to the designated location of the river. It can be difficult to find large barges that are suitable for transporting the precast segments. In addition, lifting large precast segments on the river is difficult. The situation is different from highway bridge constructions where lifting equipment can be stationed on the ground.

For pier construction, a respondent stated in the questionnaire that using precast elements for piers is not practical. It is because if the piers are tall and the elements are connected together block by block (precast segments), the sustainability and durability of the connection joints will be a serious issue. He commented that non-monolithic structures are not effective in transferring higher loads. As shown in Table 11, cast in place box girder is recommended by the majority of respondents for bridge girder constructions. In Sarawak, balanced cantilever method is normally adopted to construct box girders. This method will reduce the use of falsework and make the cast-in-place construction over the river possible. Precast I girder (CI 0.751) and T girder (CI 0.684) also have higher CIs. Precast I and T girders will bring many advantages such as saving time and cost, standardization, simple design, sustainable and high quality. However, a respondent stated in the questionnaire form that I and T girder can only be designed for span length up to 30 - 40m while box girder can be designed for span length up to 150m.

The existing literature revealed that bridge components made from steel can have many advantages such as lighter weight (Zuna & Astuti, 2018), high torsional stiffness (Armijos-Moya et al., 2019), more durable (Chavel, 2012), and more flexibility (Liu et al., 2019). However, the present study discovered that steel elements (especially steel girder and steel deck) are not recommended by the majority of respondents. The researchers are in the opinion that this is mainly because steel elements are more expensive (Xia et al., 2013) than concrete elements. The superiority of steel elements over concrete elements is subject to further research.

CONCEPTUAL CONSTRUCTABILITY ASSESSMENT MODEL

Figure 2 illustrates the mathematical model for the present study. The function of this mathematical model is to generate constructability scores for girder bridge designs (first level). The second level consists of the common girder bridge components that was assigned with constructability weightings (Table 4). The third level consists of main criteria of constructability principles which were also assigned with weightings (Table 5). The fourth level consists of the design alternatives for different design components. The CI were assigned to each design alternative based on RII method (Table 7-18).

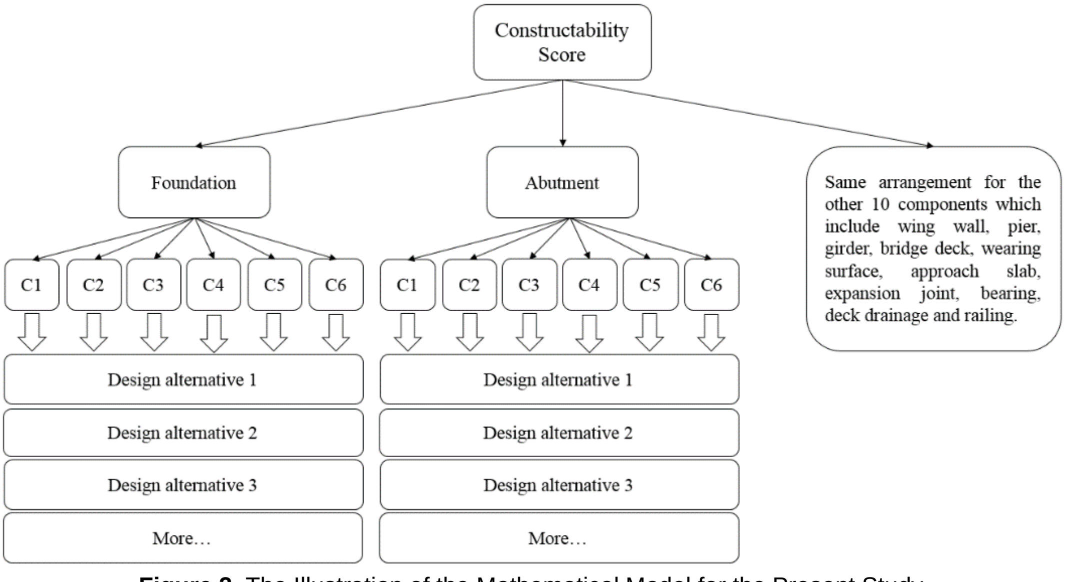

Figure 2. The Illustration of the Mathematical Model for the Present Study

By quantifying variables at every level, a mathematical equation/model was formulated in order to generate the constructability score, as following:

$$\begin{aligned}\text{Total Constructability Score} = {} & 18[\Sigma(N_{Foundation} \times CI_{Foundation})] + 13[\Sigma(V_{Abutment} \times CI_{abutment})] + 6[\Sigma(V_{Wing\ wall} \times CI_{Wing\ wall})] + 13[\Sigma(V_{Pier} \times CI_{Pier})] \\ & + 12[\Sigma(V_{Girder} \times CI_{Girder})] + 8[\Sigma(A_{Deck} \times CI_{Deck})] + 4[\Sigma(A_{Wearing\ surface} \times CI_{Wearing\ surface})] + 5[\Sigma(A_{Approach\ slab} \times CI_{Approach\ slab})] \\ & + 7[\Sigma(N_{Expansion\ joint} \times CI_{Expansion\ joint})] + 7[\Sigma(N_{Bearing} \times CI_{Bearing})] + 4[\Sigma(L_{Drainage\ system} \times CI_{Drainage\ system})] + 3[\Sigma(L_{Railing} \times CI_{Railing})]\end{aligned} \quad (3)$$

Where:

N = Percentage of number
V = Percentage of volume
A = Percentage of area
L = Percentage of length
CI = Constructability index (Table 7 – 18) of the bridge components design alternative

Figure 3 further explains how the research findings are embedded into the model. The weightings of the 7 constructability criteria were not revealed in the model because these weightings were taken into account when calculating the CI of different bridge design alternatives (detailed under Results of the second stage of questionnaire survey section).

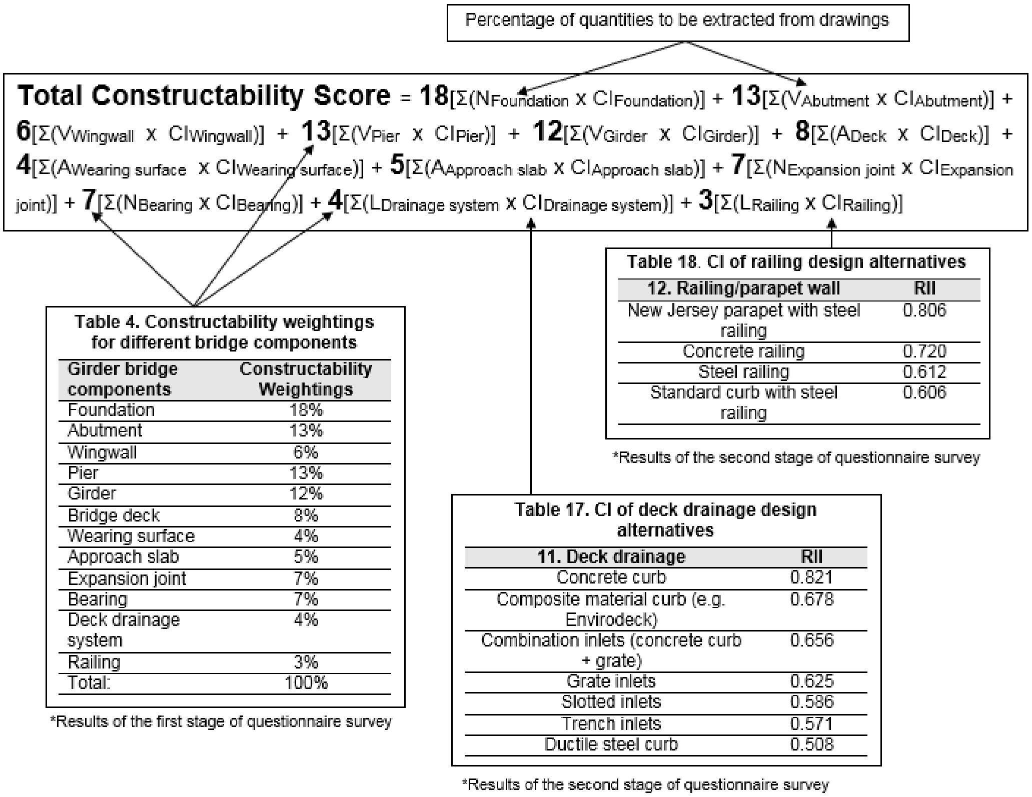

Figure 3. The Conceptual Constructability Assessment Model Explained

Constructability Assessment Mechanism

The model requires data input from the design, for example, what are the total numbers of spun piles and bored piles used? What is the total volume of piers? What is the total length of railing? The data should be expressed in percentage because for some components, more than one design alternatives will be adopted. For this model, there are four types of input from the bridge designs, namely (i) percentage of number, (ii) percentage of volume, (iii) percentage of area, and (iv) percentage of length. For illustration, assuming the data of pier and girder are as presented in Table 19.

Table 19. Data of Pier and Girder

Item	Design Alternative Adopted	Total Quantity	Percentage
Pier	CIP wall pier	9,000 m^3	45%
	CIP hammerhead pier	11,000 m^3	55%
Girder	Precast T girder	3,000 m^3	9%
	CIP box girder	30,000 m^3	91%

Based on the information given, the constructability score for pier will be:

$=13[\Sigma(V_{Pier} \text{ x } CI_{Pier})]$
$=13[(45\% \text{ CIP wall pier x CI } 0.703) + (55\% \text{ CIP hammerhead pier x CI } 0.785)]$
$=13[0.748]$
$=9.724$

The constructability score for girder will be:

= 12[Σ(V_{Girder} x CI_{Girder})]
= 12[(9% Precast T girder x CI 0.682) + (91% CIP box girder x CI 0.807)]
= 12[0.795]
= 9.540

The same process can be used to calculate the constructability scores of the rest of the components. Then, the total constructability score can be calculated by totalling up the scores of all design components:

= Foundation score + abutment score + wing wall score + pier 9.724 + girder 9.540
+ deck score + wearing surface score + approach slab score + expansion joint score
+ bearing score + drainage system score + railing score
= Total score (out of total 77.624)

The total score of this model is 77.624 instead of 100 for the reason explained under *Limitations of the study*.

SIGNIFICANCE OF STUDY

The contributions of the present study are summarized as following:

- The proposed constructability assessment model is the first in Sarawak for the assessment of girder bridge projects. This model can help the assessor to generate constructability score for a design. As the constructability is quantified, the assessor will be able to tell how construct-able a design is. The assessment of constructability will be more efficient and systematic by using the model.
- This study also fills the gap of the current literature because the existing quantitative constructability assessment models for infrastructure projects are limited.
- The constructability model is comprehensive because it covers 12 major components of a river-crossing girder bridge. There were 119 design alternatives being included and assigned with CIs.
- This study will help to promote the implementation of constructability model at the design stage. It will also create awareness among the construction industry to implement the constructability concept at other project stages to improve the productivity/performance of construction projects in Sarawak.

LIMITATIONS OF THE STUDY

There are a few limitations of the present study:

- The full constructability score for the present study is 77.055. It is because no design alternative was getting RII one (1), which is the full mark. The chance of getting full marks is very low.
- The model is conceptual in nature and it is subject to further extension or improvement. Besides, the model needs frequent update to suit the development of new construction technology.

- The model is only suitable to assess the river-crossing girder bridge design in Sarawak. All data were collected from the professional engineers and contractors in Sarawak. Professional engineers and contractors outside of Sarawak may rate the design alternatives differently because the construction environment is different.
- The model developed is suitable for long river-crossing bridges that are in between 1 to 2 km in length. Short bridges were not considered in the present study. Other bridge types such as highway bridge, arch bridge, truss bridge, suspension bridges were not considered.
- This model was validated by 5 bridge construction experts. All experts advised that although the model can be used as a guideline for bridge designs, it should not be rigidly followed. Engineers need to make judgement on how to ensure better constructability by considering the situation of every project (allows for flexibility).

CONCLUSION

Questionnaire surveys were conducted to collect data for the development of the quantitative constructability assessment model. The collected data were analyzed using SPSS factor analysis, SPSS Descriptive Statistics, and Relative Importance Index (RII) method. The results were then integrated to form a quantitative constructability assessment model. The research findings presented can provide guidelines to the construction practitioners at the design stage when designing bridges. The proposed conceptual constructability model is the first in Sarawak for the assessment of river-crossing girder bridge projects at the design stage. The assessment of constructability will be more efficient and systematic by using this model. This study also fills the gap of the current literature because the quantitative constructability assessment models for infrastructure projects are limited. Through this study, it is anticipated to create awareness among the construction industry to implement constructability concept to improve the productivity/performance of construction projects in Sarawak.

FUTURE DIRECTIONS

There is a potential of the quantitative models to be embedded with Building Information Modelling (BIM) so that automated assessment is made possible and thereby improving bridge designs and constructability (Ting et al., 2019a,b). Besides, similar research can be repeated for shorter span bridge (e.g., less than 300m). The results can be compared with the present study to broaden the body of knowledge of constructability concept. Furthermore, quantitative models for other bridge types such as highway bridge, arch bridge, truss bridge, and suspension bridge can be developed.

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ACCESSING CURRENT PRACTICES OF WASTE MANAGEMENT IN MALAYSIAN CONSTRUCTION INDUSTRY

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Abstract
Rapid growth in construction activities as a result of Malaysia's growth in population and urbanization produces a huge amount of construction waste. The problems of construction waste issues have escalated expeditiously throughout the whole nation due to poor implementation and ineffectiveness of waste management in the industry. Hence, the root causes of waste generation and current waste practices should be reassessed. This study seeks to investigate the current practice of waste management in the Malaysian construction industry through identifying the causes of construction waste and exploring the current waste practices. A questionnaire survey has been conducted after a thorough literature review. The findings reported herein are based on feedbacks from 121 construction practitioners who are the developers, contractors and consultants that acquire sufficient knowledge concerning the waste management in construction projects. The findings showed that the top factors contributing to construction waste are on-site management and planning; design; material storage; site operation; and material handling. The findings also discovered that recycling; reduction of construction waste; reuse of construction; other disposal sites; and construction and demolition landfill as the five most frequently used current disposal methods in the Malaysian construction industry. This study presents specifically investigated the perceptions of local construction practitioners in waste management. Therefore, the outcome of this study helps to develop a better understanding on waste management in the Malaysian construction industry.

Keywords: *Waste management; construction waste; waste practice; recycling.*

INTRODUCTION

Construction waste is generated from different stages of construction activities such as excess of unused materials during the pre-construction stage, construction stage and post-construction stage (Crawford et al., 2017). A huge amount of construction waste arises from the construction industry owing to the continuing growth in the industry to carry out the mega construction and infrastructure projects in Malaysia (Nagapan et al., 2018). Waste minimization is necessary to be implemented by every developing country (Noh et al., 2018). However, in practice, the level of understanding of waste management is still low in Malaysian construction industry and the measures taken by the construction practitioners against this issue are rarely seen. It has been discovered that waste reduction is often not the primary concern during the strategic planning for a construction project in Malaysian construction industry (Cheng and Mydin, 2018). Although the huge amount of construction waste generation has brought serious impacts on the environment, time, cost and productivity, there is still limited information concerning the efficient waste management practices in the Malaysian construction industry (Hasmori et al., 2020). Previous researches in Malaysia found that construction waste generation was affected by improper waste management methods practised on-site. It was found that it is necessary to explore the effective means to avoid illegal waste management methods in managing the construction waste generation activities in Malaysia. Therefore, this study is initiated to assess the current practices of waste management in the Malaysian construction industry which is essential in identifying the root causes to the shortages of the waste generation. This would then enable appropriate adjustments and improvement in reducing wastes arising from the construction projects.

LITERATURE REVIEW

Generally, waste refers to 'any final products that have no residual value at the end to the owner' (Rajendran and Gomez, 2012). Besides, Hasmori et al. (2020) stated that construction waste is described as 'a great number of construction debris produced from the construction activities'. Additionally, the construction wastes refer to 'any building materials such as concrete, steel, timber and other materials which are arising from various construction activities' (Shen et al., 2004).

There are four classifications where the building materials can be categorized during the construction process which are used materials, surplus materials, reuse of waste materials and waste materials. Nonetheless, some contractors often neglect the importance of reuse surplus or wastes material as it only generates a small profit which they consider this as unnecessary works (Saadi et al., 2016). Apart from that, the waste is often generated not only from the materials of the building components but also due to human error such as poor material handling, poor material storage, improper material ordering and other external factors. Noh and Mydin (2018) further indicated that waste is produced in various activities during the construction process which will cause direct or indirect costs such as more human resources required, more time and equipment needed but do not generate interest to the product in the end.

Causes of Waste Generation

The causes of construction waste are originated from the beginning to the end in different stages of a construction project. The origins of the construction waste can be categorized into several factors which include the material procurement process, design, on-site management and planning, site operation, transportation, material ordering, material storage, material handling and others. It was discovered that material procurement errors usually occur when quantity surveyors prepare inadequate quantities or details for the main elements in the bills of quantities especially the structural elements which will eventually result in waste generation (Nagapan et al., 2011). Those errors in design that are caused by the design consultants can lead to destruction, alteration of work or use of faulty materials which will produce on-site waste. It was found out that the act of management is very essential in minimizing construction waste. There are lots of waste materials generated on-site due to lack of supervision during the construction stage (Afolabi et al., 2018). Also, improper methods of unloading are the root cause leading to construction waste (Wahab and Lawal, 2011).

One of the examples for inappropriate material storage is workers handle bricks and blocks vigorously upon material delivery that may cause damages to the materials. The wrong material ordering factor is another element to consider in the generation of construction waste. Wrong material ordering may cause materials shortage in the middle process of construction works as it involves the temporary cessation of works thereby resulting in the delay of works. Improper material storage has also an essential impact on the construction waste generation where contractors tend to encounter problems in storing and having appropriate protection on the materials (Luangcharoenrat et al., 2019). Poor materials handling has also become a primary determinant for the increasing construction waste generation. Waste often arises from an inadequate protection approach for materials storage. Meanwhile, there are some external forces inducing the generation of on-site material waste which includes weather conditions, shortages of labour and materials due to deterioration, robbery and vandalism (Muhwezi et al., 2012). Contractors will usually make some provision for these uncertainties to reduce the impact on the contractor's risks.

According to Dosumul, Idoro and Onukwube (2017), the errors in contract documents were the main reason for the non-completion of construction projects on time, increasing construction cost and poor quality of materials. To further prove the gravity of mistakes in contract documents, it has been discovered that more than 82% of all construction errors committed are due to the errors made by the design consultants in the contract documents.

Current Waste Practices

It is essential to identify current waste practices adopted by industry stakeholders in Malaysian construction industry. There are 9 current waste practices after extracting the results and findings from previous researchers which are recycling, composting (eg on-site dig and bury), incineration, inert landfill, construction and demolition landfill, other disposal sites, combustion, reduction of construction wastes and reuse of construction wastes. According to Moh and Abd Manaf (2014), it has been found that the recycling process is known as a method used to gather, divide, purify and treat the waste materials to transform them from debris to a commercial product that can contribute to the country economically by creating more job opportunities. Besides, composting is a major tactical approach to sustainable waste management that can be used to combine waste such as industrial waste, domestic waste and so forth to reduce the waste generated on sites (Samsudin and Don, 2013). Incineration is also one of the disposal methods to be considered in the current Malaysian construction industry. However, it is currently the most expensive sustainable waste management approach to be adopted since this method acquires proficient labour force and proper custody along with high initial and operation costs (Ogunmakinde et al., 2019).

Inert Landfill is the earliest sort of waste disposal. It comprises an empty area to bury unwanted waste substances (Polat et al., 2017). The debris from construction and destruction are defined as 'waste materials generated during the development of building structures'. It has been discovered that construction and demolition landfill method is categorized as non-harmful landfills which normally are governed by local and state governments. Combustion ought to be classified among the last selections for disposing of construction waste and must be provided that the local authorities have given their consent on this method (Nagapan et al., 2012a). To avoid any unfavourable health effects and out of control situations, precautionary steps must be taken into account when the burning takes place. Eusuf, Ibrahim and Islam (2012) asserted that waste is being generated at a very fast pace in the Malaysian construction industry. The precedence for the realization of good on-site waste management should be focusing on how to mitigate the waste generated (Kibert et al., 2000). There are lots of materials that are discharged from deconstruction that can be restored or kept for possible future use (Eusuf et al., 2012). Hence, reuse of materials is very essential in value transformation for life cycle costs of building material, the economics of a country, sustainability of the environment and conservation of natural resources (Saadi et al., 2016).

METHODOLOGY

A quantitative approach was applied to obtain a huge amount of quantitative data in a limited time by conducting online survey questionnaires through social media such as email. The population selected in this study were construction practitioners who have knowledge concerning the causes of waste generation and current waste practices in construction projects. The introduction page of the questionnaire clearly stated the requirement of experience in waste management before the respondents start to answer the questionnaire. The respondents are the developers, contractors and consultants who are currently working in the construction industry. Although consultant usually does not involve directly in the handling of waste management, they are amongst the key personnel who advise the owner on the requirement of waste handling system including the requirement of waste separation or waste recycling. There are several research studies revealed the significance of the design phase during implementation for the management of construction waste (Arshad et al., 2017; Llatas, 2011; Nagapan et al., 2018; Ikau, Joseph and Tawie, 2016). 33% of on-site waste has been determined owing to Architects failed to implement a legitimate waste treatment during the design phase (Nagapan et al., 2013). In other words, the construction waste that has been created at this stage can be ascertained as errors in design by an inexperienced and careless designer. Besides, the site staff may also not capable to solve the design errors during the construction process. Those errors in design that are caused by the design consultants can lead to destruction, alteration of work or use of faulty materials which will produce on-site waste.

Non-probability sampling was adopted in selecting the respondents to collect the data with convenient sampling method. The questionnaires were emailed to the contacts available by the authors and contacts. The respondents used Google form to answer each questionnaire. Klang Valley was selected as the targeted area as there are some top construction companies in Malaysia that have been at the forefront of nation-building are located within this area. The amount of construction waste generated in Klang Valley is also amongst the top in the country due to the large demand for development projects (Noor et al., 2013).

The questionnaire in this study was structured into three sections according to the objectives to ensure that the questions asked are factual and relevant. All the closed-ended questions were arranged systematically to provide the respondents with a 5-scale Likert scale. Before the questionnaire distribution, there was a pretest of questionnaire where a total of 4 respondents were directly selected for pretest to examine the applicability and appropriateness before the commencement of the survey on the prepared questionnaire. These 4 respondents were chosen based on the convenient sampling, from contacts of the author based on their experience in waste management handling. The drafted questionnaire was amended according to the comments collected from the pretest. The comments cover on grammar and some refinement of the terms used in the questionnaire.

Statistical Package for Social Science (SPSS) was used in this study to analyze the collected data and generate reliable results and findings. The data was tested through the Cronbach's alpha reliability test which is to test the reliability of the data test and make sure that the test results were consistently reflected in the construct. Meanwhile, mean ranking was adopted to show the importance of the factors by determining their mean value. Kruskal-Wallis test was used to determine the perception from different respondent groups while Mann-Whitney U Test was adopted to find out which of the groups are statistically different from one another after a statistically significant result was obtained from Kruskal-Wallis test. Non-parametric tests were selected due to the small sample number and the convenient sampling method used. The data might not have a normal distribution.

RESULTS AND DISCUSSION

Out of 500 sets of questionnaires sent, only 121 (24%) sets of completed questionnaires received. In this survey, the respondents are 8 developers (6.6%), 85 contractors (70.2%) and 28 consultants (23.1%) which make up a total of 121 respondents in the Malaysian construction industry within Klang Valley area and 44.6% of the respondents are Quantity Surveyors who are working in the contractor firm. The demographic data indicated that a range of professionals in the construction field had participated in this survey which they are believed to be able to provide a wider range perspective to this study and give a good cross-section of opinions. The respondents were required to use the 5-Likert scale to rate their agreement on the causes of waste generation and current waste practices in a project life cycle, on a scale from 1 'strongly disagree', 2 'disagree', 3 'neither agree nor disagree', 4 'agree' to 5 'strongly agree'. Cronbach's Alpha test was adopted to examine the internal consistency of the data. In this study, the reliability test on the data was carried out and it was found that the alpha values are 0.883 and 0.735 respectively which is more than 0.7. This indicates that 88.3% and 73.5 % of the data were true scores and the data collected was highly reliable.

Table 1. Causes of Waste Generation

Causes of Waste Generation	Means Score	Overall Rank
On-site management and planning	4.182	1
Design	3.918	2
Material Storage	3.810	3
Site operation	3.785	4
Material Handling	3.752	5
Transportation	3.657	6
Procurement	3.648	7
Material Ordering	3.518	8
Others	3.393	9

As shown in Table 1, the 'On-site management and planning' factor was ranked as the highest cause of waste generation with a mean score of 4.182. This is similar as stated in Nagapan et al. (2018) that the on-site management factor was also the highest rank as it was reported that supervision during the construction stage is the most influential part that causing failure in adopting waste management during different phases in a project life cycle. Unquestionably, proper on-site supervision and coordination are vitally important as it could furnish important pointers to different elements that may eventually lead to waste generation. 'Design' factor (mean score of 3.918), was the second-highest cause of waste generation. Similarly, Adewuyi and Odesola (2015) also found out that the design factor is the common phenomenon to construction projects where there are frequent design changes and design errors that may contribute to the level of material waste generated by this factor group. The 'Material Storage' factor was ranked third with a mean score of 3.810 among the causes of waste generation. As a result, the level of construction waste increases as if there are no storage spaces for materials to be stored on-site which will generate more material handling errors (Ikau et al., 2016). 'Others' factor (mean score of 3.393) was ranked last among all the causes of waste generation. This shows that most of the respondents perceived that the 'others' factor was not a significant cause that often led to waste generation as it ranked the least among all the nine main factors.

Table 2. Current Waste Practices

Current Waste Practices	Means Score	Overall Rank
Recycling	4.013	1
Reduction of construction waste	3.961	2
Reuse of construction waste	3.842	3
Other disposal sites	3.645	4
Construction and demolition landfill	3.553	5
Inert Landfill	3.303	6
Composting (eg on-site dig and bury)	3.145	7
Incineration	2.934	8
Combustion	2.882	9

In Table 2, 'recycling' with a mean score of 4.013, was the most common current waste practice adopted in the Malaysian construction industry as indicated by the respondents. According to Tey et al. (2012), recycling construction waste is based on the notion of making full use of the resources before disposal. Therefore, recycling should be advocated because it will aid in minimizing the amount of solid waste stored in landfills and mitigate air, water as well as land contamination caused by poor waste disposal. 'Reduction of construction waste' (mean score, 3.961), was ranked the second most common waste practice that being used to dispose of construction waste in the Malaysian construction industry. In accordance with Eusuf, Ibrahim and Islam (2012), it was reported that the highest priority in waste management is first to reduce the quantities of waste generated. 'Reuse of construction waste' method was ranked third with a mean score of 3.842 that is used to dispose of construction waste in the Malaysian construction industry. This waste practice was also highly ranked in Eusuf, Ibrahim and Islam (2012) where it has been said that the materials which were extracted from construction and demolition can be reused or retained for possible future use. The architectural components, for example, can often be reused for future construction projects. 'Combustion' was ranked least (mean value, 2.882) among all the current waste practices that are being used to dispose of construction waste in the Malaysian construction industry. This can be explained as in Nagapan et al. (2012b) whereby it has been found that the combustion method ought to be classified among the last selections for disposing of construction waste as burning the waste without taking appropriate measures may further damage the environment and produce even more waste production.

Kruskal-Wallis Test was adopted to determine the opinions from different groups of respondents which are developer, contractor and consultant on the causes of waste generation in the Malaysian construction industry. The two hypotheses generated from the Kruskal-Wallis test are as follow:

1. Null hypothesis (H_o); There is no significant difference between developers, contractors and consultants on the causes of waste generation and current waste practices in Malaysian construction industry.
2. Alternative hypothesis (H_1); There is a significant difference between developers, contractors and consultants on the causes of waste generation and current waste practices in the Malaysian construction industry.

Table 3. Kruskal-Wallis Test Result for Causes of Waste Generation

Ref	Causes of Waste Generation	Developer (N=8)	Contractor (N=85)	Consultant (N=28)	Kruskal-Wallis H	Asymptotic Significance
		Rank	Rank	Rank		
A	**Procurement**					
A1	Errors in contract documents	16	23	19	0.090	0.956
A2	Contract documents is incomplete at commencement of construction	17	21	22	0.459	0.795
A3	Lack of early stakeholders' involvement	6	18	22	1.663	0.435
A4	Poor communication among parties	1	6	5	1.249	0.535
A5	Lack of allocated responsibility for decision making	6	10	4	0.447	0.800
B	**Design**					
B1	Frequent design changes	11	8	6	1.108	0.575
B2	Design and construction errors	18	7	8	2.175	0.337
C	**On-site management and planning**					
C1	Poor on-site waste management	2	1	2	0.929	0.628
C2	Delays in passing information	5	3	14	6.408	**0.041***
C3	Lack of on-site material control	2	2	1	0.386	0.824
D	**Site operation**					
D1	Accidents due to negligence	8	14	9	0.619	0.734
D2	Equipment Malfunction	20	15	18	4.955	0.084
D3	Poor workmanship	8	4	3	3.172	0.205
E	**Transportation**					
E1	Damage during transportation	19	20	13	1.934	0.380
E2	Improper methods of unloading	10	11	10	0.692	0.707
F	**Material Ordering**					
F1	Ordering errors	23	17	16	5.178	0.075
F2	Poor quality of materials	14	13	12	1.368	0.505
F3	Shipping and suppliers' errors	24	24	17	2.525	0.283
G	**Material Storage**					
G1	Insufficient site storage space	22	12	20	8.764	**0.012***
G2	Improper storing methods	13	5	11	3.237	0.198
H	**Material Handling**					
H1	Poor material handling	4	9	7	0.192	0.908
H2	Materials supplied in loose form	15	16	15	0.453	0.797
I	**Others**					
I1	Weather	20	19	24	3.620	0.164
I2	Vandalism	11	22	21	0.949	0.622

[a] *. The mean difference is significant at the 0.05 level of significance.

Table 4. Kruskal-Wallis Test Result for Current Waste Practices

Ref	Current Waste Practices	Developer (N=8)	Contractor (N=85)	Consultant (N=28)	Kruskal-Wallis H	Asymptotic Significance
		Rank	Rank	Rank		
M1	Recycling	4	1	1	5.068	0.079
M2	Composting (eg on-site dig and bury)	8	8	7	0.527	0.768
M3	Incineration	8	9	8	0.797	0.671
M4	Inert Landfill	4	7	6	0.040	0.980
M5	Construction and demolition landfill	4	6	4	0.228	0.892
M6	Other disposal sites	2	5	5	1.172	0.556
M7	Combustion	4	3	9	1.154	0.562
M8	Reduction of construction waste	1	2	2	2.752	0.253
M9	Reuse of construction waste	2	4	3	0.013	0.994

As shown in Table 3, the alternative hypothesis (H_1) is accepted as there is a significant difference between developers, contractors and consultants on the causes of waste generation in Malaysian construction industry. Since a statistically significant result was obtained from this test, the Mann-Whitney U test was required to be conducted to know which of the groups are statistically different from one another. In Table 4, all the significance values are of greater than 0.05, this indicates that with 95% of confidence level, the null hypothesis (H_0) is failed to be rejected. Since the null hypothesis (H_0) is failed to be rejected, this can only be concluded that it is failed to prove there is a significant difference between developers, contractors and consultants on the current waste practices that are being used to dispose of construction waste in Malaysian construction industry where there is insufficient evidence to support its denial as the sample size in this research is insufficient to accurately represent the whole Malaysian construction industry.

Table 5. Mann-Whitney U Test Result for Causes of Waste Generation

Causes of Waste Generation	Statistically Significant Variables	Respondent Groups	Asymp. Sig. (2-tailed)
On-site management and planning	Delays in passing Information	Contractor Consultant	**0.014***
Material Storage	Insufficient site storage space	Contractor Consultant	**0.010***

[a] *. The mean difference is significant at the 0.05 level of significance.

As we can see in Table 5, there is a statistically significant difference in the contractor/consultant group. The heterogeneous view between the respondent groups is probably owing to inadequate coordination and communication between contractors and consultants. A construction project is a series of related tasks and a delay in any one of the tasks can delay the whole project lifecycle. Therefore, the contractors rank it as one of the significant causes of waste generation in 3rd place. Besides, the consultants rank this cause at 14th place, who do not get affected much as consultants are the people who are employed to carry out their works more on the pre-construction stage such as design works. In other words, the consultants are still able to complete their works without taking into account the information from the contractors. Therefore, some consultants do not see the ‘delay in passing information’ as one of the significant causes to waste generation. Thus, the contractors may be more particular in passing information than the consultants and perceive that the delay in passing information will lead to construction waste generation in Malaysian construction industry.

The ‘insufficient site storage space’ has been revealed to be statistically significant differences among the contractor/consultant group. Contractors rank the ‘insufficient site storage space’ as one of the significant causes in waste generation at 12th among all the causes of waste generation while consultants rank the ‘insufficient site storage space’ as one of the least significant causes at 20th place. The divergent thought is probably due to the roles of contractors and consultants are different where the client appoints a consultant engineer mainly for design works but not for supervision works on-site as supervision is done by the contractors. The contractors are generally the stakeholders responsible for evaluating the client's needs and actually perform the work and likewise storing the construction materials during the progress of work. Thus, the contractors may be more particular in site storage space than the developers and consultants and perceive that the ‘insufficient site storage space’ will lead to construction waste generation in Malaysian construction industry. Unquestionably, contractors and consultants are the two closest parties to each other. Therefore, they tend to have different opinions regarding construction issues and the conflicts are constantly evolving among them.

CONCLUSION

The findings revealed that Malaysian construction practitioners in Klang Valley perceived the ‘on-site management and planning’ factor, ‘design’ factor and ‘material storage’ factor are the top three key causes of construction waste generation. It was found that there is a statistically significant difference in the contractor/consultant group towards the variable ‘delays in passing information’ and ‘insufficient site storage space’’. Such differences are probably due to inadequate coordination and communication between contractors and consultants. Not to mention their different roles and responsibilities while performing their works in construction projects which make them tend to have different opinions regarding construction issues. Besides, the findings disclosed that ‘recycling’, ‘reduction of construction waste’ and ‘reuse of construction waste’ as the three most commonly used waste practices in Malaysian construction industry. It was found that the respondents from different groups were having homogeneous perceptions on the current waste practices in Malaysian construction industry as the test result failed to prove that there is a significant difference across the three different groups of the respondent.

All the objectives of this study have been achieved. By reassessing the root causes of waste generation and current waste practices in the current construction industry, this will help to refine the practices to handle construction wastes and create greater awareness to the construction practitioners on this issue.

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POTENTIAL AND CHALLENGES OF HISTORICAL BUILDING INFORMATION MODELING (HBIM) FOR BUILT HERITAGE IN MALAYSIA

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Abstract
The Building Information Modelling (BIM) has been perceived as a powerful technology in the Architecture, Engineering and Construction (AEC) industry. Its capabilities in representing physical and functional characteristics of a facility in the form of digitalization further enhancing its potential in heritage sector. Despite its huge potential, BIM is more widely spread and use in the new build construction projects compared to existing and historic buildings. Therefore, this paper attempts to identify the potential of the application of BIM in the heritage sector and challenges that hinder its implementation. A semi structured interview was conducted amongst a purposive sample of ten (10) stakeholders from different organizations who have the knowledge in BIM and heritage matters in Malaysia. The study found that the integration of BIM in conservation activity provides opportunities for documentation, cost and time reduction, sustainable project, elimination of lengthy traditional works, integration of different kinds of data into single model, and better communication and coordination between project teams. Using the NVivo 8.0 software, these potentials are further classified into four emergent themes: management tool; information sharing; sustainability; and knowledge enhancement. While lack of the software expertise and specialist has been identified as the most fundamental issue facing the implementation of HBIM in heritage sector of Malaysia, the paper concludes with recommendations in promoting the HBIM adoption in Malaysia conservation activity.

Keywords: *Built Heritage; challenges; Historical Building Information Modeling (HBIM); potentials.*

INTRODUCTION

Adopting modern technologies and practices such as Building Information Modeling (BIM) for improving construction productivity had become a national agenda through Construction Industry Transformation Programme (CITP) 2016-2020. In line with the 11th Malaysia Plan (RMK-11), BIM is considered as an emerging technology and modern construction method that will enhance efficiency of the implementation of construction projects. The National Building Information Modeling-United States defines BIM as a digital representation of physical and functional characteristics of a facility. As such, it serves as a shared knowledge resource for information about a facility, forming a reliable basis for decisions during its life cycle from inception onward. According to Azhar et al. (2012), BIM can be traced back to the parametric modeling research conducted in USA and Europe in late 1970s and early 1980s. Its powerful benefits have further driven the Architecture, Engineering and Construction (AEC) industry to adopt it and increasingly implement the technology in various domains starting mid-2000s. BIM is eliminating more of the traditional works of design process, reducing human error, saving cost and time, providing better coordination between project team, and ultimately escalating productivities in a development project (Ahmad Jamal et al., 2019b; Zainon et al., 2016).

Following to its huge potential, the application of BIM technologies has now been expanded in heritage projects all around the world. Conservation projects such as the Manchester Town Hall in England, Edinburgh Waverley Railway Station in Scotland, and the Woodseat Hall in Staffordshire have shown that historic building conservation projects delivered using BIM can yield benefits for managing the building's life cycle (Historic England, 2017). The output from published case studies of San Cipriano Church and St. Maria Church restoration projects in Italy are also promising with regard to BIM implementation for heritage buildings (Continenza et al., 2017). Application of BIM in buildings with cultural significance which called as Historic Building Information Modelling or HBIM is a new system of modeling historic structures that carries all information related to the building including its method of construction, material makeup and manufacturers detail (Murphy et al., 2013). As argued by Azhar et al. (2012), the key difference between BIM-based technology and conventional 3D CAD is that the latter does not possess capability to store intangible information thus missing 'I' of BIM. Hence, HBIM serves as an important documentation tool in aiding future investigations of a conservation project (Hung-Ming et al., 2015; Jordan-Palomar et al., 2018). It allows the integration of all information relating to historic structures into a single model and serves as a collaboration platform between stakeholders.

In Malaysia, the need for this technology is highlighted by the fact that there is no proper documentation practice is being undertaken. A plausible explanation is that no statutory implications offered for such exercise. Documenting historical structures not only paves the way for the establishment of the significance of the places but also provides guidance for those who may involve in managing and regulating historic places (Australia ICOMOS, 2013). This corresponds with the suggestion recommended by the ICOMOS Principles for the Recording of Monuments, Groups of Buildings and Sites 1996 on the need for recording as one of the principal ways available to acquire an understanding of cultural heritage, its value and evolution; permit informed management and control of construction works, and of all change to the cultural heritage; and to ensure that the conservation of the heritage is sensitive to its physical form, materials, construction and most importantly its cultural significance. The application of HBIM will accelerate the process and improves the accuracy of repository by eliminating the lengthy manual measurement systems used for surveying and recording historical assets (Ali et al., 2018; Zainon et al., 2016). Although adoption of HBIM has been widely debated and increasingly adopted in several developed and developing countries, Malaysia is still lagging behind in its implementation. As argued by Zahrizan et al. (2014), this is not surprising since the adoption of BIM itself is still an emerging field. For Construction Industry Development Board (CIDB) Malaysia (2017), construction industry players are still facing difficulties in understanding the benefits of implementing BIM into practice. Therefore, this paper attempts to identify the potentials of the application of BIM in the heritage sector and challenges that hinder its implementation. In achieving this aim, this paper presents how conservation of historic structures can benefit from the use of HBIM and what are the key barriers to its implementation. Theoretical findings is further strengthened through a semi structured interview with key stakeholders who have the knowledge in BIM and heritage matters in Malaysia.

POTENTIALS OF BIM APPLICATION IN HERITAGE SECTOR

BIM is an innovative approach introduced to manage building design and project data in digital form throughout a building's life cycle (Othman et al., 2020). Construction Industry Development Board Malaysia (2017) perceived BIM as an advanced ICT with the potential to transform the construction industry by enhancing efficiency, productivity, and quality. BIM has incredibly shown powerful benefits within new-build construction projects (Othman et al., 2020) compared to existing and historic buildings. The technology can integrate information into the 3D model which improved communication between project teams (Cuperschmid et al., 2019; Zainon et al., 2016). In this process, imaging surveys will be conducted, and advanced 3D laser scanning equipment is used to scan the site to convert data into meaningful information which then integrate within the BIM model. Through BIM, this information can be shared and hence encourage collaboration and coordination between different disciplines. As argued by Mohd-Nor & Grant (2014), BIM is seen as a means to overcome communications and information management difficulties that have plagued the industry. Conservation projects within heritage sector could similarly benefit from the adoption of BIM (Historic England, 2017). The use of BIM for heritage and archaeology is referring to Historic Building Information Modelling or HBIM.

HBIM has also achieved strong adoption in several developed and developing countries following its potential in improving multi-party collaboration and communication (Ahmad Jamal et al., 2019; Eastman, 2010; Ismail et al., 2017; Othman et al., 2020). For Historic England (2017), the term historic BIM in itself is defined as a multi-disciplinary process that requires the input and collaboration of professionals with different skillsets. Azhar et al. (2012) highlighted that the information about building systems and equipment in BIM model can be assessed by multi-disciplinary members of a project. The researchers further argued that building information model carries all information related to the building and changes to dimensions in one view will automatically reflected in other views. For Ahmad Jamal et al. (2019), this attribute contributes great benefits towards project delivery as it provides an information platform for communication between project teams. Following this potential, Hung-Ming et al. (2015) perceived HBIM as an essential communication and coordination tool in historical building projects.

According to Ali et al. (2018), HBIM is a project simulation consisting of the 3D models of the historic building's components with links to all information, both tangible and intangible data. The use of a computer software model to simulate the construction and operation of a facility would enable designers to use BIM tools without rebuilding existing structures and thus, enhance the productivity and profitability of a project (Hung-Ming et al., 2015). This could also save a lot of costs and time as it eliminates tedious human measurement of existing facilities, minimizes unnecessary reproduction of work tasks, and facilitates faster and better decision-making (Ahmad Jamal et al., 2019a; 2019b). Furthermore, few methods and high-end tools used in capturing dimensions, forms and typology of the building allows HBIM model development within a very short period of time (Murphy et al., 2019). By eliminating the lengthy and tedious conventional measurement, human error could be minimized (Ahmad Jamal, et al. 2019b; Zainon et al., 2016). Digital technologies in HBIM have automated the process of collecting and processing data.

While involving data capture and simulation of building elements, Mansir et al. (2016) perceived HBIM as an emerging technology that has potentials to efficiently document and manage historic buildings. As supported by Fai et al. (2011), the use of HBIM provides an opportunity for addressing the lack of appropriate documentation for many existing heritage places. While considering as an emerging technology, the role of HBIM as a data hub for documentation is undeniable. HBIM allows development of a massive information model which consists of both tangible and intangible data. As argued by Rocha et al. (2020), HBIM is an integrated process that building a model consisting information needed for planning conservation and restoration of a historic building. For Azhar et al. (2012), the models of existing facilities can be used further for renovation and adaptive re-use of existing buildings. The importance of is emphasized by the ICOMOS Principles for the Recording of Monuments, Groups of Buildings and Sites 1996 as one of the effective tools to acquire an understanding of cultural heritage, its value and evolution; promote the interest and involvement of the people in the preservation; permit informed management and control of construction works, and of all change to the cultural heritage; and to ensure that the maintenance and conservation of the heritage is sensitive to its physical form, materials, construction and its cultural significance.

The potential of BIM in heritage sector also becomes increasingly apparent through the notion of sustainability. According to Hung-Ming et al. (2015), 3D models generated using HBIM able to visualize the whole life-cycle process of construction without rebuilding existing structures and hence, eliminating the use of building materials and energy consumption involved in building a new one. Zhang et al. (2019) further acknowledged BIM potentials in influencing sustainability by reducing errors, greenhouse gas emissions, and production of demolition waste through simulation of the project. Although the adoption of BIM for sustainability has gained attention in the building sector, studies on how the technology helps in achieving goals of sustainable construction are still minimal (Chang and Hsieh, 2020).

ISSUES AND CHALLENGES OF HBIM ADOPTION

BIM for historic structures is an emerging field and appears less popular in terms of adoption by heritage professionals (Historic England, 2017). Ali et al. (2018) identified the problem of incomplete information as one of the key barriers responsible for the delay and slow adoption of HBIM technology. According to these researchers, this is because many information about historical building has been lost and some are impossible to retrieve thus creating data void problems. Data acquisition for creating model in HBIM could be much more complex than the models describing new-build construction. This problem is further exacerbated by the complex and unique characteristics of the buildings which encountered in most of the heritage projects. As highlighted by Rocha et al. (2020), the use of BIM for new build construction projects differs from existing historic buildings which usually characterized by a complex design and shape. This problem was encountered by the published case study of the Oriental Club in London. As supported by Megahed (2015), building 3D models for heritage buildings can be time-consuming, inaccurate, and requires a lot of manual effort due to the complexity of the buildings.

Furthermore, historic BIM technology would also greatly impact on cost of a project as it requires investment of equipment, software, hardware and training (Ahmad Jamal et al., 2019). For Rocha et al. (2020), the cost increases with the complexity of the historic building. This constitutes to another barrier in achieving full HBIM implementation. As argued by Construction Industry Development Board Malaysia (2017), there is no evidence of return of investment is observed through its adoption. Subsequently, professionals involved in historic preservation resist to invest on the system. Lack of understanding and knowledge about HBIM approach also contributes towards low implementation and use of the technology (Megahed, 2015). A study by Othman et al. (2020) revealed that construction players are facing difficulties to understand and practice the system. Following this, the researchers suggested that professionals need to develop their skills on the BIM implementation by attending training and seminars while practicing with the system. For Zainon et al. (2016), this is also important for these professionals to change their mindset and behaviour into liking and practicing the new technology. However, Kai et al. (2019) stressed that time is needed for these people considering the technology as new and uncommon system.

Fewer studies have also addressed low BIM adoption in education as another barrier to the implementation of the technology among construction players (Hatmoko et al., 2019; Ismail et al., 2017). Maharika et al. (2020) recognized the need to integrate BIM in the academic syllabus of architecture, engineering, and construction (AEC) related programmes in producing BIM-ready graduates and eventually skilled workforce in the industries. It is not only crucial to train the AEC students but also reducing high training and development expenses of the practitioners in the future (Zou et al., 2019). As argued by Olowa, et al. (2019), lack of skilled and educated human resources following to low implementation of BIM education hinders the successful adoption of the technology. While proposing effective BIM-enabled pedagogies and techniques, Hu (2019) also highlighted the need for the professional accreditation bodies to require incorporation of BIM courses and trainings in the curriculum.

Another obvious reason why HBIM has not attain successful implementation is due to the absence of policy and guideline related to HBIM. As highlighted by Azhar et al. (2012), there is no clear consensus on how to implement and use the system. For Attenni (2019), the procedure to be followed in using the system has not been consolidated as BIM was not originally created for modeling historical structures. In addition to this, Chien et al. (2014) further argued that there is also unclear legal liabilities and procedures that is relevant to BIM in areas such as policies, standardize contract, ownership of data, insurance, risks, and allocation of roles and responsibilities.

METHODOLOGY

The methodology used in examining the potentials and challenges of the application of Historical Building Information Modeling (HBIM) involves an extensive literature review from different kinds of materials such as reports and documents published by government and private agencies, books, published conference proceedings, and academic journals. This review is subsequently complemented by semi-structured interviews as an attempt to identify the potentials and challenges of BIM application in the heritage sector. In this study, interviews were used as it allows the researcher to obtain deeper and extensive understanding regarding the issues studied (Gill et al., 2008; Jamshed, 2014). Ten (10) interviewees participated in the interviews based on the purposive sampling among stakeholders from different organizations who have the knowledge in BIM and heritage matters in Malaysia with more than 5 years of experience in the field. The purposeful sampling method is employed as it allows information rich cases that worthy for in-depth study to be selected (Leedy and Ormrod, 2010). The study also found that the answers given by the interviewees reached saturation point with no additional information after ten interviews (Sebele-Mpofu, 2020).

An interview guide consisting of seven (7) questions grouped in four (4) major themes: background of HBIM in Malaysia conservation work; potentials of HBIM; challenges of HBIM adoption; and recommendations to promote HBIM was prepared prior to the interviews in order to guide and keep the interview focused on the desired line of action. The telephone interviews which were conducted using speakerphone, was carried out from January to April 2018, a total period of four (4) months. On average, the interviews lasted from 30 to 45 minutes in duration. All interviewees were given an information sheet which provides information about the research and a consent form in advance of the interview through emails. Furthermore, the interviews were also audio recorded with the interviewees' permission for subsequent transcription. The transcribed interviews were emailed to all interviewees for validation before the researcher begin the analysis process using the qualitative software package NVivo 8.0. In maximizing the confidentiality and integrity of the data obtained (Saunders et al., 2015), the study established and assigned an identifying code number to each of the interviewee. For example, the code P-JW-10 refers to an interviewee from National Heritage Department and was the tenth participant to be interviewed. Table 1 summarized the number and coding used for all interviewees involved in the study. The interviews were conducted until data saturation is achieved.

Table 1. Summary of Interviewees Involved

Interviewees' Affiliation	Interviewees' Code	Number of Interviewees
National Heritage Department	PJW09, PJW10	2
BIM Asia Sdn Bhd	PBI03, PBI04	2
My BIM Malaysia	PMY06	1
Building Smart Malaysia	PBS05	1
Matrix Trinity Technology & Creativity Academy (MTTC)	PMA08	1
Academician	PIP01, PIP02, PIP07	3
	TOTAL	**10**

FINDINGS AND DISCUSSION

The first section of the interviews presented the background of HBIM in Malaysia conservation work. Results from the interviews demonstrated that emerging technologies are not common in the local industry and therefore are not widely used for conservation activity in Malaysia. According to four interviewees (PIP01, PBS05, PMY06, PMA08), there is a low level of awareness of the potential advantages of HBIM among the key players in the field of cultural heritage which posed significant impact toward the transformation to HBIM-based technology. This is proven through a statement given by an interviewee from a government organization:

> We are still using manual methods in collecting and documenting information, conducting assessment, investigating condition of the structure… which often leaves damage to the structure…
>
> Interviewee PJW09

On the other hand, two interviewees from a private consultant company (PBI03, PBI04) believed that practitioners are aware of the importance of historic BIM implementation despite low percentage of its adoption. This is in line with the finding of Mohd-Nor and Grant (2014) who discovered that only 20 percent of the architecture firms in Malaysia are currently using the technology although there is a high percentage of the firms (more than 80 percent) aware of its benefits. Following this, the study took an initiative to ask the interviewees who have not currently using the technology on their willingness and readiness to integrate HBIM into their practice. All interviewees responded positively on HBIM adoption in the future. As stated by one interviewee:

> Everything is now digital, so why not embrace the workflow and starts working on some digital museum… I believed that with the adoption of HBIM may improve efficacy of the work and save time...
>
> Interviewee PJW10

Table 2. Potentials of HBIM Adoption

Concepts	Emergent Themes	Constructs
Potentials of HBIM Adoption	Management Tool	Eliminating traditional workflows as the technology allows conversion of scanned data into a single model
		Speed up project delivery
		Eliminate unnecessary cost and increase profitability
	Information Sharing	Integrate tangible and intangible information into a single model which accessible by project teams
		BIM allows information to be updated instantly and automatically throughout the model
		Serve as platform for better communication and coordination
	Knowledge Enhancement	BIM models possess capability in storing digital information for documentation
		Paves the way for acquiring an understanding of cultural significance
	Sustainability	Contribute towards sustainable project by eliminating waste production, reducing cost, and improving work efficiency

In line with the discussion in literature review sections, Table 2 demonstrated the potential of HBIM as a powerful tool that can efficiently manage time and cost involved in heritage projects. The summary models visualizing the connections between various dimensions of the potential is illustrated in Figure 1. As highlighted by three interviewees (PIP02, PMY06, PIP07), HBIM not only using for data processing and documentation but also can quickly generate 3D modeling and measured drawing thus eliminating traditional workflows of design and project delivery. The conservation project of the Manchester Town Hall Building in England has also proved the efficiency and productivity of the technology in saving money on unnecessary temporary works and saving the programme a total of nine months thus demonstrating its potential for future facilities management purposes (Historic England, 2017). Notwithstanding the fact, an interviewee from a public university (PIP01) argued that the process can be time consuming if the existing information and data for inclusion in BIM is incomplete or unavailable especially for Malaysia where historical documentation is currently absent. The interviewee further added that the distinct and unique characteristic of historic structures will also reduce the potentials of HBIM.

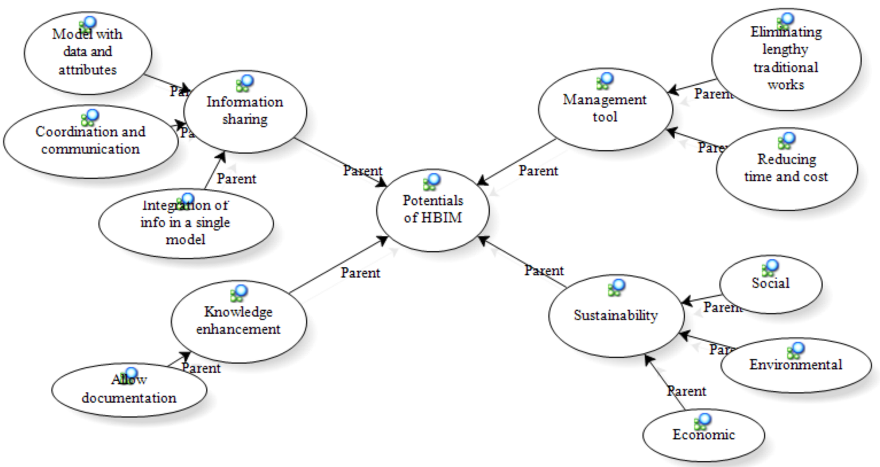

Figure 1. Potentials of HBIM

Five interviewees (PBI03, PBI04, PBS05, PMY06, PIP01) acknowledged the potential of HBIM in serving as a platform for effective communication and collaboration between project teams. As stated by one of the interviewees (PBI04), since conservation projects often involve a great number of experts, HBIM is ideal for heritage conservation and management as it allows the integration of both tangible and intangible information into a single model. Communication between stakeholders can therefore be made easier. Another interviewee from a private consultant company (PBI03) further highlighted that this feature of HBIM allows the model to be instantaneously updated and shared if one of the project teams is reviewing the model. As supported by Azhar et al. (2012), building information model carries all information related to the building and changes to dimensions in one view will automatically reflected in other views. In addition to this, three interviewees (PIP02, PBI03, PMA08) stated that the role of HBIM in knowledge enhancement is also undeniable. According to these interviewees, HBIM has the capability in storing and displaying electronic information about the cultural heritage buildings which can then be used for documentation purpose. This documentation will ultimately support the effort in keeping a record of the heritage buildings for future research and references. Interestingly, one interviewee (PBS05) said that the potential for HBIM adoption could evolved around the tripartite approach of sustainability which to fairly consider economic, societal and environmental domain.

Despite the potentials of HBIM for architectural conservation works, there are many issues and challenges that hinder the adoption of historic BIM as demonstrated in Table 3. The summary models imported from NVivo is also illustrated in Figure 2 to visualize the connections between challenges identified through the interviews. The barriers to HBIM application include lack of awareness and demand of this technology, learning difficulties, absent of clear usage guidelines, people mindset and belief, and high investment cost. However, all interviewees agreed insufficient skills and lack of BIM expertise as the most fundamental issue facing the application of BIM in Malaysia conservation projects. As commented by an interviewee:

> We are still not adopting BIM approach in heritage buildings conservation… because we have no expertise and insufficient skill in the field. Additionally, the purchase cost is relatively high…
>
> Interviewee PJW10

Table 3. Challenges of HBIM Adoption

Concepts	Emergent themes	Constructs
Challenges of HBIM Adoption	Social	Lack of awareness on the potentials of HBIM
		Insufficient skills and knowledge in using the technology
		People mindset and belief that conventional practice is working exceptionally
		Learning difficulties due to lack of expertise
	Economic	High investment cost
		Lack of incentives from government and private agencies
	Legislative	Absence of specific policy with regards to data ownership
		Absence of BIM standards and guidelines in guiding potential users

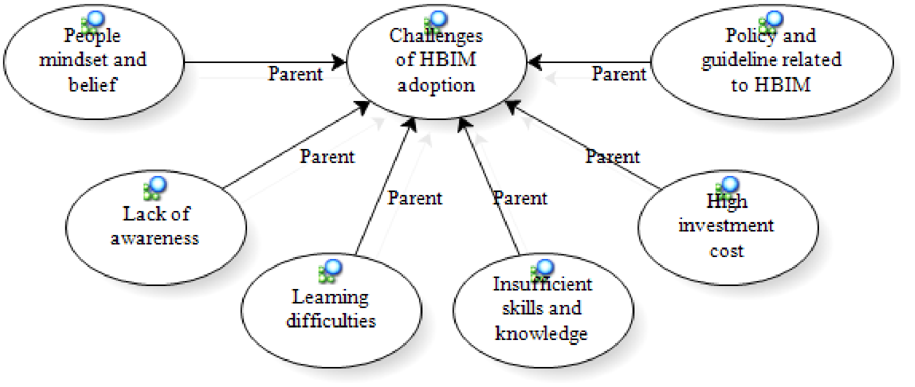

Figure 2. Issues and Challenges of HBIM Adoption

People who work in conservation industry are really lack the understanding and ability to utilize HBIM, and therefore cannot fully put this new system into practice. One of the interviewees (PMA08) said that some of the companies facing difficulties in adopting HBIM as it is considered to be a complex and delicate system. In fact, according to Ali et al. (2018), there are no case studies found using HBIM in Malaysian context. Two interviewees from public university (PIP02, PIP07) believed that this is attributable to the difficulties of the learning curve as well as high investment cost in obtaining the system. As supported by Construction Industry Development Board Malaysia (2017), high initial investment costs were identified as the major barriers and concerns for the industry which causing industry players to be reluctant to invest and develop capability in the technology. Accordingly, three interviewees (PBI03, PBS05, PMY06) stressed that the government agencies need to be proactive in promoting HBIM application in conservation activities via continuous training programme and tax exemption for purchase of the software. In addition to this, an interviewee (PIP01) further argued that the efforts from private sectors in promoting the usage of HBIM is also undeniable.

Another challenge identified through the interviews is related to the lack of clarity on the ownership of BIM data. According to two interviewees (PBI03, PMY06), the policy for the copyright of historical data is still not available in Malaysia and therefore people may copy and illegally use others' people data without permission. Accordingly, the interviewees suggested that a specific policy that can protect the owner's historical data need to be formulated and strengthen in terms of the copyright. As supported by published studies (Ahmad Jamal et al., 2019b; Ismail et al., 2017), there is a need to develop BIM standards and guidelines to encourage more BIM application as well as resolve unclear legal liabilities. An interviewee from government organization (PJW09) however argued that existing mechanisms related to national heritage preservation need to be taken into consideration in developing the standards. Other issues highlighted by the interviewees include lack of awareness on HBIM adoption, and people mindset that current and traditional practice is working exceptionally. Following these challenges, few recommendations have been proposed by the interviewees. In promoting the use of HBIM technology, seven interviewees (PIP01, PIP02, PBS05, PMY06, PIP07, PJW09, PJW10) recommended that courses and syllabus related to BIM need to be introduced at the university level in order to develop fundamental knowledge and skills among the students at the early stage. An interviewee (PBI03) further added that promotion of HBIM can also be made through media such as newspaper, television, and internet. People may be getting familiar with the importance of this technology and may greatly influence its application in the conservation as well as other industry.

CONCLUSION

Given the huge and incredible potentials of HBIM in historical building conservation, it is highly questionable that the adoption level of the technology in Malaysia is still unsatisfactory and slow. This question which demands answer essentially triggered and motivated this research to be conducted. Through published works and case studies, the research identified that HBIM has led to greater efficiency of conservation projects by eliminating the lengthy traditional workflows of design and project delivery and hence, saving time and cost. The system also enhances coordination and communication between stakeholders through sharing of electronic information within a single model. Indirectly, the process of storing and forming an information repository involved in the system enables digital documentation of the historical structures. While no statutory implications offered for such documentation, this is also extremely necessary as recent and up to date documentation of Malaysia's built heritage is still not available to date. Furthermore, documentation appears as the first step in achieving better understanding of our heritage. Its potential in contributing towards sustainable project is also undeniable. However, there are several challenges that make it difficult to model unique and complex built heritage using HBIM. These include high purchase and operation cost of the software, lack of knowledge and ability to utilize HBIM, difficulties in learning the technology, low awareness and interest from the stakeholders, false perceptions about HBIM, unclear ownership of HBIM data across multi-disciplinary teams, absence of BIM usage standards and guidelines, and lastly, difficulties to adapt in structures with complex and unique design. By bringing diverse stakeholder groups together, this study provided several recommendations in promoting the HBIM adoption in Malaysia conservation activity. Apart from the development of BIM standards and guidelines, formulation of specific policy for copyright of HBIM data, tax exemption for purchase of the software, and introduction of courses related to BIM among students, the study emphasizes on the need for both government and private agencies to work together and play an active role in promoting HBIM application via mass media, and continuous training programme. It is believed that the key to achieving full HBIM adoption lies in people awareness and interest in the innovative technology.

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SYSTEMATIC REVIEW ON THE INTERPROFESSIONAL COLLABORATION (IPC) IN BUILDING INFORMATION MODELLING (BIM) BASED CONSTRUCTION PROJECTS

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Abstract
Building Information Modelling (BIM) has been revolutionising the traditional construction management and workflow in the industry. The construction industry is known for fragmentation in its nature of project delivery. Therefore, it is essential to foster collaboration among stakeholders from various disciplines through BIM. Collaboration among the Architecture, Engineering and Construction (AEC) professions strived to enhance teamwork, interactions, and information sharing by using a cloud-based environment. Furthermore, collaboration adds value to the project team to improve the sustainability and efficiency of work. There were abundant studies focused on examining the collaboration in the BIM-based construction projects, where the interdisciplinary approach was lacking. This study intends to present an analysis of the existing literature on the interprofessional collaboration (IPC) among the stakeholders' practices in the BIM projects. A total of ninety-six research journal articles regarding IPC in BIM-based projects was guided by the PRISMA Statement (Preferred Reporting Items for Systematic reviews and Meta-Analyses) review method. Six main themes and thirty-nine sub-themes were identified as an outline of IPC, namely collaboration, individual characteristics, interactional characteristics, team interactional characteristics, organisational features, and professional roles characteristics. In the thematic analysis, team interaction was noticeably the most frequently discussed aspect in the previous studies. Further studies about the social aspects of IPC in BIM-based construction projects were recommended. It was suggested to study the subject in a quantitative or mixed-methods approach.

Keywords: *Building Information Modelling; interprofessional collaboration; building construction; systematic literature review.*

INTRODUCTION

The application of BIM had been found majorly in the architecture, engineering and construction (AEC), as well as in the utilities, infrastructure, facilities management, heritage preservation and many other sectors (Fatima et al., 2016; Fountain & Langar, 2018; Liu et al., 2017; Munir & Jeffrey, 2013; Mustaffa et al., 2017; Nawari, 2018; Zhang et al., 2017). Unfortunately, the construction industry and the related sectors are well known for its fragmented nature in the project delivery and execution. Traditionally, issues involving the management of substantial computational resources and lack of flexibility in the building processes may further complicate the building processes. However, the introduction of BIM application is aimed to reduce the fragmentation through the integration of multiple professionals and building processes.

The collaboration and information exchange in the AEC industry could be too overwhelming and challenging, mainly due to the involvement of several disciplines and interoperability issues. The introduction of BIM enhances the collaboration of work among the AEC team by integrating multidisciplinary information such as design, analysis, cost estimation and construction scheduling (Teng et al., 2018; Tibaut & Zazula, 2018). However, BIM is essential in the decision making because of its ability to analyse in such a complex, integrated and multidisciplinary system (Ninić et al., 2017), which involves people, technology and process (Belayutham et al., 2018; Enegbuma et al., 2015; Hamid & Embi, 2018; Hykkönen, 2019; Liao et al., 2017; Liu et al., 2017). BIM is proven vital in ensuring decision-making throughout the whole project life cycle. Sebastian (2011) stated that the decision made may affect 70% of the life cycle cost of a construction project.

There is a large body of work in BIM, considering the increasing adoption of technology in the Malaysian construction industry and worldwide. Over the last decade, much research related to the BIM had been introduced, defined and explored, and a body of work exists describing the development of BIM internationally. This study aims to review the existing literature and identify the influencing variables (themes) that affect the interprofessional collaboration (IPC) in the BIM-based construction projects. Having said that the successful implementation of BIM very much dependent on collaboration and information exchange from the professionals of various disciplines. Thus, this paper is dedicated and aimed to review the interprofessional collaboration topic in BIM-based construction projects systematically. The said topic is still limited, even though there is an abundance of studies available.

Interprofessional Collaboration in BIM-based Construction Projects

Interprofessional or multidisciplinary collaboration involves the cooperation, integration and association of several construction stakeholders and professionals. Such collaborations are utmost important in ensuring the successfulness of BIM-based construction projects, as the BIM enhances and relies on the stakeholders' collaboration. Therefore, this study is initiated to employ systematic review procedures to analyse the existing literature and fill in literature and contextual gaps with the help of the systematic review regarding the interprofessional collaboration in the BIM-based construction projects. Besides, this study offers a holistic baseline on interprofessional collaboration among the construction stakeholders, specifically in the AEC sector, in the BIM-based construction projects worldwide.

Moreover, the exposure the collaboration issues in various professions or disciplines (multidisciplinary and interprofessional) is increasingly essential (Alreshidi et al., 2018; Idi & Khaidzir, 2018) to enhance the project performance (Franz et al., 2017). This article was guided by the main research question to construct a relevant systematic review – how do the influencing variables and its constructs affect the IPC in the BIM-based construction projects? The study's main focus was on the social aspects that may substantially impact team collaboration throughout the project lifecycle.

The PRISMA (Preferred Reporting Items Systematic Reviews and Meta-Analysis) statement approach was introduced and detailed in the "Methodology" section. Next, relevant research on interprofessional collaboration was identified, selected and appraised in the form of systematic review and synthesis of the existing scientific literature. Finally, recommendations for future research have been identified.

METHODOLOGY

In this section, the PRISMA method was proposed to retrieve journal articles related to interprofessional collaboration among the construction stakeholders in BIM-based construction projects. Several academic databases were searched and used to run the systematic review, eligibility and exclusion criteria, steps of the review process (identification, screening and eligibility) and data abstraction and analysis.

Higgins (2016) and Petticrew and Roberts (2006) suggested the systematic literature review as a more organised, transparent, and replicable procedures to comprehensively locate and synthesise relevant research. The existing research was identified, selected, and critically appraised through a systematic technique, data were then collected and analysed to investigate a clearly formulated research question. The results of the included studies were then analysed and summarised. The literature and contextual gaps of the study were identified, and future researches have also been recommended.

Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)

PRISMA method was used as a guideline in conducting the systematic literature review. It is often utilised within the social science research, building and construction field is included. Sierra-Correa and Cantera (2015) believed that PRISMA allows research questions to be defined clearly via systematic research, inclusion and exclusion criteria to be identified, and rigorous search attempts in the large database of scientific literature a specific time frame. This study proposed to systematically review the topic of interprofessional collaboration in BIM construction projects. The paper focused on the social aspects, specifically on technology, people, and process.

Resources

This review relied on nine (9) leading academic databases and Google Scholar to find quality journal articles related to the building and construction research. The academic databases that the authors used were Scopus, Web of Science, ScienceDirect, Emerald, IEEE, Springer, ProQuest, JSTOR and ASCE Library.

The rationale for searching from few academic databases is that there is no academic database are complete, Xiao and Watson (2019) suggested using more than one database, Younger (2010) supported as well because this method may cover each other's weaknesses. Thus, more complete researches were conducted. Google Scholar may face issues with lack of quality assurance, transparency about the resources it covers and may find out much grey literature (Younger, 2010). However, it was not used alone and not serve as a sole source of literature here in this study (Haddaway et al., 2015; Halevi et al., 2017). Instead, Google Scholar forms a powerful addition to other traditional search methods, subjected to further filtration.

Systematic Review Process: Identification

It was suggested that four (4) stages should be involved in a systematic review. Initially, the keywords related to the study were first identified and searched. The process was conducted in August 2020. With the help of the thesaurus and existing studies, keywords related to 'building information modelling' and 'interprofessional collaboration' were used to search for the journal articles (Table 1). After then, the searches were then screened through, and duplicated articles were removed.

Table 1. Keywords and Searching Information Strategy Used

Academic Databases and Search Engine	Search Keywords Used	Primary Search (Numbers)
Google Scholar	("building information modelling" OR "building information modeling" OR "BIM") AND (collaborate OR cooperate OR integrate OR teamwork OR associate) AND (interprofessional OR interdisciplinary OR inter-agency OR inter-sector OR inter-organisation)	6
Scopus	TITLE-ABS-KEY (("building information model*" OR "BIM") AND (collaborat* OR cooperat* OR integrat* OR teamwork* OR associat*) AND (interprofession* OR inter-profession* OR interdisciplin* OR inter-disciplin* OR interagen* OR inter-agen* OR intersector* OR inter-sector* OR interorganis* OR inter-organis* OR crossdisciplin* OR cross-disciplin* OR cross-profession* OR cross-agen* OR cross-sector* OR cross-organisat* OR multi-profession* OR multiprofession* OR multi-disciplin* OR multidisciplin* OR multi-agen* OR multi-sector* OR multisector* OR multi-organisat*))	357
Web of Science	TS=(("building information model*" OR "BIM") AND (collaborat* OR cooperat* OR integrat* OR teamwork* OR associat*) AND (interprofession* OR inter-profession* OR interdisciplin* OR inter-disciplin* OR interagen* OR inter-agen* OR intersector* OR inter-sector* OR interorganis* OR inter-organis* OR crossdisciplin* OR cross-disciplin* OR cross-profession* OR cross-agen* OR cross-sector* OR cross-organisat* OR multi-profession* OR multiprofession* OR multi-disciplin* OR multidisciplin* OR multi-agen* OR multi-sector* OR multisector* OR multi-organisat*))	204
Emerald	(("building information model*" OR "BIM") AND (collaborat* OR cooperat* OR integrat* OR teamwork* OR associat*) AND (interprofessional OR inter-professional OR interdisciplinary OR inter-disciplinary OR interagency OR inter-agency OR intersectoral OR inter-sectoral OR interorganisation OR inter-organisation OR crossdisciplinary OR crossdisciplinary OR cross-professional OR cross-agency OR cross-sectoral OR cross-organisation OR multi-professional OR multiprofessional OR multidisciplinary OR multidisciplinary OR multi-agency OR multi-sectoral OR multisectoral OR multi-organisation))	397
ScienceDirect	("building information modelling" OR "BIM") AND (collaboration OR cooperation OR integration OR teamwork OR association) Title, abstract or author specified keywords: (interprofessional OR interdisciplinary OR interagency OR intersectoral OR inter-organisation)	46
IEEE	(("building information model*" OR "BIM") AND (collaborat* OR cooperat* OR integrat* OR teamwork* OR associat*) AND (interprofessional OR inter-professional OR interdisciplinary OR inter-disciplinary OR interagency OR inter-agency OR intersectoral OR inter-sectoral OR interorganisation OR inter-organisation OR crossdisciplinary OR crossdisciplinary OR cross-professional OR cross-agency OR cross-sectoral OR cross-organisation OR multi-professional OR multiprofessional OR multidisciplinary OR multidisciplinary OR multi-agency OR multi-sectoral OR multisectoral OR multi-organisation))	14

Table 1. Keywords and Searching Information Strategy Used (Cont'd)

Academic Databases and Search Engine	Search Keywords Used	Primary Search (Numbers)
ProQuest	Abstract: (collaborat* OR cooperat* OR integrat* OR teamwork* OR associat*) AND (interprofession* OR inter-profession* OR interdisciplin* OR inter-disciplin* OR interagen* OR inter-agen* OR intersector* OR inter-sector* OR interorganis* OR inter-organis* OR crossdisciplin* OR cross-disciplin* OR cross-profession* OR cross-agen* OR cross-sector* OR cross-organisat* OR multi-profession* OR multiprofession* OR multi-disciplin* OR multidisciplin* OR multi-agen* OR multi-sector* OR multisector* OR multi-organisat*)	29
ASCE Library	("building information model*" OR "BIM") AND (collaborat* OR cooperat* OR integrat* OR teamwork* OR associat*) AND (interprofession* OR inter-profession* OR interdisciplin* OR inter-disciplin* OR interagen* OR inter-agen* OR intersector* OR inter-sector* OR interorganis* OR inter-organis* OR crossdisciplin* OR cross-disciplin* OR cross-profession* OR cross-agen* OR cross-sector* OR cross-organisat* OR multi-profession* OR multiprofession* OR multi-disciplin* OR multidisciplin* OR multi-agen* OR multi-sector* OR multisector* OR multi-organisat*)	1
	Total Numbers	**1,054**

Systematic Review Process: Screening and Eligibility

In this stage, the inclusion and exclusion criteria were listed in Table 2 to further narrow down the findings. Only journal articles with empirical data were hand-picked, and other literature types, such as systematic review, book series, book chapter, book and conference proceedings were filtered out. Next, only English literature was selected to reduce the difficulties in translating the documents. The review focused on the recent ten years (between 2010 and 2020) research publications of the interprofessional collaboration in BIM-based construction projects. Social science-based indexed journal articles only were selected. Thus, hard science indexed papers (Science Citation Indexed Expanded) were filtered out. Also, the countries and territories are opened to the international occasion. Lastly, only articles focused on BIM construction projects are selected as the main scope of this study.

Table 2. The Inclusion and Exclusion Criteria

Criterion	Eligibility	Exclusion
Literature Type	Journal (research articles)	Journals (systematic review), book series, book, book chapter, conference proceeding
Language	English	Non-English
Timeline	Between 2010 – 2020	Before 2010
Indexes	Social Science Citation Index, Emerging Sources Citation Index, Art and Humanities Index (Web of Science)	Science Citation Indexed Expanded

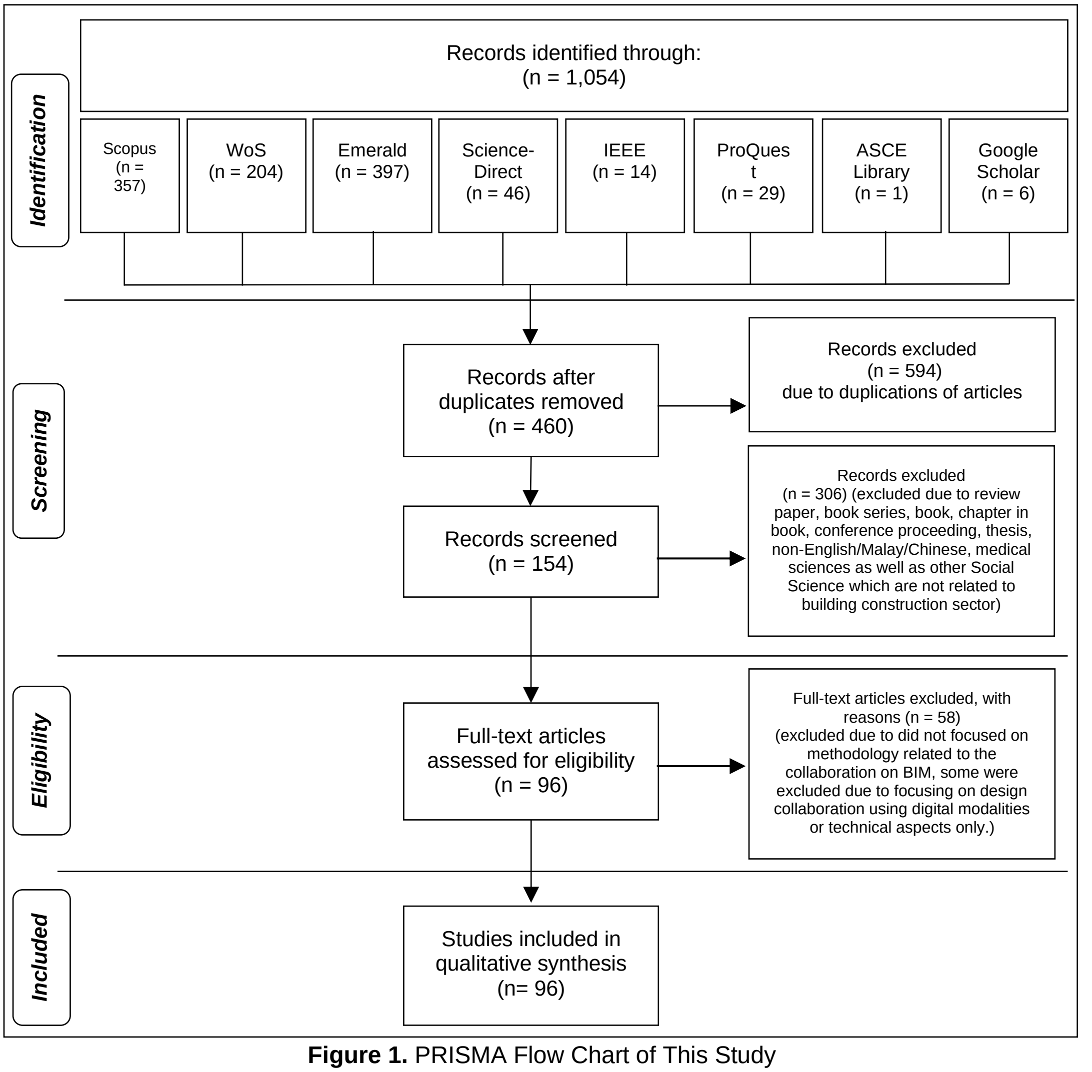


Figure 1. PRISMA Flow Chart of This Study

A total of 1,054 papers were identified and were further filtered and reduced to 96 journal articles, as shown in Figure 1. It was found out that some academic databases (such as Emerald and IEEE) having similar journal results because they are Scopus-indexed. Therefore, there are more duplicated records found. Whereas, Google Scholar is not considered as "Academic Database" but a "Search Engine", its numbers (n=6) still included here in the records. 96 Journal articles have been included. There were no records found in Springer and JSTOR academic databases.

Systematic Review Process: Data Abstraction and Analysis

An assessment and analysis of the remaining articles were conducted. In response to the formulated research question, the studies related to interprofessional collaboration in BIM construction projects were focused. The articles' abstracts were first screened through to extract and filter out the unrelated one, then followed by reading the articles in-depth. A content or thematic analysis was conducted to identify themes related to interprofessional collaboration, and sub-themes were established and classified accordingly.

RESULTS

Six (6) main themes and thirty-nine (39) sub-themes related to interprofessional collaboration were classified for this study. The six main themes are collaboration (four sub-themes), individual characteristics (five sub-themes), interactional characteristics (nine sub-themes), team interactional characteristics (ten sub-themes), organisational features (four sub-themes) and professional roles characteristics (seven sub-themes).

Descriptive Findings of the Systematic Literature Review

The systematic review was conducted on the 96 journal articles filtered through the PRISMA guidelines. Figure 2 shows the origins of the 96 journal articles identified by the authors.

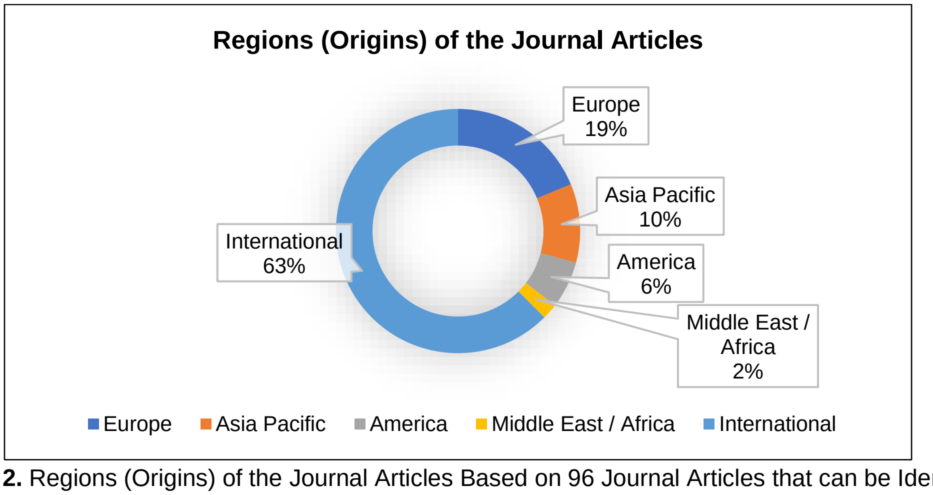


Figure 2. Regions (Origins) of the Journal Articles Based on 96 Journal Articles that can be Identified

Besides, Table 3 summarises significant concerns over the Architecture and Engineering professions, which constitute 86.5 percent of the 96 articles reviewed. Then, it was followed by Construction and Project Management (78.1 percent), Education (21.9 percent), Owner or Client and Facilities Management (with each 11.5 percent). Whereas, 53.1 percent of the articles focus on other professions and areas of focus, such as green and sustainability, energy performance, legal, mobile and cloud computing, and many others.

Table 3. Professions and Area of Focus

Items	Professions & Area of Focus	Number of Occurrences
1	Architecture	83
2	Engineering	83
3	Construction & Project Management	75
4	Owner / Client	11
5	Facilities Management	11
6	Education	21
7	Others	51

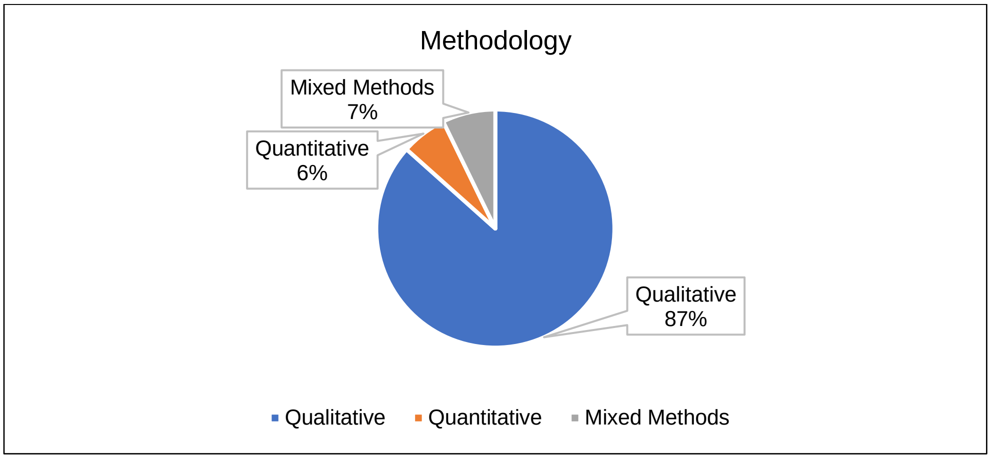


Figure 3. Methodology Used by Previous Studies

Interestingly, Figure 3 shows that the existing literature shows 84 qualitative studies compared to quantitative (6) and mixed-method studies (7). The reviewers observed that case studies were the most preferential for the studies in the context of interprofessional collaboration, as revealed in Table 4. Interviews then followed it, experimental studies, prototype testings, focus groups, thematic or document analyses, observations, ethnographic actions, and design science approach.

Table 4. Classifications of Qualitative Studies

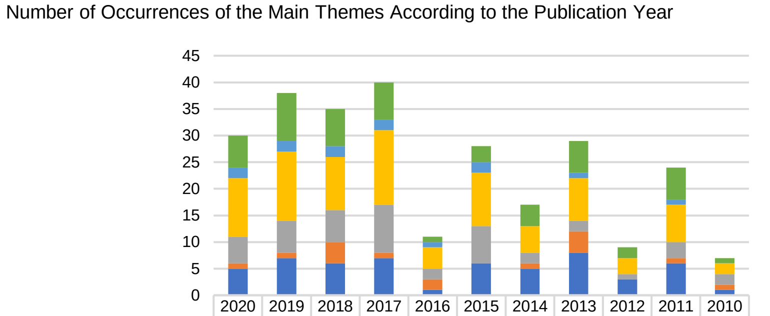
Items	Qualitative Studies	Number of Occurrences
1	Case Study	46
2	Interview	19
3	Experimental Study	18
4	Prototype Testing	14
5	Focus Group	9
6	Thematic or Document Analysis	6
7	Observation	4
8	Ethnographic Action	2
9	Longitudinal Study	2
10	Design Science	1

The systematic review resulted in six (6) main themes. Twenty-five (25) sub-themes identified, where it shows a comprehensive analysis of the current development of the interprofessional collaboration in the BIM project in the construction industry. Table 5 shows the main themes and sub-themes found out through the systematic literature review process.

Table 5 and Figure 4 clearly show that the studies related to team interactional characteristics were ubiquitous in previous research, followed by collaboration, professional roles, interactional, individual, and organisational characteristics. Additionally, it was noticeable that the studies of the main themes peaked in 2017 and getting more attention by researchers worldwide, thus showing great concern over the interprofessional collaboration in the BIM-based construction projects.

Table 5. Classification of Main and Sub-Themes through the Systematic Literature Review Process

Main Themes (No. of Sub-Themes)	Sub-Themes	No. of Occurrences
Collaboration (4)	Multidisciplinary / Interdisciplinary / Interprofessional collaboration	49
	Early collaboration	6
	Virtual collaboration	2
	Document collaboration	2
Individual Characteristics (5)	Experience	8
	Right mindset	4
	Attitude & behaviour	4
	Awareness	2
	Psychological well-being	1
Interactional Characteristics (9)	Commitment	19
	Change management	17
	Common goal / Clear process	9
	Clear guidance	5
	Transparency	5
	Leadership style	4
	Task delegation / dedication	4
	Engagement of Work	2
	Inclusiveness	1
Team interaction Characteristics (10)	Team diversity & interdisciplinarity	52
	Team communication and coordination	29
	Team strategy & decision making	26
	Team and workflow arrangement	24
	Team integration & interaction	22
	Mutual trust, respect, understanding & interdependencies	12
	Team structure	5
	Team dynamic & cohesiveness	5
	Fair competition	3
	Team synergy	2
Organisational Features (4)	Development and training	7
	Investments (time and cost)	5
	Innovation	3
	Organisational support	2
Professional Roles Characteristics (7)	Management of data & Information exchange	39
	Knowledge transfer	12
	Professional liability, roles and responsibilities	10
	Thinking out of boundaries	3
	Emerging of new professions	3
	Professional competencies	2
	Due diligence	1



	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011	2010
Professional Role Characteristics	6	9	7	7	1	3	4	6	2	6	1
Organisational Features	2	2	2	2	1	2	0	1	0	1	0
Team Interactional Characteristics	11	13	10	14	4	10	5	8	3	7	2
Interactional Characteristics	5	6	6	9	2	7	2	2	1	3	2
Individual Characteristics	1	1	4	1	2	0	1	4	0	1	1
Collaboration	5	7	6	7	1	6	5	8	3	6	1

Collaboration; Individual Characteristics; Interactional Characteristics; Team Interactional Characteristics; Organisational Features; Professional Role Characteristics

Figure 4. Number of Occurrences of The Main Themes According to the Publication Year

DISCUSSIONS

A systematic review approach was conducted in this study to analyse the existing literature on interprofessional collaboration among the stakeholders in BIM-based construction projects. Interprofessional collaboration among the construction stakeholders is a global challenge and influencing variables and its constructs identified will help recognise the impacts and create opportunities for most organisations to adopt BIM. Nine (9) academic databases were rigorously reviewed and sourced, resulting in ninety-six (96) articles related to interprofessional collaboration. The results indicate that the study of interprofessional collaboration focuses not only on AEC professions but also on other sectors like education, owners or clients, facilities management, and others.

Generally, there was evidence proving a significant relationship between the influencing factors, mainly involving 'people', 'technology' and 'process', with the interprofessional collaboration (Hall et al., 2018; Kovacic et al., 2015; Kovacic et al., 2013). Besides, five interacting core entities as a system, which there are 'structure', 'process', 'agents', 'artefacts' and context', may potentially impact collaboration in BIM (Poirier et al., 2016). Similarly, Faris et al. (2019) came out with another six factors that could lead to a successful collaboration for construction projects: 'project vision', 'participant behaviour', 'communication', 'relationship definition', 'contractual agreements', and 'systematic process'.

The above studies generally formed the aspects within the collaboration among the multiple professions where this study is proposing. The authors assemble and suggest an advance development from the previous factors based on previous studies' suggestions and came out with six (6) main themes and thirty-nine (39) sub-themes were classified in this scope of review. Team interactional characteristics, collaboration, professional roles characteristics, interactional characteristics, individual characteristics and organisational features are the six main influencing variables for interprofessional collaboration among the stakeholders.

Studies Related to the Collaboration Theme

The successfulness of the building projects in the AEC sector depends on the professionals' collaborative effort (Poirier et al., 2016). Undeniably, collaboration adds value to the professionals in terms of sustainability of the work, organisation of site and working conditions efficiency, collaboration within the supply chain sector, and reducing double handling of work (Albano & Di Giuda, 2018; Di Giuda et al., 2020; Korpela et al., 2015; Kouhestani & Nik-Bakht, 2020; Lim, 2015; Zheng et al., 2017) from sharing the same physical work environment with different disciplines (Al-Hattab & Hamzeh, 2018; Ataman, 2018; Delval et al., 2018; Kerosuo, 2017). As proposed by numerous researchers, BIM enhances (and relies on) the collaboration between various professionals throughout the project lifecycle through the exchange and sharing of information and documents generated (Hattab & Hamzeh, 2018; Holzer, 2011; Neff et al., 2010; Poirier et al., 2017; Rostam, 2019; Singh et al., 2011).

The previous statements support that the "interprofessional collaboration" is essential to ensure the BIM-based construction project's successfulness and were being frequently discussed among the researchers. However, previous researches mainly focused on "multidisciplinary/interdisciplinary/interprofessional collaboration", and few mentioned about the other three sub-themes, which there are "early collaboration", "virtual collaboration" and "document collaboration".

Regardless of which the latter sub-themes were not the centre of attention among the researchers, but they are equally imperative and closely related. Several studies suggested that early collaboration or involvement in BIM would further reap the benefits through the comprehensive building models from the early ideas (Akponeware & Adamu, 2017; Al-Ashmori et al., 2020; Kovacic & Müller, 2014; Kovacic et al., 2013; Paavola & Miettinen, 2018; Rezgui et al., 2013). Besides, virtual or electronic collaboration among professionals has a significant relationship with project performances (time, cost and quality) via a shared and integrated data model to compensate for the fragmentation in the industry (Bolshakova et al., 2017; Forgues & Becerik-Gerber, 2013; Sepehr & Ibrahim, 2017). Since the construction industry is very heavily document-oriented, the BIM introduces common data environment (CDE), which may further strengthen the collaborative approach by encouraging document collaboration in the construction process (Idi & Khaidzir, 2018; Klemt-Albert et al., 2018; Shafiq et al., 2013). Thus, "virtual" and "early" collaboration improves the project's chances of success, considering that it was appropriately implemented and applied.

Interactional and Team Interactional Characteristics

Communication, coordination, networking and exchange of information works only with the teamwork in the collaboration process (Alreshidi et al., 2018; Fuchs & Scherer, 2017; Sepehr & Ibrahim, 2017). On top of that, with the implementation of BIM in the construction projects, it promotes in-depth communication among the professionals, not just for information exchange, aggregation and storage (Deutsch, 2016; Liu et al., 2017; Papadonikolaki et al., 2019).

Various authors agreed that trust was one of the factors that influenced the professionals' collaboration in a BIM construction projects (Deep et al., 2019; Liu et al., 2017; Olatunji & Akanmu, 2015). 'Blaming culture' and lack of collaboration pre-eminently exist in the industry have been challenging and hinder communication between the stakeholders (Böhme et al., 2018; Delval et al., 2018; He et al., 2017; Roy et al., 2018). The collaboration has provided easy access that further enhance the engagement and integration of the inter-organisational and disciplinary collaboration in the team (Fadeyi, 2017; Fuchs & Scherer, 2017; Li et al., 2019; Love et al., 2013; Miettinen & Paavola, 2014; Mustaffa et al., 2017; Sepehr & Ibrahim, 2017). Thus, the efficiency, quality of work, and productivity were able to show signs of improvement in construction projects (Munir & Jeffrey, 2013) with the consideration of increasing complexity throughout the stages (Aladag et al., 2016; Li et al., 2019; Papadonikolaki et al., 2019).

To summarise the previous arguments, collaboration involves group effort from the project team, and a vast majority of discussions focused on team communication and coordination among the professionals. It was evident that communication is a crucial factor in success. Mutual trust, respect, understanding, and interdependencies are equally important despite communication in collaborative practices. Integration and interactions between stakeholders are essential in collaboration to ensure the information exchange, especially in a BIM environment. There are cross-disciplinary tasks from multiples dimensions, and cross-organisational boundaries will be laid down.

It was evident by a few researchers that their respondents were having difficulties in the transition from the traditional approaches to the multidisciplinary BIM environment (Pilehchian et al., 2015; Singh et al., 2011; Tallgren et al., 2015). Based on the previous studies, a lack of commitment and changes management has been a challenge for organisations that get more exposure to the BIM practices that may affect interprofessional collaboration. Therefore, it was suggested that change management is essential to prepare the professionals, while not forget to consider the team's commitment, the status of the organisation and the adoption rate of the BIM.

Professional Roles Characteristics

There will be a need to further elaboration on the roles, responsibilities and liabilities of the construction stakeholders before the study on the collaboration process to determine their identities. The consideration of issues like professional liability and associated duty of care, authorship and intellectual property, and admissibility of digital documents are necessary to achieve the effective integration among the professions as suggested by the various researchers (Alwash et al., 2017; Jaradat, 2020; Zanni et al., 2014).

With the emerging implementation of BIM, there is a necessity that new collaborative practice or new profession to be introduced (Forgues & Lejeune, 2015; Jaradat, 2020; Miettinen & Paavola, 2014). Therefore, the introduction of BIM execution planning (BEP) is essential in governing and defining the execution and control processes according to project objectives, power and boundaries for the professionals obliged to and investigating building performance (Forgues & Lejeune, 2015; Utkucu & Sözer, 2020). The BEP should be able to describe the roles and responsibilities of various professionals in supporting the team with data and information exchange or knowledge transfer and the professional liabilities to ensure the smooth collaboration in the team. To summarise, the professional characteristics go hand in hand with the communication and effective collaboration among the professionals and alignment with project strategy.

Individual and Organisational Features

Both individual and organisational features were not prevalent in academic researches nowadays. However, the authors find great significance and value in these features based on the following reasonings. The features must ensure a smooth collaboration process among the stakeholders, ultimately affecting the implementation and successfulness of BIM-based construction projects.

'People' is the most important aspect of collaboration in a project as people affect the development of BIM. The slowdown of the collaboration development was mainly due to the 'people' (Hykkönen, 2019; Rogers et al., 2015). The collaboration in the BIM environment is subjected to several individual traits, such as skills/experiences, attitude, mindset, and psychology and well-being that a professional possesses. Undeniably, the compilation of information from previous experiences, which involving time, cost, technology, quality and building operation aspects, may further enhance collaboration and ultimately the productivity of work in an organisation (Grzyl et al., 2017; Liu et al., 2017; Macdonald & Granroth, 2013; Neff et al., 2010; Parasonis & Jodko, 2013; Poirier et al., 2017; Roy et al., 2018; Singh et al., 2011).

Not forgetting to mention that good intention and an unselfish attitude in a collaborative practice in a BIM environment is essential as they may, directly and indirectly, influence the development of collaboration of the team. Various researches reported that the attitude aspects not just to secure the benefits of BIM usage, but also to improve the business relationships in this highly interconnected BIM-based construction network (Faris et al., 2019; Lee & Kim, 2014; Liu et al., 2017; Mahamadu et al., 2017). It was noticed that some of the myriad issues, such as poor workflow in the design process might cause overrunning of time and cost and the behavioural issues among the design teams during the BIM implementation (Hattab & Hamzeh, 2018). The belief and right mindset are equally essential to overcome the significant barriers in BIM collaboration (Al Hattab & Hamzeh, 2018; Teng et al., 2018). Therefore, the above findings informed that attitude and behaviour aspects potentially affecting the collaboration in the BIM-based construction projects.

It was summarised from various researches that the organisational support in terms of investment of time and cost for software and hardware, development and training for the AEC professions is essential to get them equipped for proper execution in BIM processes and to foster the multidisciplinary collaboration (Almaatouk et al., 2016; Alreshidi et al., 2018; Bonanomi, 2019; Garagnani, 2017; Liu et al., 2017; Mignone et al., 2016; Mlinkauskienė et al., 2020; Parasonis & Jodko, 2013; Solnosky, 2017; Taihairan & Ismail, 2015; Zhao et al., 2015). On the contrast, Lee and Jeong (2012) reported that the lack of support and failure to differentiate the professionals' disciplinary differences were the main reasons to the challenges in managing collaboration in the AEC industry.

It is also worthy to note that the client's involvement and backing would be very promising to strengthen the collaboration among the profession, directly and indirectly, through the implementation of BIM in the construction projects. A few researchers believe that the client has the ultimate authority to decide whether to implement BIM in their projects, depending on the project's objective, the scale of the projects, and cost-related consideration (Bosch-Sijtsema et al., 2017; Vilas-Boas et al., 2019). Thus, it is essential that the client first be convinced that the implementation of BIM in the project management must be reliable and able to achieve the project outcomes. There must be a demand and requirement by the client to promote the BIM implementation in the construction project in the first place. Thus, this may affect the adoption of the BIM and enhance collaboration among the team.

CONCLUSIONS AND RECOMMENDATIONS OF FUTURE STUDIES

This systematic review's main highlight is to reveal the importance of the interprofessional collaboration among the construction stakeholders in the BIM-based construction projects. Previous studies on 'people', 'technology' and 'process' aspects have been further enhanced to six (6) main themes of interprofessional collaboration in this systematic review, namely collaboration, individual characteristic, interactional characteristics, team interactional characteristics, organisational features and professional roles characteristics were identified by the reviewers. The influencing variables were further extended to thirty-nine (39) sub-themes or constructs. However, there are still many uncertainties about the other influencing factors and how they may affect the interprofessional collaboration in the BIM-based construction projects.

The systematic review shows that previous research concentrates on the subject of team interactions and the other influencing variables, which are equally important in this research. The context and literature gaps presented in this paper may serve as a reference in the studies related to interprofessional collaboration. The authors also suggested future studies may focus on the themes as suggested from the thematic or content analysis conducted, which emphasise the social aspects of the interprofessional collaboration. The emphasis on "team interaction" and other characteristics or features should be read together to identify their impacts and influences on interprofessional collaboration in the BIM-based construction projects. Further studies related to the collaboration may adopt the context and literature gaps presented in this paper using quantitative or mixed-method research design.

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IMPLEMENTATION OF GREEN COMMERCIAL BUILDING

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Abstract
Green building refers to the foundation of sustainable construction development which is environmentally friendly and resource efficient throughout a building's life cycle: from sitting to design, development, operation, maintenance, reconstruct and destruction. This construction was adopted as a strategy to reduce energy consumption and the overall impact of the built environment on our natural environment. The Green Building Index (GBI) was originated and developed by the Pertubuhan Arkitek Malaysia (PAM) and the Association of Consulting Engineers Malaysia (ACEM) which acts as a green rating tool in Malaysia. Despite the green building concepts has lots of advantages and is well known in most of the developing countries, the uptake of green building technology in commercial building is still not as apparent as it should have been. The aim of this study is to identify the barriers and benefits of implementing green buildings construction in commercial buildings and to study the method in order to encourage the developers to implement more green buildings in construction industry. In this study, the result has pointed out the challenges faced and also the effective methods to increase the implementation of green development has been identified. Qualitative approach is used for this research which is face to face interview that will produce descriptive data instead of numerical data, this allow in-depth understanding of underlying reasons, opinion and intention. This research finds out that the developers are facing different kind of barriers despite they wanted to go for green building projects. Although there is time constraint, the respondents which consist of three (3) engineers and two (2) architects from developer company are able to provide precise and accurate information to assist in this research project due to their involvement in green project in their past experience. Last but not least, with a good coordination and efforts done by different parties, the implementation of green commercial building will be secured in the future.

Keywords: *Green building; sustainability; GBI; developers; rating tool.*

INTRODUCTION

Green buildings can be defined in various resources. It can be explained by a building that can reduce or eliminate negative impacts from the perception of its design, construction and operation, at the same time contribute positive impacts towards our natural environment and global climate. (Kriss, 2014).

United States Green Building Council USGBC promoted green building rating system known as Leadership in Energy and Environmental Design (LEED) in early of 2000. Today, more and more rating systems for green building are available, there are various types of rating systems in every country. In Malaysia, Pertubuhan Arkitek Malaysia (PAM) has developed rating system for green building called Green Building index (GBI).The purpose of this rating system is to act as a tool in defining green buildings by establishing a common language and standard of measurement, promote integrated, better building design environment, recognize and reward environmental leadership, transform the built environment to least adverse environmental impact and ensure new buildings remain relevant in the future and existing buildings are refurbished and upgraded to improve the overall quality of our building stock.

The rapid development in the construction industry has continuously causes damage to the environment. 40% of the global solid waste is generated by the building sector. Building sustainability has been neglected by most of the developer during developing process and causes the environment to degrade progressively.

Greenhouse gas such as carbon dioxide (CO_2) and methane (CH4), occur naturally and play an important role in the earth surface. The accumulation of greenhouse gas (GHG) emissions in the atmosphere is the primary factors driving global warming and climate change. Buildings are the single largest end-use energy contributors to global emissions (Vong, 2016). Rising of temperature is mainly caused by manmade GHG emissions from buildings, businesses, agriculture, and transportation. The higher consumption from heating, ventilation, and air conditioning (HVAC) systems itself will give impact to the environment in producing larger CO_2 emissions, which in turn will further contribute to climate change and global warming. Therefore, it is essential to consider building designs and operations in an energy efficient way to help reduce energy demands and cut down CO_2 emission.

In order to overcome the problem of global warming, green building has been introduced to the world. Economic, social, and environmental succeed can be achieved by executing green building (Balaban & de Oliveira, 2017) at the same time reducing negative impact to the environment such as carbon emission and waste resource (Leung, 2018). Along with the positive awareness of climate change, these benefits play a huge role in promoting for the adoption and development of green building technology.

According to economic theory, tenants are more willing to pay for better yet comfortable workspace for highly utilized green and smart office, thus increasing rate of office rents (Gluszak et al., 2019). Buildings can go green in several path, it is good in energy and water efficiency. The use of renewable sources such as solar system, hydro power and wind power as electricity supply to generate energy, reduce, recycle and reuse waste material, use of toxic free, environmental friendly and sustainable product, consideration of the environment in design, construction and operation are some of the key features to achieve the concept of green building.

PROBLEM STATEMENT

Green building techniques are seeing popular usage in other countries, but Malaysia still focuses on standard building techniques rather than green building techniques. As a rapid urbanization city, Kuala Lumpur is becoming one of the highest density cities in East Asia. It is estimated that 75% of approximately 30 million of Malaysians are living in the city and 90% will be living in close proximity to cities by 2050. With this high urbanization rate, it has the urge to develop this city well (Kathy B, 2019).

World Green Building Council stated that buildings are the single largest cause of global warming. 33.33% of global carbon emissions is released from the building. 13% of total energy and 48% of electricity consumption had been consumed by both commercial and residential buildings in Malaysia (Chua & Oh, 2011). Tenaga highlighted that in year 2016, Peninsular Malaysia consumes a total of 49043 Gwh energy in industry sector, 39484 GWh for commercial field and 27119 GWh in residential area. Based on this survey, it is clearly shown that both industrial and commercial sector consumed the most electricity among the others in our country. Therefore, it is an urge for us to practice green in the commercial building. (Suruhanjaya Tenaga, 2018).

However, green building techniques are often seen as expensive alternatives for developers. With buildings currently making up 32% of global energy use, developers must be acknowledged of the advantages brought by green development and influence the property industry switch to more sustainable methods like eco-friendly designs (Krishnan, 2015).

RESEARCH OBJECTIVE

This study strives to obtain the following objectives:

1. To identify the benefits of implementing green commercial building construction.
2. To determine the barriers of implementing green commercial building in construction industry.
3. To study the method to encourage developer in implementing green commercial building in Malaysia.

LITERATURE REVIEW

Green Building Assessment Tools and Criteria

Green building rating system and green certification play a very important role to emerge green building. In many countries, green building rating system has been introduced to improve the sustainability and building performance. When the buildings successfully met the criteria for the particular assessment scheme, points are given and accumulated to determine the rating of the building. A higher rating point represents a higher level of certification and thus more sustainable approaches in the construction process.

The concept of GBI is derived and designed based on other international rating system such as BREEAM, LEED, Green Star and Green Mark and has been evaluated to adopt Malaysia's climate condition in order to achieve sustainable construction in the industry (Esa, 2017). It is the first and only rating tool which examined the performance of sustainable buildings in Malaysia based on six main criteria of Energy Efficiency, Indoor Environment Quality, Sustainable Site Planning & Management, Materials & Resources, Water Efficiency and Innovation.

In Malaysia, GBI tools are categorized into GBI for Residential New Construction (RNC) and GBI for Non-Residential New Construction (NRNC). For houses, condominium and bungalows are being classified as residential construction. While for commercial, institutional and industrial buildings such as offices, hospitals, universities, malls are classified as non-residential construction. Both share the similar criteria but each of them has different ways of allocating points in each criterion. GBI for NRNC focus more on energy efficient and indoor environment quality whereas the another one emphasizes more on environment quality of the household (Chuah & Oh, 2011).

Table 1. Rating System in Worldwide

Country	Rating System	Year Establish
Australia	Green Star	2003
India	IGBC	2001
Hong Kong	BEAM PLUS	2010
Japan	CASBEE	2001
Malaysia	GBI	2009
Singapore	BCA Green Mark	2005
Thailand	TREES	2012
Taiwan	EEWH	1999
United Kingdom	BREEAM	1990
United States	LEED	1998

(Source: Nguyen, 2019)

Importance of Green Building

Several advantages of having green building that could be found in this literature review in aspect of environmental, social, and economic benefits. All these benefits can be contributed directly when resources are reduced during construction stage and operation of the building.

Energy Efficiency

Energy efficiency can be defined as the consumption of energy through natural way (Chua & Oh, 2011). Energy efficient design in a building can be divided into two types, which is passive and active design. Passive designs take advantage of the building's location to reduce building's energy profile while active design uses mechanical and electrical method such as ventilation and air conditioning system in order to improve energy efficiency of the building.

A green building consumes half of the energy consumption compare to conventional building (Khan et al., 2018). Green building with efficiency design is installed with solar thermal system such as solar panels. Solar thermal uses the sunlight to generate power for heating purpose not only in housing area but are also widely use in commercial buildings and factory. Solar energy collected from the sunlight will then be stored in a battery and then converted to produce electricity.

Water Efficiency

Green building is design for water saving purpose. It utilizes of water by recycling, harvesting of rainwater and water saving fittings (Chua & Oh, 2011). Through green building system, GBI introduced rainwater harvesting system where the quality of water such as rainwater and greywater can be maintained and reused. Greywater recycling system can help cut down water bills, energy and chemical.

Furthermore, green building uses ultra-low flush toilet and low-flow shower head to reduce the water and cost. Bidet is fixed in the toilet to replace usage of toilet paper. Another way to reduce the water usage by green building is to use appropriate water system such as automatic self-closing appliances to prevent unnecessary water wastage, for example censor sanitary appliances. In the aspect of landscaping, planting native and adaptive plant can also promote water reduction. (Liew, 2012).

Improve Indoor Environmental Quality (IEQ)

The measure of indoor air quality is intended to reduce volatile chemical mixtures and other air pollution, such as bacterial contaminants. A normal building relies on a legally designed ventilation system to provide adequate ventilation of cleaner air from outside, filtered air and operations from different place such as kitchen (Algburi & Faizal, 2016). Whereas green building natural ventilation system is used to remove the indoor air naturally without the aids of any mechanical ventilation system such as fan and air conditioning. The concept of pressure differences from outdoor air flow that causes the inflow air between buildings to provide a fresh indoor air quality. Users in green building tend to be more tolerant than those living in conventional building in terms of indoor environment quality. The fittings in office significantly affects occupant's comfort in LEED certified office building (Zuo & Zhao, 2014).

Cost Saving

In the aspect of capital cost saving, green building is designed to help significantly save cost. During the planning process, the structure of the building is made to adapt to local climate so that the need for ventilation such as cooling and heating could be lessened, hence eliminate the requirement of purchasing high power generated air conditioning (HVAC) system and higher specification of mechanical equipment such as ductwork. Without occupying by all these mechanical appliances, more spaces can be sold or leased to gain profit (UNESGAP, 2012). In long term wise, green building can achieve low long-term operational and maintenance cost, hence an efficient whole lifecycle cost. A lifecycle cost savings can be explained by the total cost of a system or product over its entire life span (Mahlia et al., 2011). The cost saving is interrelated with better quality of building performance, particularly from the life cycle cost aspect (Zuo & Zhao, 2014).

Green procurement in the construction industry can also benefits contractor in cost and resources saving during construction process. With that enforcement, contractors will purchase more efficiently and make use of renewable raw materials and green equipment as construction material. This can lead to overall price reduction with lesser hazardous management and waste management fees. Renewable materials can be reused and recycle therefore conserve energy, consumption of fuel and can subsequently cut down operating cost. (Khan et al., 2018). Green tendering requirements will influence the competition and develop new entrants for the ecological businessman. When there is a supply and demand, it can increase the market competition and innovation towards green development. To add on, green adoption saves money, especially when new products are created consume less energy, fewer waste, and long lasting. However, some of the product may have higher initial cost upon purchasing, but in a long run, it is more economical for whole life costing. (Testa et al., 2016).

Barriers of Implementing Green Building Concept

The lack of education among the professionals might lead to challenges in developing green building. Not every contractor has a clear perception towards green development, some of the managers are uncertain how environmental problems can be integrated into the procurement process (Brammer & Walker, 2014). This occurred due to the lack of training on issues of sustainable development, the lack of a clear definition of sustainable construction and regulatory constraints, and lack of competencies among procurers. Insufficient experience in the real working environment will be a challenge for them to implement theoretical knowledge into real practice (Khan et al., 2018). Green technologies are always something new and innovative, lack of understanding by construction related parties of the technical specification and operation of the technology might inhibit them from using. Majority of the architects are aware of the necessity of implementing green feature for building, however they are unable to apply on building design (Shafiei et al., 2013).

Client's demand and willingness are critical opportunities for green procurement growth. Resistance to change is a major barrier to develop greens. Traditional construction method and building materials has been performed over the past few decades, it is tough to change people's mindset to accept and agree with the latest method especially when people get used to do works in conventional ways (Djokoto, Dadzie, & Ababio, 2014). Client will try his possible way to bring the risk to minimum and does not willing to bear with the risk to use new structural materials and system that has no proven records. If client fails to have interest, green initiatives will not be implemented into buildings as clients plays a vital role in creating opportunity for green development (Hwang & Tan, 2012). The perception towards higher cost of green building compared to conventional building is very common. Additional transportation fee, design fee for green building cost higher and is more time consuming than conventional buildings as expertise is required in planning and design stage. As a result, higher initial cost for building prevent people from purchasing green construction. It should be noted that however, long-term perspective is being embraced. Developer will usually emphasize on the immediate payback rather than in a long run of the building and this causes purchaser who is lack of sustainable building knowledge to have a wrong cost perception towards green building.

Element Leads to Successful Implementation of Green Building Construction in Malaysia

Promoting, Encourage and Emphasizing Green Awareness

Awareness in this point is subjected to the knowledge of green feature, this information must be provided to the public, clients, stakeholders and interested parties in the construction team. Government plays significant roles in fostering and raising awareness of environmental protection to the public sector. According to 11th Malaysia Plan (2016-2020), one of the targets of the government is to engage in green growth for sustainability. Malaysia green growth strategy will lead to improve growth efficiency, enhance food, water, and energy protection. In this master plan, energy efficiency production and consumption are encouraged to reduce greenhouse gas emission.

Education and Training Effort

Malaysia government is putting in lots of efforts by working on education system, through trainings, conferences, seminars, campaigns, and workshops. The government is in the progress of incorporating green subject into the national education system and growing green technology modules and courses in higher education institutions for both public and private university. This is to ensure that they have a fully understanding regarding to green development, green products, and green appliances regardless in which education level. This is essential especially for university students that graduating to become a profession where their job scope will be related to the construction industry. Specialised training for invention of green technology should also be carried out for certain courses or profession to produce green expertise that can implement that green technology in real practice (Rostami et al., 2011).

Creating Green Market

Clients involvement in adapting new construction method will eventually motivates among each other as no one is willing to be one step behind. In some of the client's perception, implementing green procurement is one of the methods to increase organization's reputation on environmental impact (Khan et al, 2018). The more the involvements of client in using green procurement, the more the green buildings are available and due to the large amount of green buildings causes competition to occur among suppliers to provide cheaper green materials for clients. Hence, this will lower down the cost of construction which can be related to financial constraint by both clients and occupants therefore expand the green market.

RESEARCH METHODOLOGY

The research approach that had been undertaken for this study is qualitative method which is through interview. A structured interview involved the interviewer questioning the interviewee according to a list of predetermined questions. A set of question regarding to this research objectives is prepared before conducting the interview. The targeted respondents are from construction firm in Selangor and Kuala Lumpur area, such as architect and engineer who works under developer and possess the knowledge of green commercial building. A total of five respondents with minimum five years of working experience have been interviewed. This method is chosen because this topic of the research requires professional individual that poses the knowledge of building sustainability to respond to the interview questions. The data obtained through interview may be more detail as it could come with more elaborations and explanations given by the respondent.

According to Reeves (2015) stated that interviews are capable to give voice to minor communities and individual in society that cannot be seen anywhere. There are several ways of interview such as face to face interview, online media such as Skype, Zoom or through phone calls. In this dissertation, due to the Covid-19 pandemic and Movement Restriction Oder (MCO) constraint, face-to-face interview will be difficult to conduct. Therefore, alternative way is which is video call is chosen and will be conducted to achieve in-depth information.

Data Collection Method

Note taking and voice recording is done during the interview process. Extensive note will be written down for black and white purpose, whereas voice recording allows better understanding of the information provided by the interviewee and thus ease the analysis process. It also acts as a prove of the whole interview process and rewind what has been discussed during the interview.

Data Analysis Method

Content analysis is carried out in this research, it is a widely used qualitative research technique. This research method is used to identify patterns in recorded communication, it is useful for tabulating the results of interviews. There are few advantages of content analysis. First and foremost, it has a high flexibility which can be conducted at any time, any location. Other than that, the data from different sources can also be validated, establishing reliability is easy and straightforward. The data collected has been further analysed based on each finding by using “Coding” method. This practical method categories and generalise the overall data collected from the interviewee according to themes and keywords. All these data are tabulated for further analysation and transcription in table form to achieve a better understanding towards research objective as well as to reach an effective conclusion.

Qualitative coding is a process of extracting the meaning of the data to be analysed. After the transcript has been done, the data collected from the interviewee are categorised into different categories based on its similarities. Information that has the same keyword, concept or similar meaning from different interviewees will be classified in the same category. A specific code is given to label each category which represents the meaning of the sentence to enable linking of the data between different respondent, thus, the data has been organised and analysed in a structural way in accordance to each question.

DISCUSSION AND KEY FINDINGS

Benefits of Implementing Green Commercial Building Construction Malaysia

Table 2. Interviewees Response on The Benefits

Aspect	Benefits
Economic	Increase in property value
	Savings on utility bills
	Low maintenance cost
Environmental	Energy efficiency
	Water efficiency
	Reduce carbon footprint
Social	Increase occupants comfort level
	Improve mental health

Based on the data obtained in Table 2, the benefits of implementing green commercial building can be divided into three categories, which are environmental, economic, and social benefits. These three categories of benefits are in line with previous research in literature review respectively.

The respondents stated that green commercial building contributed the most benefits towards economic aspect in the construction and property industry. This shows that respondent felt that the saving of utilities such as electrical and water bill can be achieved through green building. Although green construction required a high initial cost due to expensive green products, however, building materials with high durability is better in terms of maintenance. Respondents also stated that green features adopted in a building could be a selling point for the property buyers, or tenants who wish to rent for business used. It can create an iconic image to the building. Data collected has proven most of them are looking into green environment. This is a good trend in relation to this research aim. As a result, when there is more demand towards green building, higher property value can be achieved.

A building can achieved environmental benefits such as water efficiency by using rainwater harvesting system. The rainwater is recycled and stored in a separate water tank to irrigate the plants or for general washing such as flushing for toilet. This is important especially for commercial building where the water consumption is very high. This is in line with the findings in by Chua & Oh (2011), stated that green building is design for water saving purpose and rainwater harvesting is one of the innovations. Censor for sanitary appliances are usually fixed in the toilet for self-closing purpose to prevent excessive waste of water. This is important especially for commercial building where the water consumption is very high. Although few interviewees had mentioned that solar panel is expensive during the discussion, it is still widely used in most of the building because it could generate energy in the most efficient way. Material used during construction process such as green building blocks can also save on 20% of carbon footprint.

In terms of social benefits, green building is said to be more comfortable for occupants. Cross ventilation adopted in the building allowed fresh airflow and increase the comfort level. People surrounded in green environment will also have a better mindset and behaviour.

Barriers of Implementing Green Commercial Building in Construction Industry

Table 3. Interviewees Response on The Barriers

No.	Benefits
1	Government policies
2	High initial cost
3	Priorities on maximizing profit
4	Unproven future benefits
5	Poor coordination
6	Consistency in maintenance
7	Lack of supplier
8	Expensive material
9	Company social responsibility
10	Time consuming

All five (5) interviewees agree with high initial cost is the main barrier towards implementation of green commercial building. Green building requires a higher initial cost due to extra system fixed in the building. Different kinds of material and system selection will affect the construction cost of the building. For example, the used of façade is not only for aesthetic purpose. In green projects, facade plays an important role in thermal and weather resistance of a building, it needs to be designed carefully and take account of different factors, this is where the cost comes in. Whereas M&E part adopts rain harvesting system in the building, extra water tanks, pumps and separate piping system are needed to distribute recycled water all over the building. This causes additional expenses to the developer as they need to conduct two different piping system. In a green building, air handling unit (AHU) will be induced in pre-cool system to reduce the cooling capacity. This particular unit is not necessary in a traditional building, therefore increases construction cost for the project due to the extra fittings. Some of the green materials might cause a spike to the cost and turn down the developer from using green concept. Energy efficiency material such as solar system requires solar panel to be fixed on top of the building. The cost of panel itself is very expensive compare to other green materials, even though a higher scoring point can be achieved in GBI assessment. Respondent mentioned that some developers are really interested to invest in green building, however considering the high upfront cost and insufficient cashflow, they have no choice but choose to turn down this idea if the last resort which is applying banker load had failed too.

Unproven future benefits have been stated by three (3) respondents as one of the barriers. Most of the architect is just doing their job to comply with all assessment checklist without knowing how much they can actually save up by utilising all these green features. Although back then the research studies pointed that savings could reach around 30 – 50% on utilities bill, however, there is no solid proof on how much the actual return is in a long run and how long it is needed for the return. Respondent also stated that the return on interest (ROI) on green features need to be proven before developer decides to go for green procurement. This barrier is suggested to be overcome by installing building energy modelling (BEM) to provide a detail building's energy analysis.

Furthermore, government policy plays an important role in affecting green initiatives among developers. Unlike certain countries, it is not mandatory for developers to comply with minimum score of GBI in Malaysia. Tax exemption is not given by the government to the supplier and purchaser in purchasing or selling green materials. With the implementation of tax exemption, a reduction in upfront cost can definitely be seen.

Different developers would look into different social responsibilities. Most developer priorities maximizing profit more than considering the environmental benefits. This can be referred especially to those developers who do not develop the building for own use since maintenance and operation cost are no longer their responsibility after the building is sold to third party. Even if they are going operate the building by themselves, green features that requires consistency maintenance by specialist has led to a factor that hinder developers from going green. They have to appoint a specialist for maintenance each time and they find it quite troublesome as compare to conventional building which a normal cleaner is enough for cleaning and maintenance.

Method to Encourage Developer in Implementing Green Commercial Building

Table 4. Interviewees Response on Ways to Encourage Developers in Green Commercial Construction

Parties	Method
Local authority	Enforce minimum GBI requirement
	Grant additional plot ratio
Property agent	Promote and further explain on green development to purchaser
Government	Tax exemption
	Provide financial incentives
Media	Public sustainable related topic
Education body	Involve sustainable related topic in education system
Professional institution	Seminars and trainings for more expertise

Referring to the result in Table 4, efforts that can be done by intervention of different parties to overcome the barriers are discovered. Government plays the most important role among all. Most of the interviewees suggested that government encouragement will always be the pushing factor. Instead of just acknowledging the benefits of green building to the public, it can be done by imposing tax exemption on green equipment and materials. Since the cost of these materials have always been a concern by the developer, with this initiative, developer will be able to enjoy reduction on the price. This leed to low initial cost needed and thus resulting in higher usage of green products. The demand towards green property may increase if there is a relief on paying property tax, since demand and supply chain is linked together, the supply of green building by developer will eventually increases. Instead of deduction on the pricing, financial incentives in monetary form can also be given by 'install and sell' concept, where developers install solar panel to harness energy for electricity and in return a certain incentive will be given by the government to buy back the extra energy hardness from them.

Dewan Bandaraya Kuala Lumpur (DBKL) and Perbadanan Putrajaya (PPJ) had already made it as a requirement for certain projects upon approval. If all local authorities impose this as a requirement for all new development, the developers will have no choice but to comply with and thus increasing the implementation of green buildings. Extra plot ratio can also be granted to the project that adopts higher ranking of GBI in every states.

Seminars or special training for engineers and architects should be conducted by Professional institutions like Pertubuhan Akitek Malaysia (PAM), Association of Consulting Engineers Malaysia (ACEM) and board of Engineers Malaysia (BEM). Professionals need to be trained to achieve the most efficient design of building in adopting natural ventilation at the same time maintain the aesthetic value in the building, also to assist client on green building solution on site instead of just helping to obtain GBI assessment point for submission.

Furthermore, promoting green property by property agents can be done by organizing roadshow. It is useful to attract more buyers to be interested in green development as most of the buyers do not have in-depth understanding towards green buildings. This action could give a rise in awareness of the public at the same time increasing more green development when there is more demand on it.

Respondents also suggested that educational bodies such as teachers or lecturers can focus more on green topic discussion in the education system especially for youngster so that they could expose more on how green environment benefits to our community and give a good impact on future green environment. Lastly, the benefits of green building can be published on media such as newspaper, TV programme, and also the internet to increase the acceptability for all age especially for the older generations.

Prospect of Implementing Sustainable Practice in (5) Five Years Time

Based on interviewees' point of view, most of them have a positive perception towards implementation of green in commercial building in the future development. Three (3) out of five (5) interviewees agree that this practice will remain optimistic despite the current pandermic and economic crisis situation which causes suspension of work on site. It will increase gradually in five years time. In fact, it will not be a shoot up in a short period unless government revise and implement more benefits in Budget 2020. On the other hand, two (2) interviewees think that it is not possible to have any stable increment in five years time. They pointed out that construction industry is always depending on the country's economy and are both interrelated. Insufficient cashflow by from developers and the client will result in less budget allocated for the project, with the limited budget, developers do not have more money to spend on expensive green features and appliances. Therefore, they will go for the traditional construction method. As a result, number of green commercial building will remain like current situation, perhaps just slightly increase in few green projects.

CONCLUSION

The findings of the data have successfully achieved the three (3) objectives of this research. It can be concluded that most of the people are aware and agree that green building has contributed lots of benefits. However, the barriers and problems in different aspects faced are more than the benefits stated, thus hinder developers to implement green commercial development. Developers are facing different kind of barriers despite they wanted to go for green building projects. Therefore, it requires good coordination and efforts to be done by different parties, in order for the implementation of green commercial building to be secured in the future. Last but not least, with a good coordination and efforts done by different parties, the implementation of green commercial building will be secured in the future.

RECOMMENDATION

More should be said, the research on calculation for Return on Investment (ROI) in using green appliances shall be done in the future as a solid prove in costing aspect for developers. Maintenance cost on different green appliances should also be taken into consideration. More information or calculations are needed by engineer to prove that the energy saved on utilities bill is worth for the construction cost for each green appliance because maybe it is only worth to invest on certain green products but not for all.

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GREEN BUILDING MAINTENANCE FOR HIGHER EDUCATION INSTITUTIONS

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Abstract
All buildings require maintenance to allow them to continue to operate, keep their values and extend their lives. Building maintenance is also important to provide a safe and better working environment and to maintain the aesthetic value of a building. Based on extensive literature review, there are a number of research on building maintenance. However, there are limited research related to green building maintenance practice for Higher Education Institutions. Therefore, this paper aims to study and identify the green building maintenance criteria for Higher Education Institutions. To achieve the aim of this study, quantitative research method was adopted to gather data from 120 respondents who have involved in building maintenance works in Higher Education Institutions. Rasch model was used to analyse the collected data. The results show that thermal performance and energy efficiency are the most important criteria in practicing green building maintenance to higher education institutions. The outcomes of the research may answer the highlighted objectives and increase the contribution to the building maintenance works. It is expected that the research findings would broaden the existing knowledge of green building maintenance.

Keywords: *Green building; maintenance; higher education institution.*

INTRODUCTION

Every building element requires care to restrict the deterioration and exposure of the elements which eventually thirst. According to Chua et al. (2016), it is important for buildings to have the activity of building maintenance to keep them in good condition of working. Their opinions are also in lined with Ali et al. (2010) who agree that, building maintenance is defined conclusively from the different definitions as a combination of technical and related administrations actions to ensure that all building items and elements are working and work in satisfactory and acceptable standards.

Building Maintenance can be used for facilities, services, elements, facades and structures and each maintenance activity is different in their classification while; all buildings require maintenance to allow buildings to continue to operate, keeping their value as high as possible and extending their lives (Chua et al., 2016). Chua et al. (2016) also suggested that to get good maintenance practices in the building, it is important to take into account the whole maintenance management aspect, which is standard maintenance, maintenance planning, statutory control, maintenance information, cost management, maintenance organization, service delivery, maintenance document, and sustainability. Everything must be well designed to provide a good application for building maintenance. Strategy of maintenance is one of the important elements to be carefully selected based on factors such as building size, user standard, budget and functionality, as well as any relevant factors reflected to the Building Maintenance.

In order to achieve Malaysia's Advanced Economy by 2020, the Eleventh Malaysia Plan 2016-2020 (Zakaria et al., 2018) gazetted six core strategies where one of them focuses on continuing green growth for sustainability and endurance. This is the beginning of the country's effort in green growth especially in the development of new projects. Besides, it will also become a way of life for Malaysians. Besides government and public sectors, NGOs and private companies will also take initiatives in developing green environment and culture.

Therefore, this study aims to seek for the main criteria of green building maintenance for Malaysia Higher Education Institutions. Although the application of green building in Malaysia is still at the initial stage, there are some successful applications of green building (Zakaria et al., 2018; Ismail et al., 2012). Nevertheless, the green building application for Higher Education Institution is considered relatively low in the country. Due to the merits that green building offers, the trend of applying such green building is slowly growing in building industry particularly in Malaysia's Higher Education Institution.

In building industry, maintenance is a must. It should be practically handled. Maintenance is a work undertaken to keep, improve or restore every part of the building; to extend the life and maintain value of the building (Tan et al., 2014; Seeley, 1976). Building maintenance is so important to provide a better and safer working environment and to retain the value of aesthetic for the building (Chua et al., 2016; Wood, 2009). Different types of building functioned differently. Hence, it adopts different maintenance management method (Ali et al., 2016). With the availability of numerous benefits, maintenance for green building should be promoted and used widely across the country.

BACKGROUND OF STUDY

The building maintenance strategy that is generally applied in Malaysian buildings is reactive or unplanned and sometimes the strategy and the criteria are not suitable for the building itself. The strategy is considered ineffective if it causes frequent breakdown or downtime and require high maintenance cost for repairing or replacement work (Chua et al., 2016; Au-Yong et al., 2014). Chua et al. (2016) and Au-Yong et al. (2014) stress that the lack of specified building maintenance measures will lead to poor performing building maintenance to existing building and green building, hence, the same will be on Higher Education Institutions in Malaysia.

The Urban Wellbeing, Housing and Local Government Ministry carried out a survey and reported that more than 50% of the Malaysia Higher Education Institutions were ranked below average in the assess of property management standards. The survey also found that the residents who stay in these building were feeling dissatisfied with the service quality of current building maintenance management (Abd-Wahab et al., 2015; Feng, 2016). It is necessary to manage a physical asset in an effective and systematic way as it will affect the value of the site and the facilities.

Gazetted by Ministry of Energy, Green Technology and Water (KeTTHA) are to improve green technology and environment (KeTTHA). Meanwhile, the Malaysian Institute of Architects / Association of Malaysian Architects (PAM) and Association of Consultants Malaysia (ACEM) have developed the Green Building Index (GBI) (Zakaria et al., 2018) as an assessment tool for assessing and evaluating the building green status. Malaysia Green Technology Corporation (GreenTechMalaysia) has also been formed to enact legal mechanisms for regulating and enforcing green technology, and to determine the role of each government agency involved in the implementation of green technology in the country (Ali et al., 2016).

There are also many green technology exhibitions and conferences that were held and established in Malaysia itself. The largest green technology exhibition and conference in the region, Green Technology and Water (KeTTHA), Ministry of Energy, Greentech International and Eco and Conference Malaysia Product (IGEM) Exhibition is held every year since 2010. This suggests that Malaysia has been looking into sustainability specifically in the essential requirements of water efficiency, energy efficiency, materials and resources management, sustainability and planning, quality closed environment as well as new innovations.

Nowadays, Green building play an important role and we can see that many country start to practice and construct this concept of building. In 1992, the concept of “green building” was proposed at the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro formally (Liu et al., 2016). Thus, each of the country using different rating systems out from others country to provide practical guide on the development of green building (Zuo and Zhao, 2014, Brown and Vergragt, 2008). There are numerous definitions for the green building. While Zuo and Zhao (2014), Kilbert (2008) and Yudelson (2010) identify green building is designed and built by applying ecological principle and the impact to human health and environment is in the minimum degree to effect. The Environmental Protection Agency (EPA) defines green building as “the practice of creating structures and using processes that are environmentally responsible and resource-efficient throughout a building's life-cycle from siting to design, construction, operation, maintenance, renovation and deconstruction.” In the course of design and construction, green buildings use recycled materials, less water, less energy and resource efficient techniques, thereby minimising adverse impact on the environment (Latif et al., 2018). Green building consume less resources and to provide a good indoor air quality. It has 4 pillars and 6 main criteria of green building which the pillars is environmental sustainability, life cycle perspective, health issues and impacts on the community (Zuo & Zhao, 2014; Robichaud, 2010). The 6 main criteria for the assessment tools which is material and resources, water efficiency, energy efficiency, indoor environmental quality, sustainable site planning and management and innovation (GBI tool, 2011, Usman et al., 2018).

Although the GBI rating tool is recently introduced, it can still play the role as a benchmark for buildings to accomplish the green status. One of the criteria for assessing GBI's assessment is to ensure existing buildings are properly upgraded and refurbished to remain relevant and new buildings are keep relevant in the future (Zakaria et al., 2018). The relevance is greatly significant the building maintenance towards green building. However, Malaysia does not have framework or guidelines which specify on building maintenance due to the lack of exploration in the area.

As Malaysia is moving towards Sustainable Development Goals (SDG) implementation, therefore, a clear identification on the criteria of building maintenance practice in green Higher Education Institution is truly appreciated to overcome the stated issues.

Table 1. Building Maintenance Criteria

No.	Criteria (Authors)	Nik-Mat et al. (2011)	Olanrewaju (2009)	Talib et al. (2014)	Nesan et al. (2015)	Sodangi et al. (2013)	Total
1	Assurance	√					1
2	Reliability	√	√				2
3	Responsiveness	√					1
4	Relevance	√					1
5	Timeliness	√					1
6	Validity	√					1
7	Cleaning & Landscaping	√			√		2
8	General Maintenance	√					1
9	Lighting	√					1
10	Air Conditioning	√					1
11	Lifts/ Escalators	√					1
12	Mechanical & Electrical	√		√			2
13	Sanitary & Washing Facilities	√		√			2
14	Access, Signage & Parking	√					1
15	Safety & Security	√	√	√	√		4
16	External Finishes	√		√			2
17	Internal Finishes	√		√			2
18	Durability				√		1
19	Material Sustainability			√	√		2
20	Compatibility				√		1
21	Health and Safety				√		1
22	Material Economy				√		1
23	Material Availability				√		1
24	Functional Performance				√		1
25	Thermal Performance				√		1
26	Acoustical				√		1
27	Structural Components			√			1
28	Roof Component			√			1
29	Life Cycle Cost		√				1
30	Maintenance planning		√				1
31	User's Satisfaction		√				1
32	Retaining Cultural Significance					√	1
33	Clear Maintenance Policies					√	1
34	Management Plan					√	1
35	Management Processes and Procedures					√	1
36	Change in Attitude					√	1
37	Maintenance Prioritization					√	1
38	Regular Inspection					√	1
39	Information Management					√	1
40	Maintenance Staff Training and Expertise					√	1
41	Conservation Consciousness					√	1
42	Financial Planning and Budgets					√	1
43	Monitoring and Review System					√	1
44	Planned Maintenance Approaches					√	1
45	Organizational Culture and Structure					√	1
46	Integration with Corporate Strategy					√	1

There are many different criteria for building maintenance. Hence, the study will identify the criteria of building maintenance which are practiced in different types of building. Table 1 shows the criteria of building maintenance from different references and the maintenance for different types of building. They researched on building maintenance for normal building; Nesan et al. (2015) defined the criteria for building maintenance particularly for material and Sodangi et al. (2013) identified the criteria for building maintenance on heritage building. Among the 46 criteria, the most popular criteria discussed by the authors are safety & security.

Table 2 listed the criteria of building maintenance on green building. Among the 12 factors pointed out by 5 different authors, thermal performance, life cycle approach and energy are of greater concern.

Table 2. Building Maintenance Criteria on Green Building

No	Criteria \ Authors	Kumar and Buddhi (2013)	Zainol et al. (2014)	Olanrewaju et al. (2015)	Forste et al. (2015)	Saharuddin et al. (2017)	Total Referred
1	Drainage System					√	1
2	Waterproofing Membrane					√	1
3	Structural Deck					√	1
4	Thermal Performance	√				√	2
5	Wall and Roof	√					1
6	Lighting	√					1
7	Solar Energy	√					1
8	Life Cycle Approach			√	√		2
9	Material and Component			√			1
10	Energy		√		√		2
11	Resources Emission		√				1
12	Building Facilities		√				1

RESEARCH METHODOLOGY

The methodology used for this study is quantitative methodology where a structured questionnaire was sent to the targeted respondents. There are 120 respondents who are involved in building maintenance directly and indirectly at Higher Education Institutions in Malaysia. The structured questionnaire is derived from the literature review from the previous researchers. Where a further questionnaire survey sends to the targeted respondents from four green building and sustainable status of Higher Education Institutions in Malaysia.

The results from the surveys will be calculated and analysed. The final analysed data will be in the percentage form. The analysis of the data further presenting in percentage form of result via frequency analysis.

Finally, the information will be translated in the basic structure, for example, diagram, chart, tabulation and graph. In view of the information arrangement and figure, information will be depicted and clarify. From the understanding of data gathered, the result is delivered. In view of strong fact of conclusion, suggestion will be created to improve the present circumstance and to conquer issue experienced in this study.

ANALYSIS AND FINDING

The questionnaire for the survey was distributed through email and WhatsApp to four green building and sustainable status of Higher Education Institutions in Malaysia. Only 120 respondents responded. The basic requirement for the target respondent is those who have maintenance experience or in the maintenance management field of Higher Education Institutions in Malaysia.

The respondents are divided in 5 groups based on their age. The 5 age groups are 18 to 24 years old, 25 to 34 years old, 35 to 44 years old, 45 to 54 years old, 55 years and above. Figure 1 shows the percentage of age distribution of the respondents.

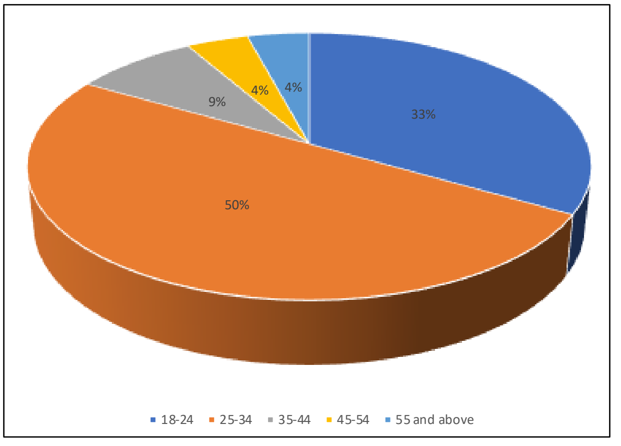

Figure 1. Respondents' Age

Figure 2 presents the distribution of the respondents' education level. As shown in the Figure 2, there are 33.33% of them who possess a diploma, followed by 66.67% of them who have bachelor's degree qualifications. There are no respondent with the education level of foundation, A-Level or STPM. However, the data gained from the 2 different types of qualification will definitely have some significant effect to this study.

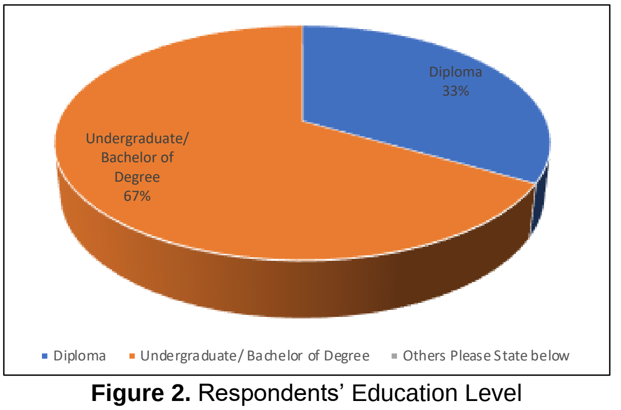

Figure 2. Respondents' Education Level

As shown in Figure 3, years of experience of the respondents in the management field is divided into 4 groups. The groups consist of the range within 2 years, between 2 to 5 years, between 5 to 10 years, and more than 10 years of experience in the management field.

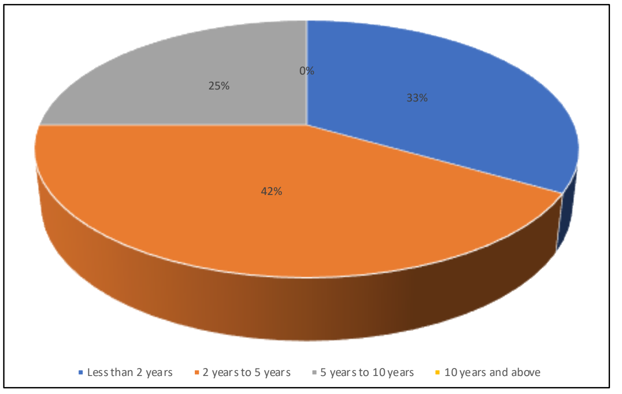

Figure 3. Respondents' Years of Experienced

As shown in Figure 4, the results for drainage system, structural deck, wall and roof, solar energy, material and component and resources emission are similar to those in Section E. 30 respondents strongly agree, 60 respondents agree, 15 respondent chose average, 10 respondents disagree, and 5 respondents strongly disagree on the stated criteria. Waterproofing membrane, thermal performance, lighting, life cycle approach, energy and building facilities got the same result as 25 respondents strongly agree, 80 respondents agree, 15 respondent chose average and no respondent disagree and strongly disagree on them.

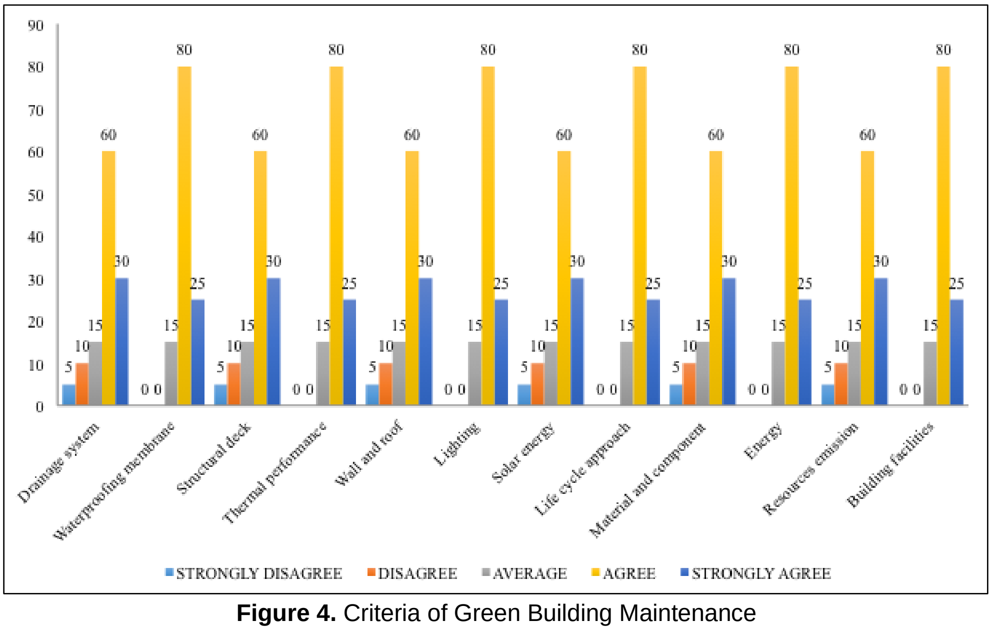

Figure 4. Criteria of Green Building Maintenance

CONCLUSION

Based on extensive literature review, the criteria of building maintenance for green building are obtained. The different criteria for green building maintenance have been identified.

From the background of study, thermal performance, life cycle approach and energy have been mentioned by most of the authors; while the criteria of waterproofing membrane, thermal performance, lighting, life cycle approach, and energy and building facilities get the most agree by respondents through questionnaire. The criteria of thermal performance and energy efficiency can be considered as a very important criteria based on the number of reference in the secondary data collection and the agreement rate from respondents.

The assessment of the green building maintenance work have to assess the thermal performance as well as the energy consumption of the building. The thermal performance should not cause stress on building occupants and minimize consumption of conventional energy by the building design and selection of equipment. The electrical appliances have to be checked and maintained to reach the energy efficiency of the building. These two criteria will be considered to be set as the main criteria for the assessment of green building maintenance.

The most important thing to be stressed is to increase the awareness among the green building maintenance department to enhance the assessment for building maintenance typically for green Higher Education Institutions. For this research paper, the data collection through questionnaire is particularly set for the target respondents who have the building maintenance experience in green building particularly for Higher Education Institutions.

The objective of this study has been achieved. Since this study includes only green building universities, future research should cover Higher Education Institutions without green building status to examine their awareness of green concept. Besides, framework related to the way to implement the green concept in Higher Education Institutions in Malaysia can be developed. This is beneficial to stakeholders and the teams who oversee the maintenance activities.

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THE ADAPTATION OF GREEN CEMETERY AS PART OF URBAN GREEN LANDSCAPE: A REVIEW PAPER

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Abstract
The increase of population in urban areas has prompted the search for new incentives for public areas that are easily accessible social interaction. Conservation and provision of green areas is an ongoing challenge for urbanization. Open space in urban areas is always utilized with profit-generating development regardless of social structure. Hence, cemeteries are usually untouched by development activities. The cemetery has unintentionally become a green infrastructure which preserves urban biodiversity, architecture and history. The focus of this paper is to review the implementation of green cemeteries as part of green infrastructure in the urban landscape. This study will review the research carried out by researchers on cemeteries as secondary use since 2016 to present. There are two factors behind the greening of cemeteries in urban areas, namely due to health factors in which local communities consider the cemetery is the cause of the epidemic spread. The second factor is to create harmonious atmosphere for pilgrimages by embellishing the landscape of the cemeteries while honouring the dead. Literature selection is performed carried out using systematic literature review (SLR) with online digital search using selected keywords. The research findings have identified three components discussed from the researchers' study, namely biodiversity, cultural and open space. The features of extensive and landlocked cemeteries in urban areas are indeed desirable for the use of open spaces. In addition, historic cemeteries keeps the tangible cultural architecture of the former societies while preserving nature biodiversity. Overall, the finding which can be addressed here behind the greenery of the cemetery is that the urban landscape can be established by utilising the existing space with a significant intensity on the environment, society and economy.

Keywords: *Green cemetery; urban cemeteries; garden cemetery; park cemetery.*

INTRODUCTION

Urban growth and expansion place green spaces at growing risk in urban areas. Based on reports from the United Nations, the expansion of urban areas during the period of 1990-2015 has grown faster than the rate of population growth. This is because most urban areas have experienced an increase in the number of built-up areas per person based on the current population (United Nations, 2020). Limited green space has led architects and engineers to explore the design of green buildings to meet the concept of a sustainable city. The establishment of green roofs on buildings in cities has emerged in the urban landscape recently. The goal of this concept is to meet the Green Building Index (GBI) which allows buildings minimise its energy, electricity and the gas emissions (Aboelata, 2021; Ali Arif et al., 2019; Solla et al., 2020). However, the availability of open space and recreation for the public is very limited in urban areas causing urban population began to exploit the use of open spaces in the outskirts and rural areas. Therefore, there is a recent study has been carried out where the cemetery has been practiced to be part of the open space.

The purpose of this study is to examine the implementation of urban cemeteries as part of the green infrastructure in the urban landscape. Lately, studies on the use of cemeteries as a secondary function have evolved. The study emphasizes the contribution of urban cemeteries in urban areas that indirectly contribute to the environment as well as urban sustainability.

Although the main purpose of the cemetery is to provide an area for burial activities and is always associated with elements of horror (Nordh et al., 2017; Nordh & Swensen, 2018), it also has the potential to be a platform for green spaces due to its landlocked position in urban areas. Nevertheless, the land use of the burial sites today is predominantly restricted from agricultural and forestry uses and has been usually regarded for spiritual purposes (Löki, Deák et al., 2019).

Land has long been used for the disposal of bodies by humans. Land in the cemetery will be used for the long term where quality soil is maintained as a fundamental natural resource whose sustainability is preserved. However, land is always in high demand due to the increasing human population today (Scalenghe & Pantani, 2020). There are two main principles that give rise to the idea of integrating a formerly crowded burial ground in an urban area and a churchyard into such a green burial ground with an appealing landscape (Al-Akl et al., 2018; Curl, 1983).

The first is related to health factors where the community is worried about the spread of the epidemic from the cemetery (Al-Akl et al., 2018). Throughout the early 18th century, churchyards often emitted unpleasant smells, ground surfaces were coated with unsafe black mucus and the ground was often damaged for new burials. Even trees and grasses cannot be planted and cultivated. Funeral activities that take place inside the church also produce an unpleasant smell so that forces the congregation to leave the church (Tarlow, 2000).

Concerns regarding pandemics or diseases from churchyards, cemeteries were "reinvented" by enlightened reformers in 1800 in order to sustain the air clean and open space (Vanderstraeten, 2014) by establishing a large green cemetery located in a suburban area away from the population. The second principle is to create a beautiful and harmonious atmosphere to glorify the dead (Al-Akl et al., 2018; Curl, 1983). This greenery concept would make it easier for pilgrims to peacefully visit the cemetery without any apprehension. Abney Park Cemetery in London is Europe's first non-denominational cemetery, where an area of 32 acres is integrated with a concept of garden-cemetery (Gandy, 2012). The Abney Park Cemetery was established in 1840 as a private cemetery as the British Parliament passed a bill in 1832 to ease the pressure of the churchyard. It was planned to be unique, contained an exotic arboretum and to preserve its historic landscape and structures (Abney Park Trust, 2020). Abney Park has become the largest biodiversity area, home to several of 200 'old' trees and nearly 95% of the trees not planted by humans (Abney Park Trust, 2020; Miller, 2008).

Although some countries establish green cemeteries for the utilization of social recreation and environmental conservation in urban areas, Denmark's green cemeteries mainly focus on burial practices. The Danish individual burial plot is surrounded by small hedges and small gardens (Kjøller, 2012) where the aesthetic value and arboretum can only be seen in burial areas.

PROBLEM STATEMENT

Global urban population growth is expected to increase to 2.5 billion people by around 2018 and 2050. It is expected that around 68 percent of the world's population will be concentrated in urban areas by 2050 (United Nations, 2019). Cities across the world are experiencing very limited green area and more worryingly these green areas are threatened with depletion and extinction. This is worsened when there is no political will by cities in developed countries to retain green lungs of the city rather than to utilize all the spaces for building and infrastructure (Chan, 2015).

After many years of old cemeteries being established, the area will begin to be abandoned by future generations due to numerous reasons such as the migration of family members that cause the deceased to be forgotten. As a consequence, the cemetery will be left unmanaged and neglected which causes the community to lose substantial local history in terms of tangible and intangible heritage found in the area. However, Cemeteries are beginning to be considered as another option for peoples to enjoy the green environment in urban areas.

The land use in contemporary cemeteries is restricted from being used in the agriculture and forestry sector. Therefore, urban cemeteries are constantly threatened to be relocated out of urban areas to make room for new development. Old cemeteries are more dependent on historical values practiced in society for the purpose of spiritual and social values to contemporary society (Löki, Deák et al., 2019).

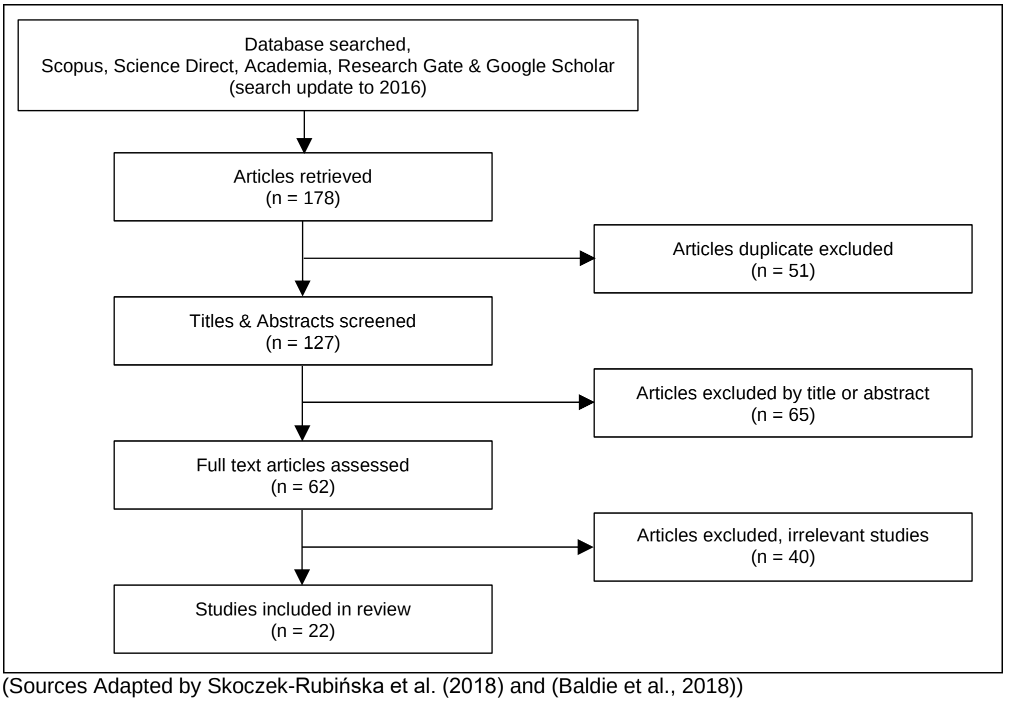
Green and spacious cemeteries have urban park elements even though they are considered sensitive place in the community. According to Carmona (2010), a cemetery is defined as a public open space that has the characteristics of an organized green space although temporarily managed, the area is always green, accessible and open to the public. However, not all cemeteries are considered public open spaces since there are privately owned cemeteries that make it difficult for visitors to enter the area.

METHODOLOGY

Literature review was conducted under two main themes namely green cemetery/garden cemetery and urban cemeteries where the study area must be situated within the urban area. Consideration in selection during the search process was given to the literature discussing the possibility of cemeteries for secondary use. The emphasis of this study considers on conservation and recreational practices that will be adapted to existing cemeteries. Articles on the role of cemeteries for green areas became the main focus of this study.

Research method in this study was performed with systematic literature review (SLR), by identifying keywords to find relevant research materials in the online database. Digital searches were conducted to be studied using online databases from Google Scholar, Scopus, Science Direct, Research Gate and Academia. Searches are made for relevant articles or papers published over the last five years (2016-2020) to obtain the latest research conducted. The tools offered by this database help in refining the terminology, year of issue and type of documents.

Thus, the following keywords were used in the search, which is 'green cemeteries', 'urban cemeteries', 'cemetery and parks', 'cemetery and open space', 'garden cemetery' and 'cemeteries and landscape'. As a result of the database searched, there were 178 literature studies related to selected keywords found. Only 22 relevant studies that can be overviewed in this study was found after a screening phase based on Figure 1.



(Sources Adapted by Skoczek-Rubińska et al. (2018) and (Baldie et al., 2018))

Figure 1. Research Flow of The Study

DATA ANALYSIS

Figure 1.0 shows the screening process of literature review carried out in classifying the research that fits the theme of this study. The abstracts of each selected literature were evaluated before the full literature was reviewed and interpreted. Literatures not related to the theme of this study was removed after a thorough reading of the full literature was done. As a result of the search, 22 published journals were identified that address the practice of green cemeteries in urban areas with the findings of different ideas. Data from these journals were then extracted in more depth to identify the main themes of their study.

As a result of the analysis, several themes and research objective in those journals have been identified. The relevant themes from these journals that can be discussed in this study are the involvement of urban cemeteries in contributing to the social, environment and sustainable development of urban areas. Therefore, the focus of the article studies can be divided into three significant components in the study of green cemeteries in urban areas namely biodiversity conservation, cultural and open spaces shown in Table 1. Most of the studies have been conducted in European countries especially in Scandinavian countries. This indicates that the Scandinavian community has a high interest and awareness in the use of cemeteries as an alternative to urban parks as part of the open space while utilizing existing spaces at a low cost.

Table 1. A Review of Studies Related to Green Cemeteries in Urban Areas Published in Recent Years

Component	Author (Year)	Country	Findings
Biodiversity Conservation	Yılmaz et al. (2018)	Turkey	Conservation of urban plant diversity
	Löki, Molnár V, et al. (2019)	Turkey	
	Tryjanowski et al. (2017)	Poland, Slovakia, Czech Republic	Home to a variety of bird species
	Smith and Minor (2019)	United States of America	
	Buchholz et al. (2016)	Germany	Home to biodiversity in urban areas
	Kowarik, Buchholz, von der Lippe, Seitz, et al. (2016)	Germany	Cemeteries as part of green infrastructure and ecosystem conservation areas in urban areas
	Quinton et al. (2020)	Canada	Conservation of urban forests in urban areas
	Servet and Aktağ (2019)	Turkey	Home to endangered tree species
	Bovyn et al. (2019)	United States of America	A comparison of habitat types between urban cemeteries and city parks
Cultural	Swensen and Skår (2019)	Norway	Cemetery an area that stimulates between culture and religion
	Sautkin (2016)	Russia	
	Rozite and van der Steina (2020)	Latvia	Cemetery in cultural and tourism context
Open Spaces	Nordh et al. (2017)	Norway	Cemetery as a passive green area
	Lai et al. (2020)	United Kingdom	
	Nordh and Evensen (2018)	Norway	
	Evensen et al. (2017)	Norway	
	Lai et al. (2019)	United Kingdom	
	Pavel Grabalov (2018)	Norway	
	Skår et al. (2018)	Norway	
	Swensen (2018)	Norway	
	Pavel Grabalov and Nordh (2020)	Norway, Denmark	
	Al-Akl et al. (2018)	Lebanon	

RESULT AND DISCUSSION

Based on online database searched, of the 127 articles, 105 were found not to address urban cemeteries as a passive area for biodiversity conservation and open green spaces in urban areas. The studies carried out in the cemetery emphasize on three main components, namely the biodiversity conservation which highlights the habitat of flora and fauna in the area. Next is a study that examines the culture as well as the identity of the origin local area which is considered an open museum. The third component addresses the cemetery as part of a public open space for recreational and daily use by the public.

Biodiversity Conservation

Since the establishment of the cemetery, the cemetery area has long been considered a conservation area of natural resources as flora and fauna in urban areas (Gilbert, 2012). The earliest established cemetery was developed along with the local flora of the area indirectly making the cemetery a reflection of the local native flora in the area (Servet & Aktağ, 2019). This biodiversity becomes more valuable when the cemetery has been surrounded by urban development and makes the cemetery the only natural conservation area located in the urban area. The old cemetery is also known as the cultural and historical bridge because it features trees planted by previous communities based on their culture and religion (Servet & Aktağ, 2019).

The cemetery began to be the subject of researchers to study rare and endangered vegetation in the area. Yılmaz et al. (2018) states that significant plant richness has also been stored even by small-scale cemeteries and are likely to be habitat areas for some of the endangered indigenous plant species. Quinton et al. (2020) argues in his findings on several cemeteries in Halifax, Canada found that non-native plant species are more numerous than native plants in the area due to historical and the decorative factors made around the cemetery. The landscape features of the cemetery that introduced non-native plant species in the area reflect the individual, culture and religious values as well as contribute diversity (Servet & Aktağ, 2019).

The presence of vegetation in the cemetery is also influenced by the culture and religion practiced by the community as well as the layout of the cemetery. The proximity of the cemetery near one another has made it difficult for the vegetation to grow. Structure built in cemeteries often threaten the growth of vegetation such as the use of marble and concrete for the structure, making it difficult for the soil to absorb precipitation thus causing stagnant surface runoff (Servet & Aktağ, 2019). However, the old unmanaged cemetery has become an island habitat for the growth of flora where nature has taken over the place to continue for survival (Kowarik, Buchholz, von der Lippe, & Seitz, 2016).

Studies carried out by Buchholz et al. (2016) have shown that old cemeteries can sustain significant biological diversity and have an overall positive function of habitat for certain groups of species in large urban areas. Elements of greenery in urban cemeteries are the main components influencing the growth of various groups of fauna particularly birds that make the area a habitat in urban areas (Nowińska et al., 2020). A comparative study conducted by Bovyn et al. (2019) between habitat types in terms of tree cavities in urban cemeteries and city parks identified that larger trees appear to decay easily which will form cavities in the tree.

The trees in the area play a significant role in influencing the life of fauna such as insects, mammals and birds which are more prefer to make large hollow trees as shelters and breeding grounds (Bovyn et al., 2019). The Muslim community in Turkey believes that human beings should not eat the fruit grown in the cemetery in honor of the dead in the area. Thus, the fruits in the cemetery become a food source for birds and other species while improving the quality of their habitat in the area (Yılmaz et al., 2018). The quality of life of fauna in the urban cemetery not only relies on the types of tree, but it also depends on the interaction between human activities as well as the intraspecific relationship to nature in the area. Human activities in the cemetery are very different compared to the activities performed in the park which makes the area active such as picnics, sporting events, walking dogs, etc (Bovyn et al., 2019).

Increased human interference in the area including recreational activities in green areas has threatened the habitat of native plants. Therefore, processes in decision-making and design must be taken into consideration as measures to conserve the biodiversity of indigenous plants and wildlife in urban areas (Servet & Aktağ, 2019). Most tree planting in the cemetery is conducted by the family of the deceased without strict prohibition of the authority. Yılmaz et al. (2018) suggests the guidelines for planting new trees in the cemetery should be enforced to improve the quality of biodiversity as well as preserve the green areas in the cemetery. Furthermore, the diversity of plant species in the cemetery should be encouraged by the conservation in the use of shrubs, herbaceous plants and native trees to be a source of food and shelter for fauna. The cultivation of potentially invasive species of plants should be avoided to facilitate maintenance and irrigation in the cemetery (Yılmaz et al., 2018).

Dent and Knight (1998) describe that the cemetery is a special type of waste disposal site that contains organic waste well beneath the surface. This area seems to be well protected as no new land has been built and the design concept tends to be an open space that helps to facilitate the hydrology cycles. Deep-rooting trees planted in cemeteries can potentially mitigate seepage in the cemeteries and its surroundings by consuming vast quantities of groundwater and depositing in unsaturated areas (Ucisik et al., 1998). The Mount Olivet Cemetery established in 1858 has park-like features has been used as a city sponge that absorbs stormwater for Washington D.C. to reduce the risk of flash floods. The approach adopted in the area is to narrow or replace the rarely used pathways with grass, trees, flower beds, rain gardens and bio-retaining cells specifically designed to catch and degrade storm water before it enters the local drainage (Hickman, 2019).

The adaptive concept of the urban cemetery is to respond to the United Nations call in Sustainable Goal Development (SDG) 15 which supports the conservation in the sustainable use of green areas as well as maintain biodiversity in the area (United Nations, 2020). It aims to maintain the existence of natural resources in urban areas for future generations in sustainable way. This indicates a unique urban identity where flora and fauna can also coexist with humans without being threatened.

Cultural

Cemeteries are often regarded by society as sacred places that contain the dead and untouchable. The cemetery serves as more than just a burial ground, but also as a place for inter-religious, culture and the preservation of community identity (McClymont, 2016; Swensen & Skår, 2019). The cemetery is a source of information to describe the identity of the community buried in the place. The status and role of the social life of the dead can be identified from the monument's architecture, landscape and layout of the cemetery. However, there are certain traditions and religious beliefs which do not display the social status of the deceased during their lifetime, in fact, the deceased has received a new status after death (Heilen, 2012; Sautkin, 2016).

Swensen and Skår (2019) have identified two variations in the inclination of society to cemetery status that reside within community interaction in the city. The first is the inclination of society towards the concept of secularism in which personal interests as well as leisure needs are more concerned with society. Unbelievers in society began to flourish in practicing the idea of secularism by not restricting religion in the life of society. The group views the urban cemetery as part of a space to facilitate the environment and social development. The second tendency of society is a community that is drawn to a new culture, personal faith and life philosophies. Swensen and Skår (2019) refers to this group as immigrants that have brought their culture and religious beliefs with them to new places. The increasing diversity of immigrant communities in the area has revived religious interests and interreligious interactions among locals.

Local cemeteries illustrate the cultural, political and historical events of the past that have attracted the tourism industry in the dark tourism sector (Rozite & van der Steina, 2020). Dark tourism can be interpreted as visitors who wish to visit or travel to areas that have been afflicted by catastrophe or death (Pecseka, 2015; Stone, 2012). The location of tragedy and disaster is not only a memorial site but it has progressively become such a tourist attraction. Visiting catastrophe sites could provide visitors with a better understanding of the event which will have an effect on individual emotions and psychology. Among the areas of a catastrophe which attract tourists are the 9/11 Memorial & Museum in New York attracted about 10 million visitors since its establishment (9/11 Memorial, 2017).

Nevertheless, the local community possibly did not agree or were not ready to make the cemetery or tragedy area as a tourist area. It depends on the local culture and the collective memory of the locals of historical events or tragedies in the area (Rozite & van der Steina, 2020). Auschwitz concentration camp memorial in Poland has received 2.32 Million visitors in 2019 by revealing sites of ethnic cleansing tragedy (Auschwitz-Birkenau, 2019). However, there are many restrictions imposed as well as ethics at the Auschwitz concentration camp that visitors must abide with as visitors are not allowed to take pictures in the gas chamber. A code of ethics in the restrictions of photography is enforced to prescribe proper behaviour to visitors to show respect as well as in preserving relics. Visitors are also not allowed to make noise and photographs taken of visitors around the area are mostly taken by not displaying a smile or happy face. The restriction is to express respect and gratitude to the victims involved in the situation (Reynolds, 2016).

The limited activities performed by visitors have indirectly preserved the traces of tradition and history that can now be found in the cemetery. The old cemetery offers a pleasant aesthetic architectural value such as the design of monuments, statues, beautiful tomb decorations and symbols that are rarely found today (Salinas Moreno, 2018). The old and historic cemetery itself offers insight as an outdoor museum where the visitors could also explore the unique artifacts in the area. The history and value of the background of the story through the artifacts would make visitors more informed and appreciate the value of their environments simply by illustrating the historical context of the cemetery.

The outcome of this study is to ensure that human cultural and natural heritage is retained in a more sustainable described in SDG 11.4 (United Nations, 2020). Although urban areas are experiencing environmental and social changes, these areas rich in historical and cultural values should be preserved and not neglected.

Open Spaces

Creating new urban green areas in urban areas is very challenging where available land is very limited and costly to build. Based on Kabisch and Haase (2013), any vegetation found in the urban environment, park, open space, housing gardens and street trees can be generally defined as urban green areas. Therefore, most of the existing urban cemeteries can be considered as part of the urban green space (Swensen, 2018). The urban cemetery area is an ideal location in the conservation to open spaces as they have natural and preserved ecological resources that improve the quality of green areas in the city (Servet & Aktağ, 2019).

Most research papers on cemeteries as open green spaces pick Scandinavian countries as study areas because their cemeteries are green concepts (Evensen et al., 2017; Nordh & Evensen, 2018; Nordh et al., 2017; Skår et al., 2018). It is obvious that people who live in highly populated areas and have difficulty accessing the open space will much more frequently visit the public open space in other areas. This is because green areas are able to provide a high quality of life to the community. The public open space in urban areas become buffer areas of urban lifestyle pressures (Marcheggiani et al., 2019).

Most cemeteries are accessible and provide walkways, benches and pleasant green scenery which makes it considered a recreation area as it has similar features to public recreation parks. These elements are likely to attract visitors to the cemetery for purposes other than visiting the grave, such as walking, sitting, physical activity and socializing (Evensen et al., 2017). According to Skår et al. (2018), visitors are interested in visiting the cemetery due to its valuable natural green area, which serves as an urban recreation area as well as the unique quality of green area compared to the city park.

However, the cemetery is considered a ‘quite park’ which has the features of a recreational area but seems to have an ‘owner’ that belongs to a religious institute, which makes it considered a private area in the context of urban planning (Nordh & Evensen, 2018). There are also peoples that only consider entry to the cemetery only for substantial matters related to the deceased or the cemetery only. The community Oslo, Norway from a study conducted by Skår et al. (2018) considers that the cemetery is a community asset or ‘common garden’ where visitors are allowed to pass through or remain in the area. This is because most Scandinavian people are open-minded yet do not impose too much emphasis on religion since the ideology of secularism is very strong among society (Swensen & Skår, 2019).

Elements of peace, greenery and pleasant aesthetics in the cemetery are significant elements that draw visitors to the green cemetery. These factors are influenced by proper maintenance as well as the pleasant surrounding landscape has given a positive impression to the visitors (Skår et al., 2018). Visitors in three cemeteries in Malmö studied by Pavel Grabalov (2018) found visitors felt comfortable with the environment in the cemetery by using the area for jogging and recreation. Visitors even feel attached to the area so they share the activity on social media and are well received by society.

The idea in adapting the urban cemetery as open spaces is one of the alternative measures to achieve the objectives of SDG 13 in combating climate change (United Nations, 2020). Rising temperatures in urban areas are facing the threat of climate change which will cripple urban infrastructure. Therefore, the establishment of green areas in these densely populated urban areas is essential for attempts to restore the environment.

The establishment of urban cemeteries as open spaces is an alternative path to dense urban areas where dormant green areas are adapted for more functional and hybrid use. This idea can be incorporated into the town planning policy to establish more open spaces from dormant green areas at low cost. The goal is to create a resilient city as well as overhaul the inclusive urban environment for the urban population addressed in SDG 11 (United Nations, 2020).

CONCLUSION

Cities across the world are experiencing global issues in the shortage of green areas that are causing most of the urban areas to become ‘concrete forest’. However, existing green areas such as landlocked cemeteries in the city should be fully utilized as a secondary use for the populations and the environment. Therefore, densely populated cities are able to utilize the existing green space as part of the green lungs of the city while improving the urban ecology and social.

Although the main purpose of the cemetery is to bury or dispose of the deceased, the area has also indirectly helped in preserving the environment and biodiversity in urban areas. Old urban cemeteries are likely to have diverse and large habitats of flora and fauna as well as to preserve rare native trees in the area. It has indirectly maintained the habitat of flora and fauna in the area which makes the ecosystem of urban areas secure.

The issue of urbanization and rapid demographic growth not only threatens the environment, as well as the social aspects of the urban population. Therefore, the sustainability of urban development has been introduced to exploit the heritage and relics of the old cemetery to be appreciated by future generations. The attraction of the old cemetery will create new tourism attraction, dark tourism in the area as well as expand the identity of the area to a higher level.

This study would lead to innovative ideas for government agencies and other industry players in implementing sustainable development in urban areas. The adaptation of existing dormant cemeteries into functional areas will draw local authorities’ interest by formulating new policies in urban planning by utilizing every dormant space in the city as a green area. Hence, dense urban areas will encourage stakeholders and industry players to take advantage of every existing urban space to apply sustainable cities that are resilient and thriving in economy, development and social.

Studies on the utilization of cemeteries in urban areas as part of public open spaces are thriving recently. Researchers are beginning to realize the importance of cemeteries in urban areas that benefit the environment while developing sustainable urban areas. However, any activity and development in the cemetery should take into consideration the culture and belief of the community towards the area.

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METHODS OF HARVESTING WATER FROM AIR FOR SUSTAINABLE BUILDINGS IN HOT AND TROPICAL CLIMATES

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Abstract
A rapid rise in demand for fresh and potable water every day has impacted global water resources that become an international matter of significant concern in keeping with the global population's fast growth. Although tropical countries receive abundant rainfall levels throughout the year, the lack of access and supply of clean water in many rural areas in this region considers an environmental challenge of this century. Atmospheric air represents a reservoir of clean water with an estimated quantity of 12,900 km^3, while the amount of renewable fresh water on the planet is approximately 12,500 km^3. Therefore, there is a need for new sustainable methods to provide a supplementary water supply for buildings. This research aims to examine passive methods and mechanisms of extracting water from ambient air that can be used in tropical buildings compared to rainwater harvesting systems. The methodology is based on a comprehensive review to explore the potentials methods, challenges and opportunities for collecting atmospheric water on-site in the tropics. Analytical evaluation of approaches, mechanisms, systems' productivity and performance was conducted. The research results revealed two technical ways that would be effective to extract water from humid air, namely: regenerative solar desiccant/collector and dew water condensation systems. This study would help to shape the application of Atmospheric Water Generation (AWG) that is expected to be more cost-effective, sustainable and adaptable to tropical building applications.

Keywords: *Water issues; atmospheric water harvesting; rainwater harvesting; sustainable buildings; desiccant; dew collection; fog collection; tropics.*

INTRODUCTION

World Health Organization (WHO) stated there is only 2.5% freshwater, while the rest of the water is salty (WHO, 2021). In terms of atmosphere, it contains 12,900km^3 of freshwater (Meran, Siehlow, & von Hirschhausen, 2021). Also, a percentage of 2.5% of freshwater makes 30% of groundwater, while 70% appears in the form of ice and snow, which represents less than 1% of freshwater available for human consumption (Alsharhan & Rizk, 2020; Eslami, Tajeddini, & Etaati, 2018). Although many countries enjoy plenty of water resources, the distribution of these resources is unequal, leading to water shortages in many urban regions.

Due to the rapid growth of the world's population, global water resources have become a critical international concern (SILVA, 2019). The rise of the worldwide population has increased clean water resources consumption, especially for people living in arid or semi-arid areas (Zhang, Huang, Chen, & Lai, 2017). Nevertheless, the increase in water consumption over the previous century was twice the global population growth (United

Nations, 2021b; Vargas-Parra, Villalba, & Gabarrell, 2013). Access to clean water has become a crucial global concern for sustainable urban developments. Cities are increasingly growing, and their infrastructures are developing to meet residents' different needs. In order to adapt to current demands, several studies have drawn attention to new solutions for creating a greener and smarter urban environment. Furthermore, the promotion of sustainable urban development calls for reducing reliance on desalinated water sources by decreasing of energy-intensive approaches to water treatment (Farreny et al., 2011).

Freshwater is vital for life and human well-being; however, people in many urban areas lack simple access to a secure and constant supply. Due to harmful human activities and emissions, natural freshwater resources, such as lakes and rivers, are decreasing. Besides, due to different factors, the amount of rainfall has been significantly reduced in many regions (e.g., global warming) (Mancosu, Snyder, Kyriakakis, & Spano, 2015). Inefficient water distribution, treatment and disposal systems that require vast quantities of capital and energy, resulting in unnecessary extra costs and environmental degradation, are another factor compounding the issue (Santos & Taveira-Pinto, 2013). In response to this situation, extensive efforts have been made, particularly in the last decade or so, to find and exploit alternative freshwater supplies. One of the promising solutions is water extraction from atmospheric air to solve freshwater scarcity in the tropical built environment. Several approaches have been introduced in the available literature. However, careful examination of the available and relevant literature points out the need for a study that introduces the approaches and analyses their technical features.

Based on this backdrop, this review article aimed to fill the gap in the literature and investigate a sustainable solution for the provision of drinking water in tropical buildings specifically linked to UN Sustainable Development Goals: G3. Good health and well-being and G6. Clean water and sanitation (United Nations, 2021a). To reach its aim, this study will examine passive methods and mechanisms of collecting water from ambient air, which would open a new possibility to be considered in tropical buildings. Accordingly, the sections below will illustrate the potentials and challenges of generating fresh water on-site using passive Atmospheric Water Generation (AWG) systems.

METHODOLOGY

A review of relevant published studies focusing mainly on those of the last decade from 2010 to 2020 was employed to assess the mechanisms, productivity, and acceptability capability of atmospheric water generation AWG to support the demand for fresh water at tropical buildings for water sustainability. Web of science, science direct, Scopus and published official reports constituted the main sources of material for the analysis in this study.

A concept was developed from different sources through content analysis of the literature, and the research flow was divided into two stages: tropical water issues and passive methods of atmospheric water harvesting (Figure 1). The first stage analysed the current water issues in tropical regions and buildings. Accordingly, the second stage investigated the passive methods for sustainable water supply from the air, which then categorised based on its occurrence into drops collection and drops coalition. Drops collection included rainwater harvesting systems (RWH), whereas drops coalition, which refers to AWG, involved fog collection, dew condensation and vapour sorption/ desorption using desiccant materials. The analytical evaluation was conducted on the passive systems based on their mechanisms, systems' performance and productivity aspects. Subsequently, the study highlighted the challenges and opportunities of implementing AWG systems in tropical buildings.

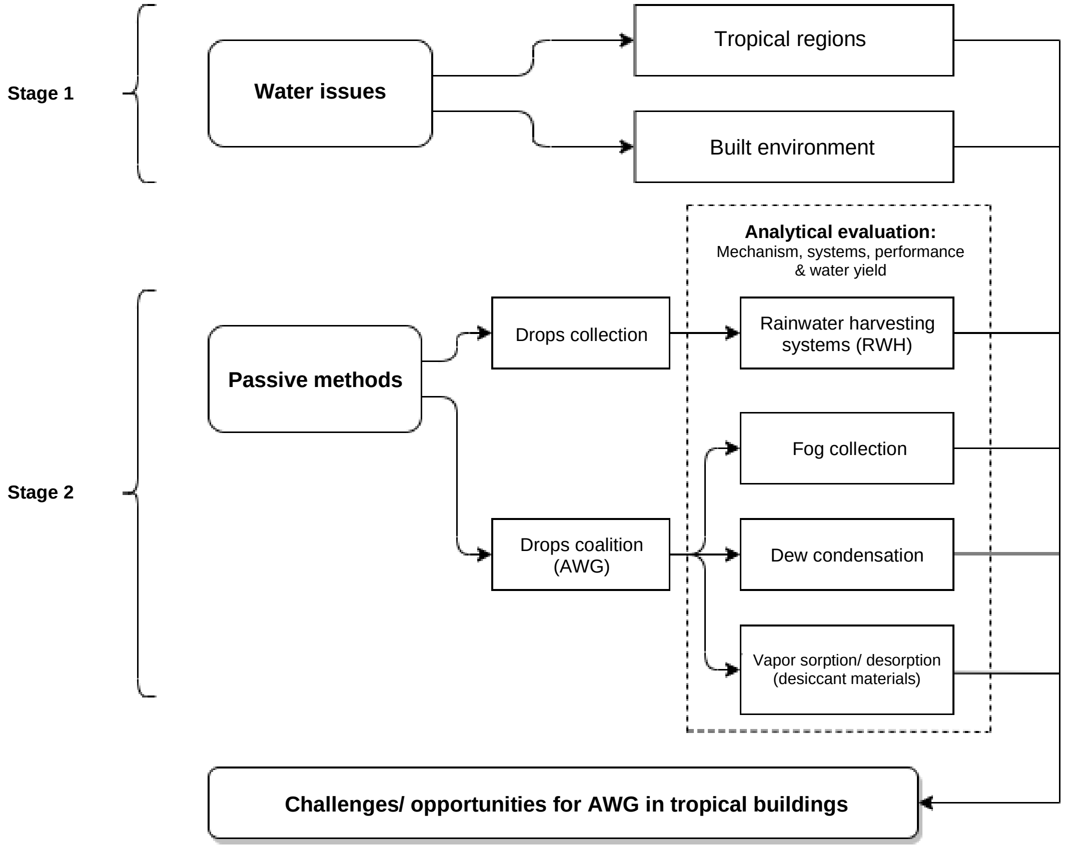


Figure 1. Review Framework for the Study

WATER ISSUES IN THE TROPICAL BUILT ENVIRONMENT

Increased global temperatures led to a rise in cyclones, hurricanes and floods in many areas of the world (Veenema et al., 2017). In terms of economic development and urbanisation, tropical regions such as Southeast Asia are considered one of the world's most dynamic regions. At the same time, the area is also vulnerable to many hydro-meteorological hazards that are likely to worsen due to climate change. Lorenzo and Kinzig (2020) emphasised that more severe disasters, particularly floods, could immediately decrease water quality after the event and for more extended periods of time, and lead to damage of infrastructure in many tropical countries. Furthermore, climate change-related water disasters (CCRWDs) have a detrimental effect on communities and people's health (Veenema et al., 2017). Moreover, Marcotullio (2007) argued at a lower level of income, the problems in water are numerous, such as increased access to drinking water and sanitation and increased flood planning.

Moreover, over the last few decades, Malaysia has never had a dire water crisis. However, rainfalls in Malaysia are unevenly distributed, leaving some areas dry and the other regions flooded. Particularly in cities such as Kuala Lumpur, Selangor and Putrajaya, despite the tropical climate and rich water resources, water is scarce sometimes (Lee, Mokhtar, Hanafiah, Halim, & Badusah, 2016). El Nino's phenomenon, which caused a severe drought in 1997/98, exacerbated this situation, with significant consequences for the country, particularly for the public water supply sector and residents. Afshar and Suhaimi (2018) found that Water resources in Kuching might not be viable for much longer, as the existing water supplies sources are almost at their height for catchments. Although the effect of climate change on water security in the tropical regions has been widely discussed, the alternatives for water production on-site to overcome water security and issues in the built environment have not been explored in as much detail (Biggs et al., 2014; Biswas & Seetharam, 2008; Weiss, 2009).

Many studies have been conducted on atmospheric water generation in the built environment. For example, Sivaram, Mande, Premalatha, and Arunagiri (2020) proposed a building integrated passive solar power technology (BIPSET) for water and power generation. The system is composed of a solar still, PV and combined with a chimney. However, the brackish water was needed to be used inside the solar still. Bradshaw (2016) proposed an air-water generator (AWG) attached to the building roof. The study employed pre-fabricated heat sinks utilising thermoelectric units to produce water from the air.

Energy use and carbon emissions are often the primary targets in green construction efforts. Even though clean, potable water is sometimes ignored, water is still a critical resource to daily life. Thus, devices of providing water to buildings have a tremendous effect on municipal water supply (Craig, 2009).

Proponents of green buildings argue that the built environment is the main factor in energy consumption and carbon emissions. So, the design and modification of buildings and their operations significantly reduce these issues. This concept is also applicable to water consumption. Even though it is challenging to achieve net-zero water buildings, reducing water consumption in every building has a major impact on alleviating the pressure on freshwater sources (Joustra & Yeh, 2015). Therefore, there is a need to improve novel systems capable of generating water on-site with little energy consumption or even reducing water quantity to be piped from distant locations.

RAINWATER HARVESTING SYSTEMS

Rainwater harvesting has a well-established historical past as a water conservation theory and supply (Haut, Mays, Han, Passchier, & Angelakis, 2015). In almost every part of the world, all communities have widely used this method. RWH has emerged as one of the interventions in response to climate changes that strengthen human society's resistance to water scarcity (DeNicola, Aburizaiza, Siddique, Khwaja, & Carpenter, 2015). RWH consists of the concentration, capture, storage, and treatment of rainwater from vertical and horizontal surfaces in urban environments, including rooftops, courtyards, terraces, and other impervious on-site building surfaces. There is a wide range of civic uses of the rainwater collected (for example toilet flushing, washing, garden irrigation, clean-up on the terrace, other intermittent outdoor applications, such as vehicle washing) (Campisano et al., 2017).

Numerous factors affect the sustainability of RWH in the built environment. These include social acceptability, quality of water and the ability to fulfil household requirements due to spatial and temporal rainfall variation (Neibaur, 2015). Water quality is an essential factor in the viability of RWH since it has a direct effect on human health (Baguma, Loiskandl, Darnhofer, Jung, & Hauser, 2010). Many studies show rainwater is usually cleaner, whereas pollution can occur once rainwater interacts with the atmosphere, roof, or storage tank (Helmreich & Horn, 2009; Schets, Italiaander, Van Den Berg, & de Roda Husman, 2010). Moreover, few studies have usually concluded that most of the rainwater's physio-chemical characteristics follow WHO guidelines (Chang, McBroom, & Beasley, 2004; Neibaur, 2015; Quaghebeur et al., 2019). Several other RWH studies indicated that stored water is contaminated by bacteria which exceeds WHO guidelines due to poor system design and poor maintenance (Domènech, Heijnen, & Saurí, 2012; Hafizi Md Lani, Yusop, & Syafiuddin, 2018; Islam, Akber, Rahman, Islam, & Kabir, 2019; Ward, Memon, & Butler, 2010). The functional feasibility and reliability of RWH mean that these systems are capable of satisfying household water demands. The temporal distribution of rainfall, consumer demand, catchment size and storage capacity affect RWH efficiency (Notaro, Liuzzo, & Freni, 2016). The predicted precipitation trends showed that feasible RWH systems are expected to be influenced by climate change.

Although Malaysia has large quantities of water resources, some areas now have water shortages (Ern Lee, Mokhtar, Mohd Hanafiah, Abdul Halim, & Badusah, 2016). The rising water demand has led to attempts to search for alternative water sources. As part of the solutions to alleviate the water shortage problem, the government suggested harvesting rainwater. The Malaysian government started encouraging the use of RWH in 1999 (Hafizi Md Lani et al., 2018). RWH has begun to achieve practical implementation with the recently increased water scarcity and rationing events. Besides, Lee et al. (2016) explored rainwater harvesting possibilities under the fluctuated climate in Malaysia. Five interconnected dilemmas were identified, namely: environmental, political, economic, social and technological aspects. In order to consolidate RWH as an alternate water supply, these issues must be addressed in planning, financing, construction, operation and maintenance. Accordingly, RWH systems could be useful in the tropical regions that enjoyed high rainfall levels; however, it needs a proper design and strategies to be applied to the tropical buildings.

PASSIVE SYSTEMS FOR ATMOSPHERIC WATER GENERATION

Extracting water from humid air is not a new technique. In this area of ancient Byzantium and particularly Theodosia, massive, mysterious structures condense the dew inside them and provide the inhabitants of the cities with sufficient freshwater supply, sited at (Carvajal et al., 2018) from (Zibold, 1905).

There are essentially three main approaches to collect water from the air: namely dew condensation, fog collection and direct vapour sorption/desorption (desiccants materials) as follow:

1. Dew condensing by exposure of air to surface temperatures is lower than the air dew point's temperature.
2. Fog collection.
3. Absorption of water from atmospheric air utilising desiccant materials with subsequent desiccant regeneration.

The first method cools down atmospheric air below the dew point temperature, but it is a very complicated and costly method. The second method increases water production higher than in other ways. Still, this method might only be implemented in specific regions, especially those with 100% relative humidity and an adequate wind speed level. In the third method, a desiccant is used to absorb humidity from the atmospheric air during nighttime, which then uses a heat source, such as solar energy, to generate moisture that is condensed after that. This method generates an acceptable amount of water, and it is easier and cheaper than the other methods. More details about the aforementioned atmospheric water generation approaches will be discussed in the following sections.

Dew Condensation

Since the radiative cooling mechanisms, physics and thermodynamics of condensation surfaces are more precisely understood, dew collections have grown in the last 20 years (Tomaszkiewicz, Abou Najm, Beysens, Alameddine, & El-Fadel, 2015). Though relatively limited yields, dew positions themselves are a viable water substitute, as they occur in many places worldwide naturally and often.

The formation of dew is a transition step from vapour to fluid or condensation. The formation process can be represented by four physical processes that repeat many times during a dew event: heterogeneous nucleation, droplet growth, renucleation and removal of droplets (Figure 2) (Tomaszkiewicz et al., 2015). Dew condensation occurs primarily when the environmental temperature is lowest, and relative humidity is usually the highest (Late at night and around sunrise the most favourable conditions for dew gathering).

The upper limit of the dew yield is 0.8 kg/day/m^2 based on the radiation cooling capacity available for condensation; however, in arid and semi-arid climates, the maximum observed dew water outputs generally fall within 0.3 – 0.6 kg/day/m^2 (Khalil et al., 2016; Tu, Wang, Zhang, & Wang, 2018). The process is usually restricted by radiative heat exchange rates, climate conditions and surface characteristics. In particular, weather conditions decide the ratio between latent and sensible heat between ambient air and the surface.

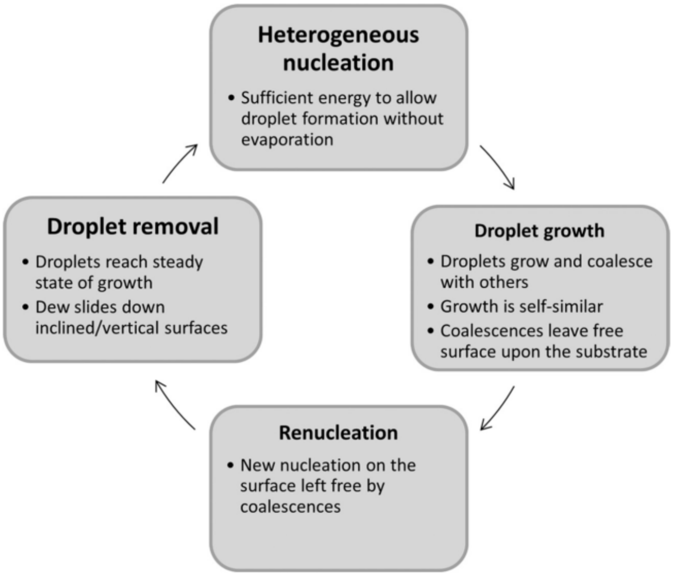


Figure 2. Dew Formation Process (Tomaszkiewicz et al., 2015)

Due to the dependence of radiative systems on the physical processes of dew formation, their design must be optimised to allow surface cooling without any external input of energy. A variety of factors are essential for improving yield. Firstly, maximising the condensing surface's infrared wavelength emitting properties is necessary to enable night surface cooling. Secondly, the visible light absorption must be decreased to prevent the condenser from heating up during the day (i.e., white materials). Third, the wind's heating effect must be minimised by reducing its velocity, typically accomplished by a tilt angle on the condenser or a particular shape. Fourth, to recover much of the water, a hydrophilic surface is required to collect it in a reservoir and prevent early morning water evaporation. Finally, a light condenser is necessary to minimise heat inertia, make it easier to adjust the surface temperature and have adequate insulation to prevent heat transfer from the ground (Khalil et al., 2016; Tu et al., 2018).

Passive cooling device study involves research on materials with low emissivity surfaces. Sharan (2011) investigated three condensed surface types that were analysed: galvanised iron (GI), commercial aluminium sheets and PETB-films (polyethylene blended with 5% TiO_2 and 2% $BaSO_4$), as shown in Figure 3. The condensing surfaces were evaluated as a 1 m x 1 m radiative condenser mounted in northwest India's semi-arid coastal area. The quantity of water obtained on most nights (60 %) ranged more or less consistently between 0.05 and 0.25 mm from the daily data collected over 2-year periods in 2004 and 2005. The maximum collection was in the PETB sheet (19.4 mm), followed by GI (15.6 mm) and aluminium (9 mm) from all three surfaces measured.

Figure 3. Different Types of Condenser Surfaces Investigated (Sharan, 2011)

The largest dew and rainwater collecting system worldwide was constructed in 2006 at Panandhro in the semi-arid area of Kutch (NW India) (Sharan, Clus, Singh, Muselli, & Beysens, 2011). This big dew condenser has a surface area of 850 m^2 net with ten ridge-and-trough modules that output a total of 6545 l for 2007, equal to 7.7 mm/day with a total registered maximum collection rate of 251.4 l/night (0.3 mm). This condenser can collect rain in addition to the dew, and sometimes it collects fog.

Fog Collection

Fog harvesters are not a new technology; they have been in use for many years by many cultures worldwide. A rectangular mesh perpendicular to the wind, which collects fog droplets, is the standard way to capture fog water. If the water droplets carried by the wind are exposed to a foggy environment, they are forced against the mesh and trapped. The droplets continue to grow after successive impacts so that they are too large to fall through gravity, and a gutter moves water into a reservoir, as shown in Figure 4 (Park, Chhatre, Srinivasan, Cohen, & McKinley, 2013). Today fog collection is considered one of the most passive and sustainable way of producing ambient water as they do not need any power to work and use only the changes in temperature and energy during the day to condense water into the mesh.

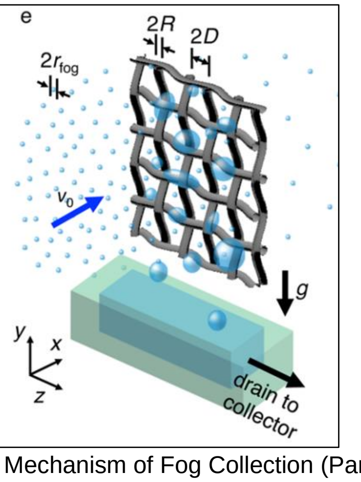


Figure 4. Basic Mechanism of Fog Collection (Park et al., 2013)

The successful initiatives influenced the development and implementation of similar fog collection projects in many areas of the world today (Batisha, 2015). Most sophisticated fog systems have a capacity of 2–11.8 kg/day/m^2 in water generation, as summarised by Tu et al. (2018) as shown in Table 1.

Table 1. Summary of the Literature Review on Fog Water Collectors (Tu et al., 2018)

Reference	Material	Location	Operation Year	Fog Days/ Year	Elevation m	SWP kg/day/m^2	Method
(MacQuarrie et al., 2001)	Raschel 65% shadow net	Nepal	2001 - 2010	122	3750	3.7	Exp.
(Fessehaye et al., 2014)	/	Peru	1995 - 1999	210	800	11.8	Exp.
(Olivier & De Rautenbach, 2002)	Polypropylene yarn	South Africa	1999 - 2001	184	1600	4.6	Exp.
(Marzol, Sánchez, & Yanes, 2011)	/	Canary Islands	2000 - 2010	354	700	10	Exp.
(Larrain et al., 2002)	Raschel mesh type	Chile (Alto Patache)	1997 - 2000	365	700	7.8	Exp.
(Fessehaye et al., 2014)	/	Guatemala (tojquia)	2006 - 2010	210	3300	6	Exp.
(Fessehaye et al., 2014)	/	Chile (padre Hurtado)	2010	365	550	2	Exp.

One of the key infrastructure expenses that made the device uneconomic and hydraulically challenging was the pipe's cost from collectors to consumers. Therefore, Abdul-Wahab, Al-Hinai, Al-Najar, and Al-Kalbani (2007) examined the potential of residential-type fog collectors built in the houses' vicinity (Figure 5). Schemenauer, Cereceda, and Osses (2003) revealed the following conditions should be met for a feasible and effective fog extraction project:

1. Fog has to occur regularly during the year and is likely to continue for a relatively long period.
2. The collection of fog water is mainly attributed to high-level locations with relatively high liquid water content.
3. The wind must accompany the aggregation of fog to enhance the performance.

Figure 5. Fog Collection Project in Oman (Abdul-Wahab et al., 2007)

Today, the major challenge in the collection of fog is the low efficiency specified as the ratio from water reaching gutters to the normal water flux from the collector mesh (Montecinos, Carvajal, Cereceda, & Concha, 2018). Dual limitations are imposed on the wire meshes currently used to collect fog: coarse meshes do not efficiently catch microscopic fog droplets, whereas fine meshes suffer blocking. Shi, Anderson, Tulkoff, Kennedy, and Boreyko (2018) proposed a way of avoiding such problems; they replaced the conventional cross-like mesh using small-scale, vertically arranged wires. Furthermore, Tian et al. (2017) showed high efficiencies in the directional transport of water by spider-web mesh assembled by low-cost cavity-micro-fibre.

FogQuest is a non-profit with fog harvesters deployed worldwide, which started conducting its projects in 1987 (FogQuest, 2020). Since the mesh is installed as a wall, the high wind easily damages the mesh, as it is the weakest part of the structure. The evolution of the FogQuest is the Warka Water Tower designed by an architect (Hobson, 2016). It provides the user with a common space and shade. The tower is conical, 30 ft high and 13 ft in diameter. It costs approximately 1500 dollars and produces 80 l/day. Design opportunities remain in structural costs and size. However, these devices are highly reliant upon the filaments' size and material that form the net for the collection of fog and should therefore not be discarded as an excellent method of water supply mitigation.

Figure 6. A Community Surrounds a Warka Water Tower (Hobson, 2016)

Desiccant Materials

Desiccant materials are widely used in the harvesting of water from the ambient air. Mohamed, William, and Fatouh (2017) depicts the concept of a solar-driven air-water generation system (Figure 7).

Many researchers have presented their work on water extraction using solid, liquid and composite desiccant materials from ambient air (Table 2). For instance, H. Gad, A. Hamed, and I. El-Sharkawy (2001) introduced an integrated desiccant/solar collector system (1.42 m x 1.42 m) to produce water from atmospheric air. This system's result showed that it could provide about 1.5 l/m^2/day of pure water. At a glance of the absorption bed's design parameters, the sand weight to desiccant ratio affects the absorption rate and hence the rate of water generation. This issue is experimentally explored by (A. M. Hamed, 2003). Also, Kabeel (2007) proposed a pyramid system consisting of a multi-shelf solar system. In the experimental stage, the researchers used two pyramids with different beds. The first pyramid bed was built of saw wood, and the second one was made of cloth. The researchers saturated the beds with 30% $CaCl_2$ solution. The findings showed that the cloth bed has better results. The cloth absorption reached 9 kg with 2.5 L/day m^2 of water production (Figure 8a).

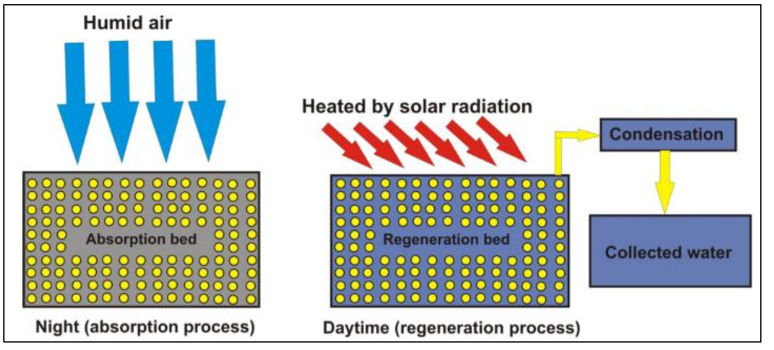
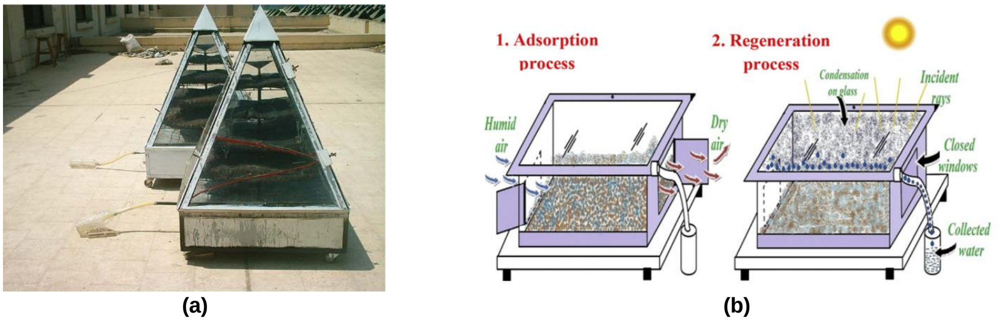


Figure 7. Schematic of Desiccant Mechanism for Water Production from the Air (Mohamed et al., 2017)



(a) (b)

Figure 8. (a) Proposed a Pyramid System (Kabeel, 2007), **(b)** Proposed (SGDBS) (Kumar & Yadav, 2015)

Ji, Wang, and Li (2007) used MCM-41, a highly efficient water-absorbent, as a hosting material with $CaCl_2$ as a desiccant to produce water from atmospheric air. This study's findings showed that the new composite material was a better absorber than silica gel, and it has a lower desorption temperature. Also, Ahmed M Hamed, Aly, and Zeidan (2011) introduced a desiccant/collector solar regenerator with an area of $0.5m^2$ for atmospheric water production in Saudi Arabia. The study used $CaCl_2$ (30% concentration) as a desiccant material and sand as a host bed. The findings showed that freshwater generated could be reached one l/m^2/day. Besides, (Kumar & Yadav, 2015) presented a solar glass desiccant box type system (SGDBS) to produce water from atmospheric air (Figure 8b). This system used the new composite material, including saw wood and $CaCl_2$. The host material was the saw wood, while $CaCl_2$ was used as a hygroscopic salt. The experiments were used during day and night with different salt concentration for absorption and water production, and the best results were obtained for 60% concentration, and water production was 180 ml/kg. Also, Kumar and Yadav (2016) used Vermiculite/Saw wood floral foam (10 x 30 $cm^{3)}$ composite as a host material with different concentrations: 9, 16, 23, 28, 33 and 37% of

$CaCl_2$ for extracting water from atmospheric air. The maximum amount of produced water was 0.35 ml/cm^3/day with 37% $CaCl_2$ concentration, leading to 76.44% for system efficiency. Kumar and Yadav (2017) repeated all the previous steps by replacing Vermiculite/Saw wood composite as a host material. The maximum amount of water produced was 195 ml/kg/day using this composite.

William, Mohamed, and Fatouh (2015) designed a fibreglass trapezoidal prism, and they used solar energy for producing water from atmospheric air. This study increased the bed surface by making the collector with multi-shelves, and they used two types of host materials, namely cloth and sand, that were saturated with $CaCl_2$. The percentage of 30% $CaCl_2$ concentration produced 2.32 and 1.23 kg/m^2/day evaporated water for cloth and sand with a system efficiency of 2.93 and 17.76%, respectively. Also, Srivastava and Yadav (2018) collected water from air using a novel design of 1.54m^2 Scheffler reflector experimentally. They investigated three absorber salts: $CaCl_2$ LiCl and LiBr with a 37% concentration and sand as a host material. The maximum production of $CaCl_2$, LiCl and LiBr composites was 115 ml/day, 90 ml/day and 73 ml/day in 270 min, 330 min and 270 min, respectively, while the annual cost of production was \$0.53, \$0.71 and \$0.86. Besides, Wang et al. (2019) presented an interfacial solar heating system based on the salt-resistant GO-based aerogel. The study used a liquid-sorbent atmospheric water generator at a high concentration ($CaCl_2$ 50 wt% solution). The results showed a clean water amount of (2.89 kg/m2/ day) with about 70% RH through solar input only, and the desorption efficiency was up to 66.9%. Generally, harvesting water from atmospheric air using desiccant materials still under research. Different parameters of desiccant properties and proper system design mainly affecting water productivity and system efficiency. Therefore, desiccants regenerative approach is considered as a promising solution for water supply in the tropical built environment.

Table 2. Atmospheric Water Harvesting Systems using Desiccant Materials

Reference	Location	Procedure	Desiccant	Water production
(H. E. Gad, A. M. Hamed, & I. I. El-Sharkawy, 2001)	Egypt	Experimental & mathematical	$CaCl_2$/ corrugated cloth	1.5 *l* /m^2/ day
(Kabeel, 2007)	Egypt	Experimental	$CaCl_2$/ saw wood	2.5 *l* /m^2/ day
(Ji et al., 2007)	China	Experimental	$CaCl_2$/ MCM-41	1.2 *kg* /m^2/ day
(Ahmed M Hamed et al., 2011)	Saudi Arabia	Experimental	$CaCl_2$/ sand	1.0 *l* /m^2/ day
(Kumar & Yadav, 2015)	India	Experimental	$CaCl_2$/saw wood	180 ml/kg/day
(Kumar & Yadav, 2016)	India	Experimental	$CaCl_2$/floral foam	35 ml/cm^3/day
(Kumar & Yadav, 2017)	India	Experimental	$CaCl_2$/Vermiculite/Saw wood	195 ml/kg/day
(William et al., 2015)	Egypt	Experimental	$CaCl_2$/ cloth	Cloth = 2320gm/m^2 Sand = 1235gm/m^2
Srivastava and Yadav (2018)	India	Experimental	LiCl, $CaCl_2$ and LiBr/ sand	LiCl = 90 ml/1.54m^2 /day $CaCl_2$ = 115 ml/1.54m^2 /day LiBr = 73 ml/1.54m^2 /day

CHALLENGES IN THE IMPLEMENTATION OF AWG INTO TROPICAL BUILT ENVIRONMENT

The lack of water resources has a detrimental effect on urban growth and residents' basic lives and has become one of the critical factors hindering social development

(Hashim, Hudzori, Yusop, & Ho, 2013). Also, observational research into the efficiency of alternative water supply technologies is urgently needed to be carried out in the built environment in line with sustainability goals (Imteaz, Ahsan, & Shanableh, 2013).

Efforts to establish sustainable water supplies, in general, must be driven by a clear and integrated national strategy (Mourad, 2020). Through national water and climate change policy, RWH implementation must be integrated, institutionalised and updated. The development of RWH systems can be authentic and coordinated by enacting laws and promoting detailed directives. The costs of constructing, maintaining and using RWH are considerably higher than those for domestic water. A comparison of the cost of RWH with domestic water is needed for promoting the RWH system as an alternative to the water supply.

RWH might not be the most suitable option for alternate water supplies in the short term, but it will be possible to reduce water consumption. Consequently, creative technological methods to upgrade RWH into the new and existing buildings must also be implemented to make RWH an integral part of the water supply system. The tropical building envelope should be utilised to enhance sustainability. However, further quantitative investigations are needed in the tropics (Ariff, Ahmad, & Hussin, 2019).

The amount of water in the air ranges from one ml to more than 30 ml per cubic metre in hot, humid regions (Lehky, 2017). Passive dew condensation method could naturally be implemented into tropical buildings for water collection from ambient air. Water yield from this method is limited and affected mainly by environmental conditions. However, radiative dew condensation systems could be integrated into RWH systems to provide an acceptable water amount. Besides, water vapour absorption into a hygroscopic substance is another effective way of collecting water in the built environment. Absorbers have a broad ability to bind water and can be transported easily. Without other air pollutants and odour, it selectively absorbs water vapour. Generally, this method could collect more water than dew condensation, especially in the tropical climate, which enjoys a high relative humidity (usually more than 90% during the night). In addition, integrating renewable energy such as solar panel (PV) or wind into those systems would increase the system efficiency and hence water yield. Also, fog collectors' projects presented themselves as an effective solution to overcome water shortage, especially in developing countries. Such a method could be adjusted to provide sufficient water for the built environment community. However, fog collection systems could be established only in specific tropical locations with regular fog occurrences and adequate wind speed.

A comprehensive awareness of the environmental changes and the resulting adjustment and mitigation of water resources is essential for sustainability development. Thus, an alternative, convenient and low-cost source of clean water for the tropical environment is increasingly required. Moisture harvesting systems do not replace traditional water systems that are accessible and sufficient, but where these alternatives are limited or costly, moisture harvesting systems may provide a sustainable source of tiny amounts of drinking water, especially during disaster events. Furthermore, in tropical or coastal regions which are warm and humid, atmospheric moisture harvesting should be more cost-effective. However, it cannot compete with the basic rainwater harvesting system (Sharan et al., 2011). Much testing and experience in the pilot projects are required before this technology can be sufficiently matured.

The topical built environment requires an effective way of collecting clean atmospheric water. This approach should be simple and reliable. It can work for a village or even households in small decentralised units without the need for costly piping systems. No fossil energy should be required. It should be easily sponsored and installed on-site from readily available materials even by uneducated people.

CONCLUSION

This study examined passive approaches and methods to produce water from the air in the tropical built environment. RWH and AWG were discussed to understand their potential, challenges and limitations to produce water on-site in the tropics. Even though RWH has emerged as a solution towards the water shortage problem, harvested water is polluted by microbiological contaminants and pathogenic organisms. Besides, RWH involves interconnected challenges, including environmental, political, economic, social and technological aspects. It is clear that there is an urgent need to introduce sustainable alternatives for water supply, such as AWG. For instance, fog collection might be applicable in high regions with 100% RH or near to oceans with a sufficient wind speed. The sorption/ desorption approach (desiccant materials) is highly recommended to produce water from the air in tropical buildings. Radiative dew condensation has a limited amount of produced water. Therefore, radiative dew condensation systems can be incorporated into the tropical building structure such as roofs and car parks in the future.

Furthermore, integrating renewable energy into either dew condensation or desiccant systems would increase water production with no effects on the tropical environment. Moreover, with more research, AWG can be more efficient and cost-effective in tropical buildings. Despite various challenges, this study highlighted the possibility of harvesting water sustainably from the atmosphere to supply clean drinking water to buildings in the tropical climate areas.

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THE ROLE OF EXTENSIVE GREEN ROOF TO REDUCE FLOOD RISK IN URBAN SCALE USING MULTI-CRITERIA DECISION ANALYSIS

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Abstract
The implementation of green roofings as one of green infrastructure strategy is still a concern for researchers, especially in the developed countries. Several studies conducted to evaluate the performance of Extensive Green Roof (EGR), primarily focusing on the pluvial flood mitigation and management. It show that EGR performs well in reducing rain water runoff. Flood disaster mitigation concerned with the activity to reduce flood risk. Flood risk influenced by the Hazard (H) factors and Vulnerability (V) factors. The H factors are determined by rainfall, slope, drainage network, and the distance to open channels. While, The V factors are defined by building type, population density, land-use, and road networking. Consequently, this research investigates the impact of EGR implementation in reducing flood risk on the urban scale. By implementing the Multi-Criteria Decision Analysis (MCDA) method integrated with the spatial scale analysis of Geographic Information System (GIS) and the Analytical Hierarchy Process (AHP) approach in Flood Disaster Risk Assessment (FDRA). This research focus on determining the levels of H factors and V factors for flood risk in urban areas of Medan, Indonesia. Series of simulation scenarios applying 60% of EGR in the total roof area of a building, using the rainfall data of the year 2019 and the spatial data from Geospatial Information Agency Indonesia and Seamless Digital Elevation Model (DEM) National Batimetri (DEMNAS) of the year 2019. Results show that the level of flood risk to this urban area could be reduced by up to 4% compared to before implementing the EGR. Therefore, even though this number could be small, however it is a promising indicator that EGR is potentially be included as one of the sustainable green architectural strategy to help reduce flood risk in the urban areas.

Keywords: *Extensive green roof; flood risk; flood mitigation and management; urban scale; Multi-Criteria Decision Analysis.*

INTRODUCTION

Rapid urbanization and global warming increase the risk of flooding in many urban areas since the last decade (BNPB, 2016). The significant changes from permeable surfaces into impermeable surfaces, like the paved and roofed areas, has had impacted the hydrology cycle in urban areas (Todorov, Driscoll and Todorova, 2018). This current type of development condition contributed to the expansive surface water runoff, faster runoff concentration, and higher rainfall-runoff peaks, and higher flow rates contradicting to the pre-development condition (Stovin, Poë and Berretta, 2013; Todorov, Driscoll and Todorova, 2018; Liu et al., 2019). Moreover, the existing condition and capacity of the drainage system are not incapable of collecting rain water runoff and therefore intensify the risk of pluvial flood, especially under heavy rainfalls (Ungaro et al., 2014; Deng et al., 2015). The pluvial flood occurs when precipitation intensity exceeds the natural proportions and capacity of drainage systems. As the impact of global warming, extreme weather caused heavy rainfalls, so raising the risk of urban flooding significantly.

In Indonesia, the central government has implemented several flood mitigation measures, including (i) constructing, upgrading, repairing, and improving rivers, air storage, and drainage, and (ii) building canals, coastal protection structures, and flood control pumping stations (The Ministry of Public Works and Housing Indonesian Republic, 2015). Structural counter measures, such as integrated drainage systems, dams, dikes, and the levees, are still the main flood prevention active strategies used to protect urban areas in Indonesia (Hapsari and Zenurianto, 2016; Thomas, 2017; Pamungkas and Purwitaningsih, 2019). At the same time, it is important to recognize that rainwater is not to waste, but it has to be returned to the ground as part of the hydrological-cycle and groundwater recharge (Hapsari and Zenurianto, 2016).

However, in many parts of developing countries, the structural counter measures used are not significantly able to reduce the flood risk, and it is because it often difficult to invest a huge budgeting for disaster management, primarily on the prevention and preparedness stage (Matsumaru, 2015). A few factors that affected the structural counter measures levels of performance for flood risk mitigation are because of the uncertain conditions of climate change, urbanization patterns, and sustainability issues for future development (Dong, Guo and Zeng, 2017). Nonetheless, there are a few more strategies proposed to be adopted to deal with climate change, i.e., green city or forest city idea concept and a green building (Hamid et al., 2014; Malek and Zainordin, 2019).

In addition, a Low Impact Development (LID) was designed and it is actually a system particularly to manage rainwater at the source by restoring some of the natural hydrological functions in urbanized areas (Jia, Yao and Yu, 2013; Liu, Chen and Peng, 2015). The LID design principle manages rainwater at the source by utilizing uniformly to reduce water runoff without releasing water to sea immediately. The idea of LID is to keep the rainwater should in the city and properly managed to be recycled within the urban area (Zhang, Cao and Meng, 2007). Compared to other LID counter-measures, the green roof is preferable to be used by many because it can be implemented without the use of a new land, but to use existing roof area, which is applied throughout retrofitting scenarios (Hill et al., 2017).

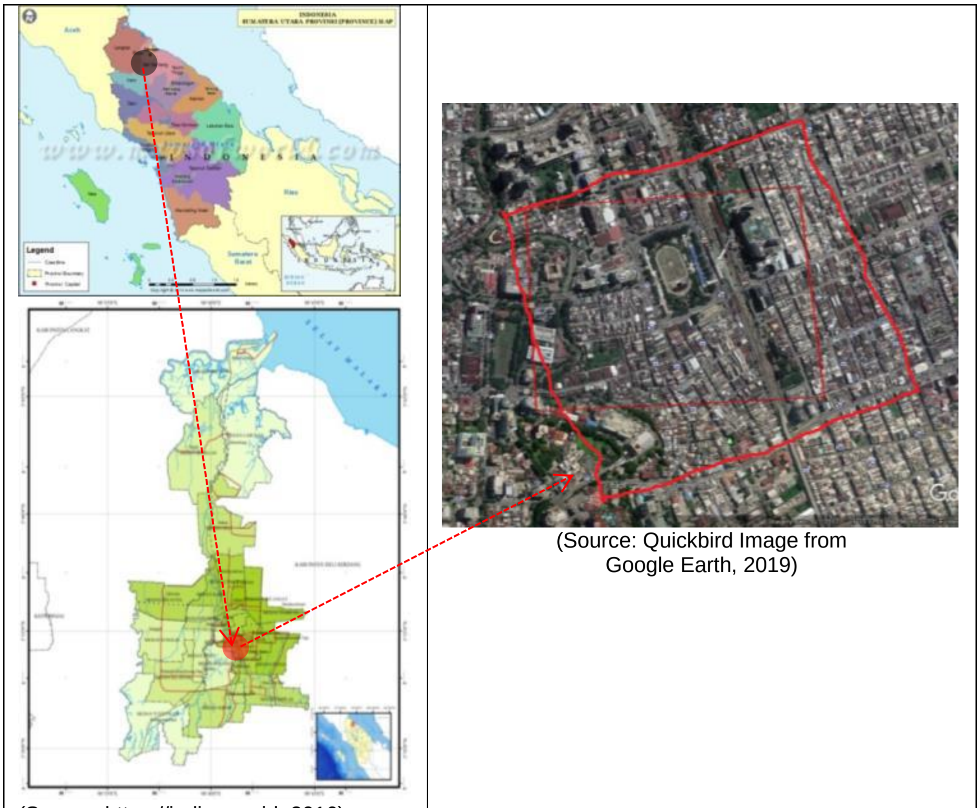
Many research about the EGR has been conducted to identify the performance of the EGR in reducing rainwater runoff in urban areas (Hill et al., 2017; Soulis et al., 2017; Wang, Tian and Zhao, 2017; Schultz, Sailor and Starry, 2018; Yin, Kong and Dronova, 2019). From the studies, several stated that a green roofs can reduced rain water runoff by up to 90% of the total rainfall depth in particular rainfall events, and the performance of green roof reduced as the rainfall depth increased (Hakimdavar et al., 2014a; Hill et al., 2017; Soulis et al., 2017; Gong et al., 2018). In one study by Yin, Kong and Dronova (2019), some reductions of 11.05% to 100% rain water runoff have been recorded in the peak flow rates in the green roof systems compared to the conventional roofs.

Green roofs are regularly categorized into two categories, dependent on the substrate depth layer which are (i) extensive (15 cm thick or less) and (ii) intensive (thicker than 15 cm) (Vijayaraghavan, 2016). The EGR are widely used than intensive green roofs (IGR) because EGR has lighter load, lower construction cost, and less maintenance and preservation (Hakimdavar et al., 2014b). However, there are still limited studies to identify the impact of EGR performance on reducing water runoff related to flood risk reduction on the urban scale. Therefore this research aims to identify EGR performance for reducing flood risk in urban scale with spatial analysis method.

STUDY AREA

Medan is the fourth most populated city in Indonesia with 2.2 million population, after Jakarta, Surabaya, and Bandung, making Medan the most significant city outside the Island of Java (BPS, 2015). Medan is sited on the north western coast of Sumatera Island by the Strait of Malacca, which connects to the Indian Ocean in the north (Figure 1). Medan is directly linked to one of the busiest ocean trade traffic in the world. The city constitutes the capital of North Sumatera Province and has significant growth over the last few decades, particularly in its economy and development area expansion (Archer, 1992).

The fast urbanization and growth in Medan however, raises urban flood risk, and the rapid development puts Medan as one of the ten cities in Indonesia in the high flood risk category (BNPB, 2016).



(Source: Quickbird Image from Google Earth, 2019)

(Source: https://indiemap.id, 2016)

Figure 1. Research Location

For this research, the Merdeka Square was selected as the researched area because this area is always flooded every time high precipitation events occur. Merdeka Square is located in the central of Medan. Nowadays, Merdeka Square land use is dominated by commercial, businesses, and office building facilities (it is 66.29% of the total landmass).

MATERIAL AND METHODS

The Multi-Criteria Decision Analysis (MCDA) method is used by integrating Spatial Scale Analysis (SSA) of Geographic Information System (GIS) (Van Westen, 2013; Mishra and Sinha, 2020) and Analytical Hierarchy Process (AHP) approach in Flood Disaster Risk Assessment (FDRA). The implementation of MCDA using the SSA and the AHP approaches was implemented by earlier researchers in disaster risk assessment such as: (i) seismic vulnerability assessment (Alizadeh et al., 2018), (ii) flood risk assessment (Fariza et al., 2020; Mishra and Sinha, 2020; Sun et al., 2020), and (iii) earthquake vulnerability assessment (Jena, Pradhan and Beydoun, 2020). MCDA is a prospective tool that analyzes actual complex problems to determine diverse preferences under several indicators for an appropriate decision (Malczewski and Liu, 2014). Meanwhile, one of the reasons for adopting the GIS-based software in the risk decision-making process is the probability of developing the 'what if?' analysis by distinct variables therefore resulting in other alternatives in a spatial context (Longley et al., 2005). Among several MCDA approaches, The AHP developed by Saaty (2008) is one of the best known and most widely used approach through pairwise comparison, to identify how dominant one factor is over another factor with respect to the criterion to which they are compared.

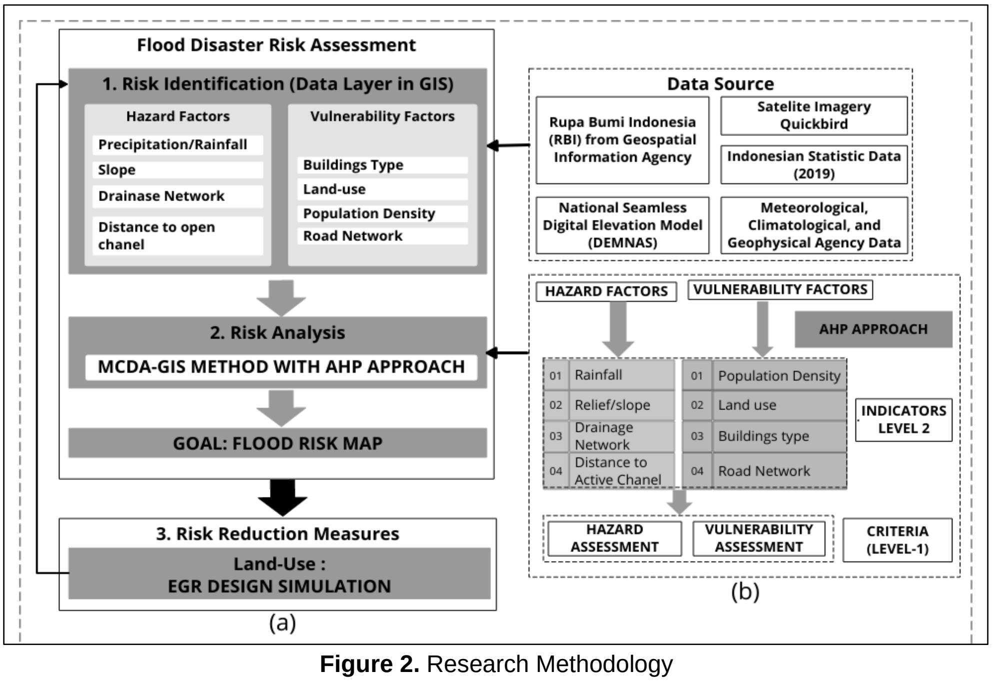


Figure 2. Research Methodology

This research was conducted in three main stages, as shown in Figure 2a. The first stage is risk identification process, that possible hazards, element at-risk or exposure, and vulnerability factors that contributed to flood risk are identified (Van Westen, 2013; Berndtsson et al., 2019; Lyu et al., 2019). Flood risks identification is actually developed from original surveyed information based on the recorded actual flood events that could assist in the development of the flood risk map for the studied region (Table 1). The second stage is the risk analysis process was conducted in the MCDA-GIS using AHP approach There are two level analysis (level 2 and level 1) to identify the flood risk map using AHP approach (Figure 2b). Finally at the final stage, the EGR design was simulated as part of vulnerability factor at land-use factor to investigate the overall performance of the EGR in reducing the risk of flood to the Merdeka Square Area (Figure 6).

Flood risk identification at Merdeka Square, Medan, is divided into two main assessment variables, i.e. the hazard factors (H) and vulnerability factors (V) (Van Westen, 2013; Lyu et al., 2019). All of the variables are then transformed into thematic layers in the GIS with additional datasets, the City of Medan rainfall data, satelite imageries, detail of the spatial plan for drainage network, building type, and land use, statistical data of population density of Medan City, and road network maps (Table 1).

Table 1. Recommended/Acceptable Physical Water Quality Criteria

Criteria	Thematic Layers	Data Source
Hazard Assessment (H)	Precipitation/Rainfall	Meteorological, Climatological, and Geophysical Agency, 2019
	Terrain/Slope	Seamless Digital Elevation Model (DEM) and *National Batimetri* (DEMNAS)
	Drainage Network	*Rupa Bumi Indonesia* (RBI) from Geospatial Information Agency
	Distance to open chanel	*Rupa Bumi Indonesia* (RBI) from Geospatial Information Agency
Vulnerability Assessment (V)	Building Type	Spatial Plan of Medan City
	Land use	Satelite imagery Quickbird
	Population density	Statistic Center Agency
	Road Network	*Rupa Bumi Indonesia* (RBI) from Geospatial Information Agency

Flood risk analysis is using MCDM-GIS with AHP approach. The AHP method in spatial-decision-making comprised a few phases as described by (Saaty, 2008), which are:

1) **Determining the score of each criterion**. A pairwise comparison matrix should be performed to get the score. Each option can be compared with a particular criterion (x1, x2, x3, ….., xn) of alternatives applying the scale, which uses absolute numbers from 1 to 9 for each pair to present the individual preference (Table 2).

Table 2. Fundamental Scale for Pairwise Comparison in the AHP

Weight/Rank	Intensities
1	Equal
3	Moderately dominant
5	Strongly dominant
7	Very strongly dominant
9	Extremely dominant
2, 4, 6, 8	Intermediate values

2) **Criteria for weight estimation.** To determine every criterion's weight, a comparison between the criterions should be in a pairwise manner. There is a set of eigenvalues called Estimated Eigen (EE) value for each criterion.

3) **Priorities and consistency estimation.** Every comparison is determined by the consistency of experts assessment. Saaty (2008) recommendes the consistency ratio

(CR) for consistency check. There are two stages to quantify the degree of consistency. The first step, the consistency index (CI) is calculated using Equation (2).

$$CI = \frac{(\lambda \max - n)}{(n-1)} \tag{2}$$

where n is number of criterion and λ_{max} the maximum EE value of the comparison matrix. The second step calculates CR as the ratio between CI and the random index (RI) as the Equation (3). CR is less than or equal to 0.10

$$CR = \frac{CI}{RI} \tag{3}$$

where RI depends on number of criterion and defined by Saaty (2008) as shown on Table 3.

Table 3. Random Index (RI) Value Depends on Number of Criterion

N	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
RI	0.00	0.00	0.52	0.89	1.11	1.25	1.35	1.40	1.45	1.49

Altogheter there are eight different thematic layers were amalgamated and ran through the GIS program to simulate the Flood Disaster Risk Assessment (FDRA) map for the Merdeka Square area. The arrangement of the thematic layers were based on the relative weightages of the H and V factors. Hence the goal of the FDRA is a diagramatic maps displaying the spatial variability through the 2D images which informs the classification of flood risk in Merdeka Square Area. The FRDA maps produced are categorized into five different categories based on the Natural Jenks Classification (1967).

RESULT AND DISCUSSION

Flood Disaster Risk Assessment (FDRA)

The first stage of the research is flood risk identification, which divided into Hazard (H) and Vulnerability (V) factors. Flood Hazard (H) factors identification diagrams help in indicating the probability of flooding incidents to happen in a spesific locations based on the hydrological and geomorphological factors of the Merdeka Square area. Risk identification map was identified to describe decision factors and how it can influence the flood risk disaster (indicators Level 2). The calculation of relative importance weightage for level 2 hazards indicators is shown in Table 4.

Table 4. The Calculation of Relative Importance Weightages for Hazard (H) Factors

a) Rainfall (mm/day) (Level 2)						
Decision Factors	**L**	**M**	**H**	**VH**	**E**	**EE**
0.5 - 20 **(Low)**	1	1/3	1/4	1/5	1/7	**0.04**
20 - 50 **(Medium)**	3	1	1/3	1/4	1/5	**0.08**
50 - 100 **(High)**	4	3	1	1/3	¼	**0.15**
100 - 150 **(Very High)**	5	4	3	1	1/3	**0.26**
> 150 **(Extremely High)**	7	5	4	3	1	**0.47**
λ max = 5.29; C.I= 0.0716; CR = 0.06						
b) Relief/slope (in degree, x^0) (Level 2)						
Decision Factors	**S1**	**S2**	**S3**	**S4**	**S5**	**EE**
Up to 3^0 (5%) (S1)	1	2	3	5	7	**0.43**
$3^0 – 6^0$ (6-10%) (S2)	1/2	1	2	4	5	**0.27**
$6^0 – 10^0$ (10-18%) (S3)	1/3	½	1	3	4	**0.17**
$10^0 – 15^0$ (18-27%) (S4)	1/5	¼	1/3	1	3	**0.09**
>15^0 (>27%) (S5)	1/7	1/5	1/4	1/3	1	**0.05**
λ max = 5.14; C.I= 0.0358; CR = 0.03						
c) Drainage Network (Level 2)						
Decision Factors			**AD**	**CD**	**AT**	**EE**
Artery Drainage (AD)			1	1/3	1/7	**0.09**
Connector Drainage (CD)			3	1	1/3	**0.24**
Another type of road Drainage (AT)			7	3	1	**0.67**
λ max = 3.007; C.I= 0.0035; CR = 0.01						
d) Distance to Open Channel (m) (Level 2)						
Decision Factors		**DAC1**	**DAC2**	**DAC3**	**DAC4**	**EE**
0 - 500 (Very High) (DAC1)		1	1/3	1/5	1/7	**0.06**
500 – 1000 (High) (DAC2)		3	1	1/3	1/5	**0.13**
1000 – 3000 (Moderate) (DAC3)		5	3	1	1/3	**0.25**
> 3000 (Low) (DAC4)		7	5	3	1	**0.56**
λ max = 4.02; C.I= 0.01; CR = 0.01						

A heavy rainfall is topping the main factors that significantly causing the pluvial flood risk. Pluvial floods are often occured during high precipitation events. However the area's annual rainfall is relatively light and ranges between 0.5 – 20 mm/day (BPS, 2019). Even though the precipitation experienced by this area is light, but the original topography (i.e. physical characteristics) of the area is steep and slopy varying from 6^0 to 10^0 (29.87% of total studied area). It does affect the flow of surface water, therefore the area is easily inundated by water every time the rain is heavy. In some areas with a slope less than 3^0 (17.01%) there is possibility of waterlogging conditions and the cause of pluvial flood. Therefore the low slope areas were given higher weightage values, and vice versa for shallower slopes for computing the flood hazard (H) index (Table 3b). Figure 3 shows the slope map of the Merdeka Square area based on the Seamless Digital Elevation Model (DEM) and National Batimetri (DEMNAS).

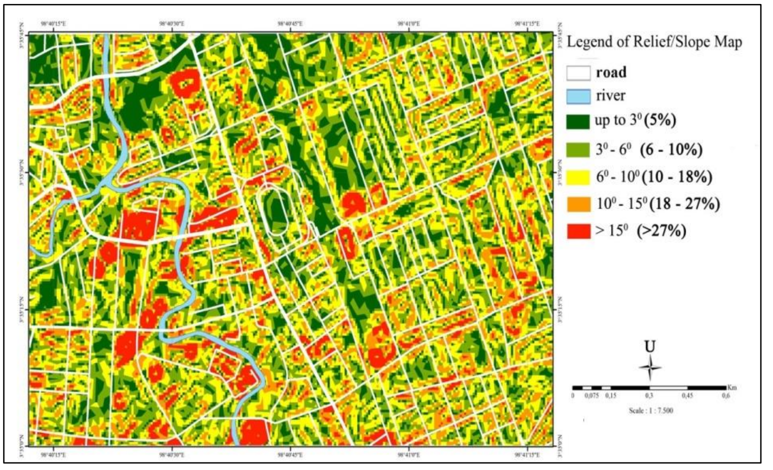


Figure 3. Slope Map of Merdeka Square Area

Another crucial factors that contributing towards the H factors is the distance to an active water channels, especially for the area with limited drainage capacity. The more the distance from an active channel, the bigger H value, i.e. risk of flooding hazard. Figure 4 below shows the distance form points around the studied area to the nearest active channel, the Deli River.

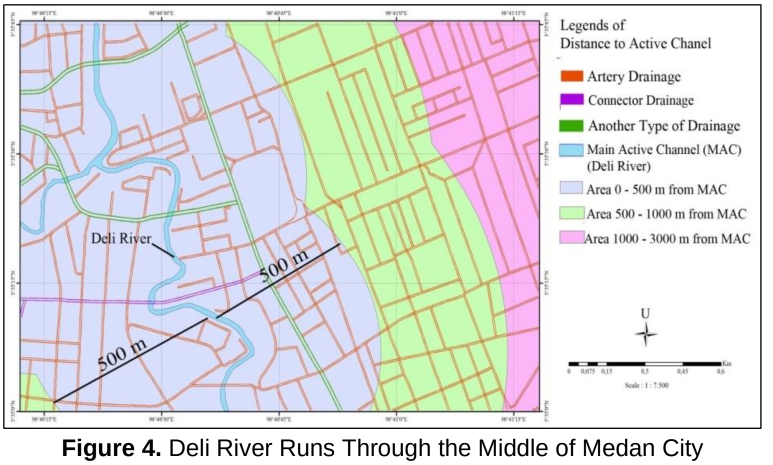


Figure 4. Deli River Runs Through the Middle of Medan City

Flood vulnerability (V) reflects the degree of potential hazards under particular conditions of socio-economic and infrastructural susceptibility and resilience capacity in a particular region over a specific time. The diverse specific factors implemented for flood vulnerability are based on their presence, absence, and functional relation with flood hazard (Mishra and Sinha, 2020). The calculation of relative importance weightage for level 2 vulnerabilitiy indicators is shown in Table 5.

Table 5. Calculation of Relative Importance Weightage for Vulnerability (V) Factors

a) Building Type (Level 2)						
Decision Factors	**B1**	**B2**	**B3**	**B4**	**B5**	**EE**
Housing **(B1)**	1	1/7	1/6	1/5	1/3	**0.04**
Business/Commercial **(B2)**	7	1	2	3	5	**0.43**
Industry/Housewares **(B3)**	6	½	1	2	3	**0.26**
Office **(B4)**	5	1/3	1/2	1	2	**0.17**
Public Service **(B5)**	3	1/5	1/3	1/2	1	**0.09**
Λ max = 5.15; C.I= 0.04; CR = 0.03						

b) Land use (Level 2)							
Decision Factor	**L1**	**L2**	**L3**	**L4**	**L5**	**L6**	**EE**
Built-up areas **(L1)**	1	3	5	7	9	1	**0.50**
Bare soil **(L2)**	1/3	1	3	5	7	1/3	**0.26**
Park/Garden (combination of bare soil and vegetation) **(L3)**	1/5	1/3	1	4	5	1/5	**0.14**
River/Water bodies **(L4)**	1/7	1/5	1/4	1	3	1/7	**0.07**
Forest cover (Natural Vegetation) (**L5**)	1/9	1/7	1/5	1/3	1	1/9	**0.03**
λ max = 5.30; C.I= 0.08; CR = 0.07							

c) Population Density (person/hectare) (Level 2)					
Decision Factor	**P1**	**P2**	**P3**	**P4**	**EE**
< 150 **(P1)**	1	1/3	1/5	1/7	**0.06**
151 - 200 **(P2)**	3	1	1/3	1/5	**0.12**
201 - 400 **(P3)**	5	3	1	1/3	**0.26**
> 400/ha **(P4)**	7	5	3	1	**0.56**
λ max = 4.12; C.I= 0.04; CR = 0.04					

d) Road Network (Level 2)				
Decision Factors	**Ar**	**C**	**An**	**EE**
Artery Road (**Ar**)	1	1/3	1/5	**0.11**
Connector Road **(C)**	3	1	1/3	**0.26**
Another type of Road (**An**)	5	3	1	**0.63**
λ max = 3.04; C.I= 0.0194; CR = 0.03				

The population at risk is one of the primary indicators that need to be considered to assess the vulnerability to floods in a specific area. The population density is an indicator of potential danger to human life and health – the main focus in flood risk assessment. The higher the density of a population in an area, the higher the probability of losings lives and the properties (Kandilioti and Makropoulos, 2012). More people will be affected in a highly-populated area compared to a less populated area in case of flood disasters of similar level of severity. Therefore, population density serves as a proxy for the cost of life and property in a given region that may be at risk due to flood, hence it is set to receive the highest weightage in the flood vulnerability analysis. The classified population map based on the 2019 census information received from Statistic Center Agency of Indonesia, it shows that the density of population at Merdeka Square are low (i.e. under 150 people per hectare).

Besides the population density, surface permeability also has its impact on overall hydrological performance of a place. Land-use types of a place will affect the capacities of place to intercept rainfall and prevent flooding, i.e. forest compared to built-up areas (Duo et al., 2018). Merdeka Square area is dominated with built-up areas (82.52%) (Figure 5b) which are dominated with business and commercial building (Figure 5a). There are a lot of buildings with 'shop- house' model, but the owners only used the building for business and not for leaving. Built areas are more prone to flood hazard than the current fallow/bare lands and marshy areas because of lack of absorption. Therefore, the built-up areas criterion was given as the highest weightage based on the land-use factors at level 2 (Table 4b).

(a) Building Type Map (b). Land-Use Map

Figure 5. Vulnerability Identification Maps

Flood risk analysis is the second stage to get the flood risk map of the Merdeka Square area by integrating the H and V layer identification map (indicators level 2) into a simulation using GIS program. Furthermore, the thematic layers analyzed by GIS considered the weightage of H and V factors of level 1 to gain flood risk map result as a goal (Table 6).

Table 5. Calculation of Relative Importance Weightage for Flood Risk Factors (Level 1)

a) Hazard Factors (Level 1)

Decision Factor	RF	S	D	DAC	EE
Rainfall **(RF)**	1	3	5	7	0.56
Relief/Slope **(S)**	1/3	1	3	5	0.26
Drainage Network **(D)**	1/5	1/3	1	3	0.12
Distance to Active Chanel **(DAC)**	1/7	1/5	1/3	1	0.06

λ max = 4.12; C.I= 0.0395; CR = 0.04

b) Vulnerability Factors (Level 1)

Decision Factor	P	L	B	R	EE
Population Density (P)	1	3	5	7	0.52
Land use (L)	1/3	1	3	5	0.27
Building Type (B)	1/5	1/3	1	3	0.14
Road Network (R)	1/7	1/5	1/3	1	0.07

λ max = 4.12; C.I= 0.0395; CR = 0.04

In this study, the H and V layers were multiplied in the model builder to generate the Merdeka Square Area flood risk map and classified into five categories using Jenks Natural Breaks Classification (1967). Further, the classified flood risk map (Figure 6) shows that 82.3 % (233 km2) of the Medan Square area falls in the low-risk category, and 17.54% (49.65 km2) identifies as very low risk. There are only 0.2% (0.46 km2) categorized as moderate risk. FDRA map is given significant evident which shows the flood characteristics of Medan Square area. Flood which occurred at Medan Square area is generally in the form of inundation with a depth of not more than 50 cm. It just related with the observation result during the research in study area.

Figure 6. Flood Disaster Risk Assessment (FDRA) Map of Medan Area Square

The low risk condition is affected by annual rainfall condition (the highest H factor) and population density (the highest V factor) at Medan Square area is still in low condition. However, this condition is giving a warning for the local government. Medan Square area can run to moderate level of flood risk, if annual rainfall intensity is higher than now (> 20 mm). It is occurred because the other factors is already in high risk condition i.e., slope and land-use condition. Meanwhile, the structural measures by the construction drainage system still have limited access due to the urban morphology condition.

Risk Reduction Measure for Medan Square

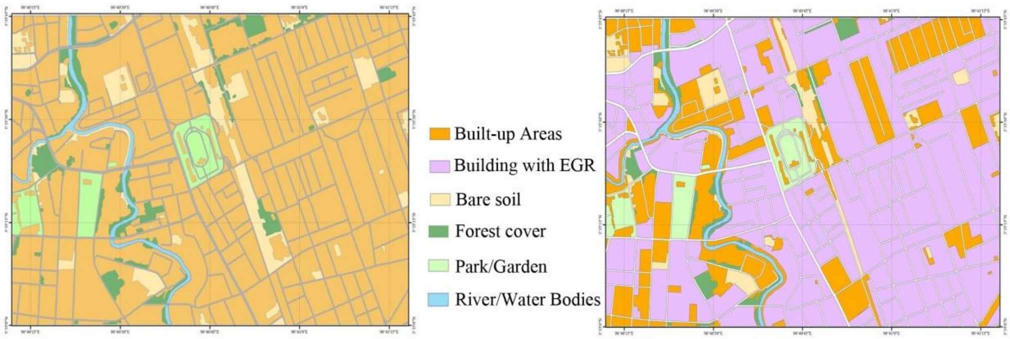
The final stage of this research is applying risk reduction measure to reduce flood risk at Medan Square area. Risk reduction measure focused on V factors which are applying EGR at the building roofs at Medan Square area. EGR categorized as land-use factor. The calculation of relative importance weightage for land-use factor at level 2 is change as shown in Table 6.

Table 6. Calculation of Relative Importance Weightage for Land Use Factors (Level 2)

Decision Factor	L1	L2	L3	L4	L5	L6	L7	EE
Built-up Areas **(L1)**	1	2	3	5	7	9	1	**0.39**
Green Roof (L2)	**1/2**	**1**	**2**	**5**	**6**	**7**	**1/2**	**0.27**
Bare soil **(L3)**	1/3	½	1	3	4	5	1/3	**0.16**
Park/Garden (combination of bare soil and vegetation) **(L4)**	1/5	1/5	1/3	1	3	4	1/5	**0.09**
River/Water bodies **(L5)**	1/7	1/6	1/4	1/3	1	3	1/7	**0.05**
Forest cover (Natural Vegetation) (**L6**)	1/9	1/5	1/5	1/4	1/3	1	1/9	**0.03**

λ max = 6.28; C.I= 0.06; CR = 0.05

EGR is implemented on roof of business, commercial, and office building. There is 65.3% area of the total studied area (165.49 km2) which simulated to use EGR on the roofs. (Figure 7).



(a) Land-Use Map Layer Non-EGR (b) Land-Use Map Layer with EGR

Figure 7. Land-Use Map Simulation

Land-use map layer with EGR implementation is integrated with the other layers into a simulation using GIS program to get the flood risk map of the Merdeka Square area. The result shows the EGR implementation can reduce the flood risk by 4% (Figure 8) and decrease the area's risk category (Figure 9).

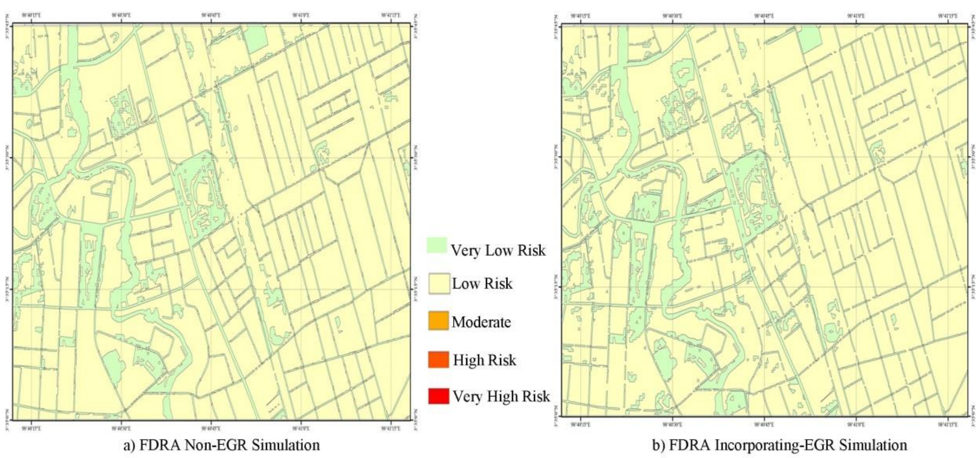


Figure 8. Comparison between FDRA Map Non-EGR and Incorporating EGR

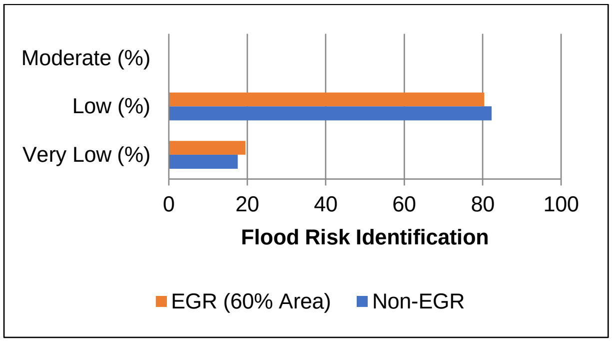


Figure 9. The Comparison of the FDRA Maps in between an EGR and the Non-EGR Approaches

So, the implementation of EGR has to be developed as part of the sustainability infrastructure to reduce the flood risk in this area.

CONCLUSION

Flood disaster risk influenced by hazard and vulnerability factors. High rainfall, low slope, and distance to active channels are recognized as the most critical hazard factors, especially in pluvial flood disaster. The risk reduction measure in flood disaster risk management focus on vulnerability factors to adapt with the unpredictable condition, i.e. rainfall as the highest hazard factor in FDRA. Meanwhile, land-use is the critical criterion in vulnerability factors after density of population. The improvement of permeable areas is one of significant measure to reduce flood risk. One of reduction measure is EGR implementation which can mimic as 'land' and retain rain water runoff.

EGR implementation has had a good impact on decreasing flood risk in the urban area and given promising indicators as green sustainable architecture strategy. As part of the Low Impact Development strategy, EGR needs to be developed as part of government policy in urban water management. EGR can be used in retrofitting scenarios, while an intensive green roof can be designed from the beginning of building construction. EGR researches must be developed to get the appropriate implementation in every climate condition.

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EXPLORING GREEN PROCUREMENT AS AN IMPORTANT TOOL IN CONSTRUCTION PROJECTS

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Abstract

Green growth will be the ultimate goal for every nation in the world. Green growth is intended for economic growth and development while ensuring the natural and continuous survival of human life and the whole system. Green procurement has been identified to be an essential tool as the key to the green growth mission, including green procurement for the construction industry. However, green procurement is perceived as less critical by the construction stakeholder compared to other green practices such as green materials and green technology. Thus, this paper aims to highlight the importance of green procurement for the construction industry and explore the perception of the current green procurement practices, specifically in Malaysia's construction industry. Accordingly, a purposive random sampling technique was used to select one hundred and fifty (150) respondents out of which ninety seven (97) responses were used for the data analysis. The research involved experienced practitioners in green building projects in Malaysia. The outcome from this research revealed that green procurement practices had been adopted in Malaysia's construction industry, which included the Industrialised Building System, passive green materials, Environmental Management System, and energy efficiency products. This research can guide the construction stakeholders and provides evidence on the importance of green procurement as an effective tool for green growth and construction projects.

Keywords: *Construction; green; procurement; Malaysia; questionnaire.*

INTRODUCTION TO GREEN GROWTH

Recently, most countries including Malaysia are experiencing rapid economic expansion which can improve the society's quality of life and reduce the poverty rate in the country. However, this process of economic development contributes to environmental degradation such as water pollution, noise pollution, and air pollution (Saufi, Daud & Hassan, 2016). The introduction of green growth has been widely endorsed to mitigate this problem. Green growth is a new strategy that has been suggested as a solution to deal with environmental issues, for example waste reduction and pollution, energy conservation, and renewable generation. According to the Egyptian Competitiveness Report (2010), green growth can enhance the economy's efficiency by minimising pollution, implementing new green technology, increasing productivity, reducing the cost of production, and increasing the competitiveness of the country.

In 2015, Malaysia launched its 11th Malaysia plan 2016-2020, where in the plan it is stated that there are six strategic thrusts to assist Malaysia to achieve the objective in developing an advanced economy through a low-carbon, resource-efficient and socially inclusive approach by 2020. One of the strategic thrusts that is stated in the 11th Malaysia plan 2016-2020, is green growth. Green growth can help Malaysia to face environmental challenges and opportunities in a rapidly evolving global and political environment.

Three strategies have been fixed by the government to support the agenda of green growth, i.e., enhancing governance to encourage green growth, creating awareness on responsibility, and implementing sustainable financing mechanisms (EPU, 2015). Other than that, as has been mentioned by Yatim, Sue and Hon (2017), Malaysia has implemented a few policies that are related to policies on renewable energy and climate change. These policies comprise the Renewable Energy Act (2011), National Policy on Climate Change (2009), National Green Technology Policy (2009), and the National Renewable Energy Policy and Action Plan (2009). Based on the research by Olayeni, Mosaku, Oyeyipo and Afolabi (2018), green growth provides benefits to the construction industry such as sustainable construction enhances the sustainability of the organisations' environment, provides economic value, develops a humane environment, dignifies the environment, and creates equitable working environment.

INTRODUCTION TO GREEN PROGRESS FOR CONSTRUCTION PROJECT

Green construction aims to create the balance between what we seek to build and what our environment can ultimately support. It can increase productivity by making employees more comfortable and healthier. In some cases, it is more cost effective, saving money on utility bills and operating costs. Green construction consumes less energy and natural resources and reduces the waste and pollution that we create. The elements of green construction are materials, waste management, indoor air quality, energy efficiency, water efficiency and heating, ventilation, and air-conditioning (HVAC). The concept of green building from the World Green Building Council is a building that, in its design, construction or operation, reduces or eliminates negative impacts and positively impacts our climate and natural environment (BOMA, 2011).

Procurement is the acquisition of the materials, supplies or services that are needed to successfully operate a business or complete a project. In construction, this refers to the goods and services that are needed to successfully complete a building from start to finish (Mark, 2019). Green procurement has been identified to be an essential tool as the key to the green growth mission, including green procurement for the construction industry. The Malaysian government has introduced the concept of Green Government Procurement (GGP) practices, starting with the GGP products and services. In its 2012 initiative, the Malaysian government has introduced MyHIJAU Mark & Directory to promote the sourcing and purchasing of green products and services in Malaysia; it is a platform for procurers, government ministries, and members of the general public to find information about all green products and services. However, green procurement is perceived as less critical by the construction stakeholder compared to other green practices such as green materials and green technology. The term 'green procurement' is not being used broadly across the construction stakeholders, unlike some green practices that are related to procurement that are being developed in the industry (Bohari, Skitmore, Xia, & Teo, 2017)."

GREEN PROCUREMENT PRACTICES FOR CONSTRUCTION PROJECT

Theoretical Setting

Construction procurement in a simple term that refers to the act of producing a building or infrastructure. Procurement in a construction project is an important process to determine the project direction and activities. The organisation buying behaviour theory could provide insights on the procurement activities and highlight the three important key points- the participants, the procurement process model, and the influence on the procurement decision. The construction procurement is a complex process compared to the procurement of products and services. The planning stage is essential in the construction procurement as it will heavily affect the design at the later stage such as design, tendering and construction (Abu Hassim, Kajewski and Triganarsyah, 2011).

The gradual deterioration of global environments triggers the industry to look at the alternative option for environmentally friendly project. The 1987 Brundtland Report's posed the idea that environmental sustainability must be considered for the benefit of future generations (WSSD, 2002). The environmental management theory highlights the natural environment as part of any organisational responsibility. This means that every sector must include environmental protection as their responsibility; including the construction industry (Wu, Yan and Huang, 2012). In the Triple bottom theory of sustainability, environmental protection is introduced and should be promoted to various parties, including policy makers, scholars and industry practitioners. The sustainability triple bottle line has suggested that the environmental consideration must be balanced well with another two concepts that are the economic and social (Shelbourn et al., 2006; Hussin, Abdul Rahman & Memon, 2013).

The construction industry is one of the economic sectors and thus also requires its organisation to stay competitive. The green business theory has coined the idea that the organisation that is committed to the principles of environmental sustainability in its operations, strives to use renewable resources and tries to minimise the negative environmental impact of its activities. Correspondingly, Hirsch identifies nine categories of green business behaviour including introducing the environmental policy, reducing customer's environmental impacts, reuse and recycling of materials that are used in the production process, concerns on energy efficiency, improving their resource productivity, implementing systems to identify waste reduction, pollution prevention, energy efficiency or resource productivity opportunities throughout the company or facility, promoting the organisation's environmental commitment, stakeholder's input on environmental decision making, and investing capital into purchasing green materials and services.

Hirsch also identifies nine categories of green business behaviour and explains the claim that when firms go green, they exceed legal requirements by:

1. Directly reducing their own regulated or unregulated environmental impacts in ways that will reduce the regulator's risk, improve company brand, and allow firms to get out in front of anticipated regulations;
2. Reducing their customers' environmental impacts and decreasing their customers' exposure to unhealthy substances;

3. Increasing their reuse and recycling of materials that are used in the production process.

Table 1. Application of Sustainability Principles in Construction Procurement

The Organisation Buying Behaviour Theory	**Triple Bottoms Theory** *Robins (2006)*	**Intended Green Performance Based on Sustainable Principles** *Adapted from Berry and McCarthy (2003); Kibert (2012); Ahn & Pearce (2013); Hussin, Abdul Rahman, & Memon (2013); CIDB, (2015)*	**Green Practices Related to Green Procurement**
Stakeholder procurement process model and influence on the procurement decision	Environmental Aspect	Reducing greenhouse emissions Reduce pollution levels Manage natural resources Waste Management	• Compliance MS1525 • Green specification • Rating tools • Eco-labelling guideline • basic environmental requirement • Industrialised Building System • Building Information Management • Waste management plan
	Economical Aspect	Value for money Internalise green cost	• Value management • e-tendering • Life cycle costing
	Social Aspect	• Enhance a participatory approach by involving stakeholders • Promote public participation • Provide high customer satisfaction	• Priority to green suppliers

Source: Author compilation

Green Procurement Definition and Concept

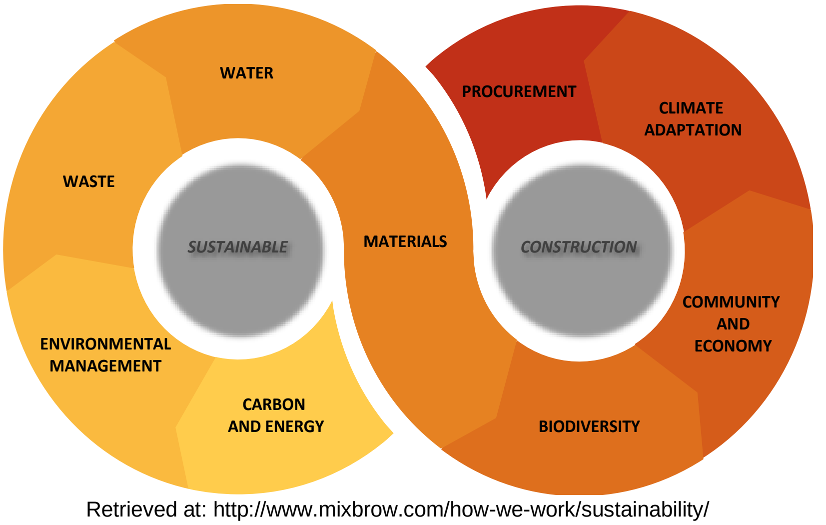
Green procurement has been known as an efficient way to minimise environmental impacts in product and consumptions. The term green procurement is defined as purchasing products and services which reduce and give constructive impacts on the environment, focusing into the strategies of purchasing, policies and directions (Green Council, 2010).

Green Procurement is a process where environmental problems can be reduced, and this will lead towards maintaining human well-being as a whole. In the construction stages, the first stage which involves decision making is the most important part that ensures that the impacts on the environment can be reduced (Bohari et al., 2017). This is where integrating green procurement in the earlier stage of construction is the most important consideration to ensure that the green practices in construction can be successfully delivered (Bratt, Hallstedt, Robèrt, Broman, & Oldmark, 2013; Ruparathna & Hewage, 2015; Zsidisin & Hendrick, 1998).

Green procurement is still a developing concept in Malaysia and in other Southeast countries (Bohari et al., 2017). Green procurement has been widely introduced to ensure that the implementation of green construction practices can be adopted in construction projects (Ruparathna & Hewage, 2015). Adham and Siwar (2012) have highlighted that the concept of green procurement for government projects are more focused on product and services where a pilot project has been conducted. Therefore, to promote the concept of green procurement, more trainings are introduced. Although there is no legal policy that insists on the implementation of green procurement in construction projects, there are green practices that have been adopted in construction project deliveries, for example, green rating tools to assess and recognise buildings that meet certain green requirements and standards, and also the Malaysian Carbon Reduction and Environmental Sustainability Tool (MyCREST) to guide, assist, quantify and reduce the built environment's impact.

Green Procurement Positioning in Construction

It is important to balance the three aspects of environmental, economic and social aspects in order to achieve balance in sustainable growth. Figure 1 shows that the nine (9) aspects to achieve sustainable construction include carbon and energy, environmental management, waste, water, materials, biodiversity, community and economy, climate adaptation and procurement.



Retrieved at: http://www.mixbrow.com/how-we-work/sustainability/

Figure 1. Sustainable Construction

This is where the positioning of procurement lies in construction projects. In the construction lifecycle there are phases involved, from initial to planning, implementation, execution, performance and monitoring, and closing. It is important for the procurement to start at the planning phase of the building lifecycle. Integrating green procurement in the early construction phase will help to reduce environmental impacts.

Green procurement help the stakeholder to make a right decision as early as planning stage to enable the project is greener. The green procurement is not a new procurement system but rather an improvement to the existing system by enhancing the green elements and practices. The term green reflected the concern on the environmental protection and the same time considering the existing procurement priority includes the cost, time and quality outcome.

Challenges in Green Procurement Implementation

Despite the benefits of green procurement in the construction sector, there are some challenges (refer Table 2) that hinder the adoption of green procurement in construction projects. These challenges have been highlighted by several authors, which include awareness, readiness, commitment, knowledge, cost, policies and guidelines as well as training. According to Varnas et al. (2009) and Ojo et al. (2014), the lack of and poor commitment and support from the top management on the implementation of green procurement is one of the biggest challenges as well as the lacking in sustainable practices in the organisation itself. Industry players play important roles to support this initiative to ensure there are market demands on green procurement and practices. Furthermore, poor knowledge and awareness, low expertise on green practices are among the construction players biggest challenges (Bidin et al., 2019).

Several authors had also highlighted that perception on green procurement involved higher costs in terms of the lack of resources and supply of green products, higher prices in green building material and the additional project development costs (Mosgaard et al., 2013, Sourani & Sohail, 2011; Simion et al., 2019; Willar et al., 2020). One of the challenges in initiating green procurement in construction is the lack of training in green or sustainable culture among the construction players, which involves commitment (McMurray et al.,2014). In terms of policies and guidelines, there are still a lack in terms of a standard policy and guidelines in green procurement implementation. Moreover, there are scarcity in the incentive to urge green practices implementation among the construction players (Ruparathna & Hewage, 2015; Bohari et al, 2017). To ensure that green procurement is successfully implemented in the construction sector, it is important to cater to these challenges and promote awareness of green procurement as an important tool among the construction players. Higher environmental awareness among the construction players is important, as a driver to inculcate them towards sustainable construction.

Table 2. Possible Challenges of Green Procurement Implementation Categorization

No.	Categories	Challenges	Sources
1	Knowledge	Lack of knowledge Lack of practical tools and information	Adham & Siwar (2012); Buniamin et al. (2016); and Bohari & Xia (2015)
2	Training	Lack of training for procurement officers Insufficient qualified staff to handle green procurement	McMurray et al. (2014)
3	Awareness	Lack of awareness on the green procurement concept	Ruparathna & Hewage (2015); and Bidin et al. (2019)
4	Policy	Lack of enforcement by government to implement green procurement Insufficient policies and regulation Lack of guideline in implementing green procurement Insufficient research and development	Ruparathna & Hewage (2015); and Bohari et al. (2017)
5	Commitment	Lack of top management commitment including money and time	Varnas et al. (2009); and Ojo et al. (2014)
6	Cost	Lack of incentive for companies to implement green procurement High cost of green product and services Perception that green product would be more expensive	Mosgaard et al. (2013); Sourani & Sohail (2011); Simion et al. (2019); and Willar et al. (2020)
7	Availability	Limited supply for green product	Varnas et al. (2009)

PROPOSED THEORETICAL FRAMEWORK

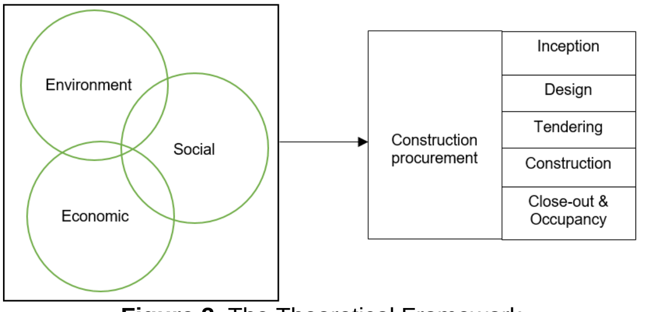


Figure 2. The Theoretical Framework

The rise in the construction industry's adverse environmental effects has made it a major player in overall energy consumption. It is therefore important to ensure the sustainability of the project over its life cycle by integrating sustainable measures and practices into the production of the construction project (Leiringer, 2020; Li et al., 2020). Green construction shall apply sustainable practices into its project life cycle, which begins at the level of the project management until its end-of-life phase. This includes the initial stage, the design phase, the tendering phase, the construction phase, and the phase of close-out and occupancy. The design that has been opted for the buildings will extend its impact on the environment, economy and society upon its completion, such as energy consumption, human health, and productivity (Presley & Meade, 2010). Thus, Table 3, 4, and 5 show the type of green practices that are related to green procurement and the principle behind the practices.

Table 3. Type of Green Practices and Its Principle Towards Providing Environmental Impacts

Environmental Impact		
Type of Green Practices Related to Green Procurement	**Green Practices Principle**	**Key Reference**
Compliance MS1525	MS 1525:2019 is a Malaysian Standards/Code of Practice for Energy Efficiency and Use of Renewable Energy for Non-residential Buildings. Drawing submitted shall be reviewed to ensure its compliance to building energy code before it is approved by the Local Authority	(Bohari et al., 2015)
Green Specification	Green specifications are written documents that go with the drawings and describe the materials as well as the installation methods. They also prescribe the quality standards of construction that is expected on the project (e.g. green design, eco-labelling, green products, green cost)	(Faith-Ell et al., 2006; Grolleau et al., 2007; Lam et al., 2009; Nissinen et al., 2009; Ofori, 2000; Ruparathna & Hewage, 2015b; Sterner, 2002)
Rating Tools	Building assessment rating tools are functioned to assess the performance of the building, guiding the entire process of the to reach the sustainable impact principles, and to accelerate the evolution and transform from the traditional construction industry practice. (e.g., MyCREST, pHJKR, LEED, BREEAM, Green Mark, etc)	(Mao, Lu, & Li, 2009)
Eco-Labelling Guideline	Green products with eco-labelling that are used in construction will minimise the environmental impacts during its whole life-cycle, which not only reduce the waste but also maximise resource efficiency. These green products shall be benchmarked with the industry standards (e.g., Code of practice, eco-labelling, EMS, ISO 14001, environment rating tools etc.)	(Bohari et al.,2015)

Environmental Impact		
Type of Green Practices Related to Green Procurement	**Green Practices Principle**	**Key Reference**
Basic Environmental Requirement	Selecting materials based on the project's minimal requirement to minimise project impact on environment	(Bohari et al., 2015)
Preliminary Study on Environmental Impact	Environmental Impact Assessment (EIA) is a process of evaluating the expected environmental impacts of a proposed project. The EIA report will be evaluated to assess its compliance with requirement.	(Adetunji et al., 2008; Appolloni et al., 2014; Grob & McGregor, 2005; Qi et al., 2010; Sood et al., 2011; Walker, Di Sisto, & McBain, 2008)
Industrialised Building System (IBS)	IBS scoring is a systematic and structured assessment system that can be used to measure the usage of Industrialised Building Systems (IBS) in a consistent way. The objective of the manual is to provide a well-structured assessment system for calculating the IBS Score.	(Hamid et al., 2008)
Building Integrated Modelling (BIM)	BIM is a process that is supported by various tools, technologies and contracts involving the generation and management of digital representations of physical and functional characteristics of places. BIM has the potential to support and contribute to the sustainability of green aspects, including energy consumption, carbon emissions, natural ventilation, solar radiation, lighting, acoustics, and water usage. Green process (e-procurement, e-tender, BIM)	(Goh et al, 2019, Roslan et al., 2019, Ahmad, Thaheem, and Anwar, 2015; Bynum et al., 2013; Grilo & Jardim-Goncalves, 2011; Hassan, 2014; Naoum & Egbu, 2015)
Waste Management Plan	Waste management principle (e.g. recycling, reverse logistic and on-site waste management)	(Bakir, 2013; del Río Merino et al., 2010; Nagapan et al., 2012; Yeheyis, Hewage et al., 2012; Zsidisin & Siferd, 2001)

Table 4. Type of Green Practices and Its Principle Towards Providing Economic Impacts

Economical Aspect		
Type of Green Practices Related to Green Procurement	**Green Practices Principle**	**Key Reference**
E-Tendering	E-Tendering utilises a set of technologies in its procurement process. It can reduce tendering time and cost and hence increases the productivity along with enhancing competitiveness and improvement in an organisation.	(Al Yahya, Skitmore, Bridge, Nepal, & Cattell, 2018)
Value Management	Value Management is a concept of relationship in satisfying the needs and objectives of a project and the resources that are required to achieve the project. Integration of Value Management (VM) practices can promote sustainable design and development during the lifespans of the construction project. VM practices is aiming for a better-quality project outcome which concerns on the value of money, better project quality, profitability and positive business image.	(Bohari et al., 2015)
Life Cycle Costing	The application of the life cycle analysis (LCA). Life-Cycle-Cost (LCC) is a tool to analyse the overall cost of a product that considers the cost of acquisition, operation, maintenance and disposal throughout the life cycle of the products.	(Pun, 2006; Klöpffer, 1997; Bohari et al., 2015; Nissinen et al., 2009; Pitt et al., 2009; Sterner, 2002)

Table 5. Type of Green Practices and Its Principle Towards Providing Social Impacts

Social Aspect		
Type of Green Practices Related to Green Procurement	**Green Practices Principle**	**Key Reference**
Priority to Green Suppliers	Encouraging the supplier to practice green principles and giving opportunity for the early adopters' competitive advantage	(Adham & Siwar, 2012; Kahlenborn, Mansor & Adham, 2013)
Public Reporting	Encourage the green procurement delivery to publish report on the GP implementation	(Grob and McGregor, 2005)
Considering Stakeholder Feedback	Engages stakeholders and the community in giving feedbacks as a lesson learnt for future adoption	(Ofori, 2000; Qi et al., 2010)

METHODOLOGY

Purposive sampling was used to determine the sample size and the unit of analysis in the survey was the internal stakeholder in the project procurement. The respondents' key selection criterion was the respondent must have experience in green building project such as the client, consultant and policy maker. The five-point Likert scale had been used in a previously established study by researchers (Adham & Siwar, 2012; Bakir, 2013; Walker & Brammer, 2009) in the research area of sustainable procurement. After the data were collected, data preparation and cleaning were conducted to ensure that the data were reliable for the analysis including coding the data, screening the missing cases, outliers and checking on the normality distribution, validity and reliability. About 19 questionnaires contained critical missing data, i.e., at least 30 percent or more of the overall questionnaires. Those cases were omitted from the preliminary analysis (Hair, 2006) and only 97 were retained in the database for further examination of normality and outliers.

FINDINGS AND DISCUSSION

Demographic Background

The profiles of the respondents were explored in this section as part of the data assessment. The purpose of analysing the demographic profiles of the respondents is to understand and describe the characteristics of the respondents, such as the respondents' experience and organisational type.

Respondent and Firm Profile

Figure 3 presents a summary of the respondents in terms of their position in the project, their level of experience in the construction industry and in green construction and how they acquire knowledge regarding green construction. The demographic information has no impact on the level of analysis of this study but reporting this is important in order to show the reliability of the respondents who are involved in this research.

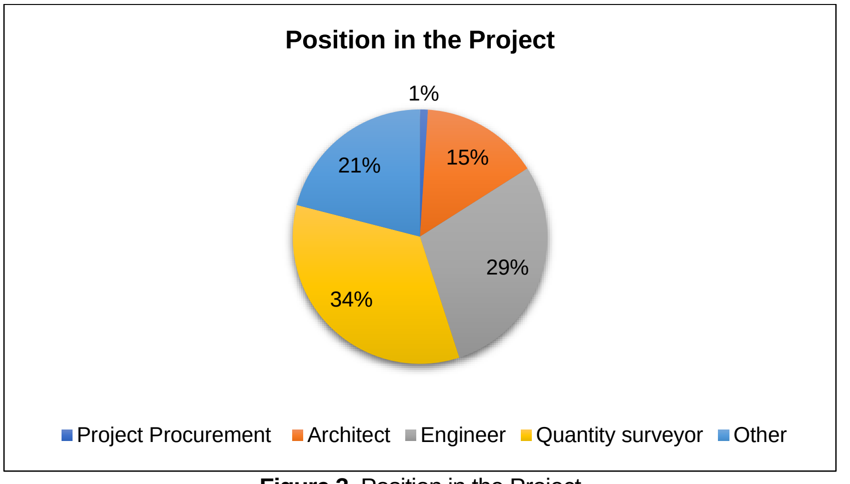


Figure 3. Position in the Project

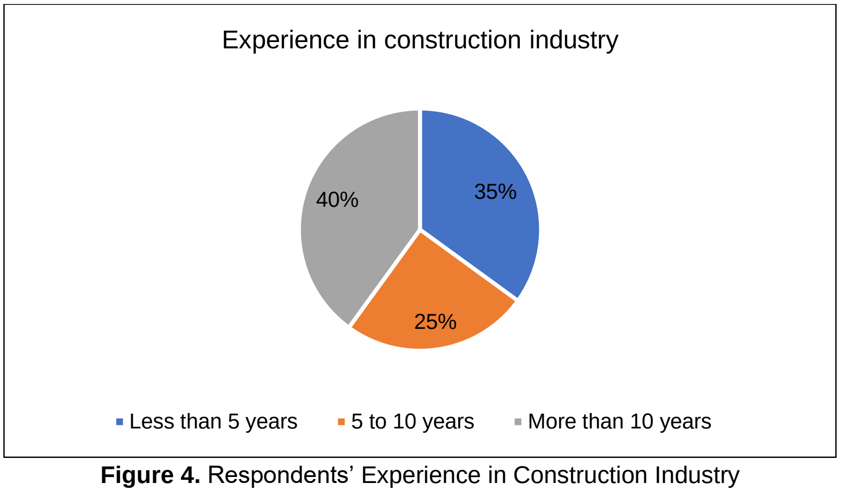


Figure 4. Respondents' Experience in Construction Industry

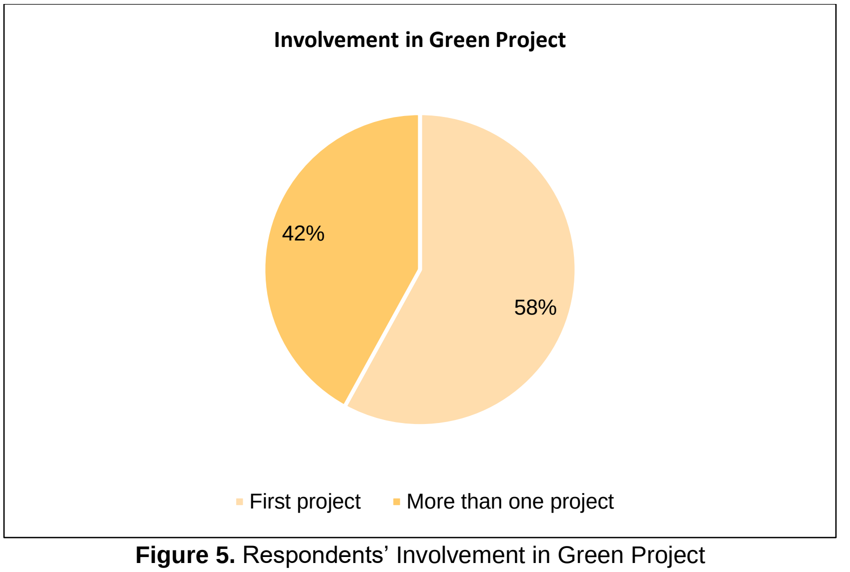


Figure 5. Respondents' Involvement in Green Project

The diversity of the respondents' professional backgrounds and their roles in their project planning and execution, and the fact that all the respondents have experience in green projects within the Malaysian construction industry, implies that their views represent the Malaysian context.

Green Practices Related to Green Procurement

The Cronbach's alpha is the most commonly used metric that is used to evaluate reliability (Gliem and Gliem, 2003), which is used in this research. The Cronbach alpha formula incorporates the number of the items on the test, so the greater the number of items, the greater the value of the Cronbach alpha. The result shows that the reliability of the variables is 0.846 for all the measured items.

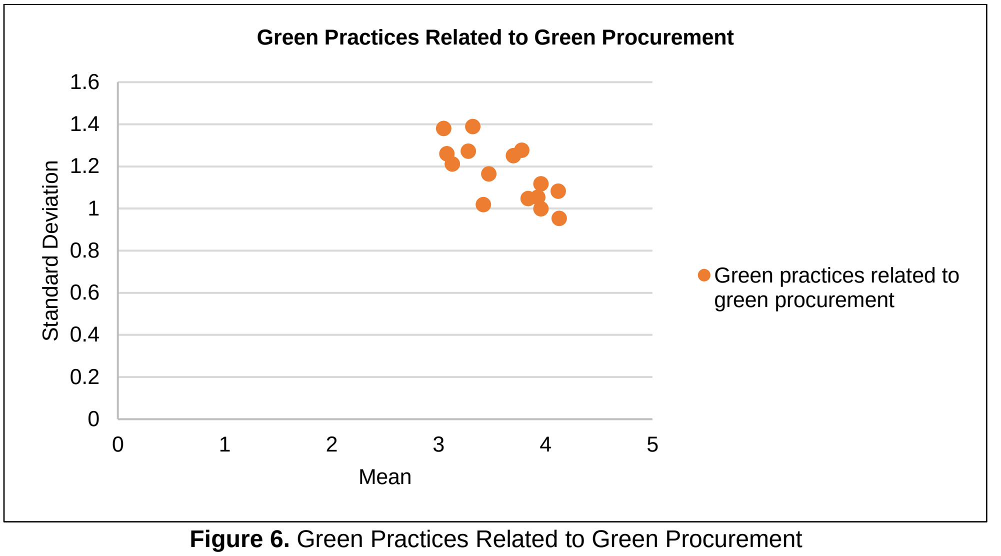


Figure 6. Green Practices Related to Green Procurement

Based on the outcome from the analysis, most of the respondents' opinion have orientated towards the agreement to show the importance of the practices towards green procurement delivery. Green specification in the tender documents and the rating tools are ranked as the highest mean with 4.13 (SD 0.953) and 4.12 (SD 1.083), respectively (refer to Table 6). Meanwhile, the public reporting and stakeholder feedbacks under the social aspect are ranked as the bottom two with 3.13 (SD 1.212) and 3.08 (SD 1.261), respectively (refer to Table 6). The analysis has revealed a high slandered deviation that is greater than 0.9 as shown in Figure 6. This explains that the factors that have been identified are significantly related to the green procurement practices. However, the ranking of the practices does not mean that the practices are not important but it is based on the respondents' perspective as to which practice is considered to be highly related to the green procurement practices for the construction industry, at the time the data are collected.

Table 6. The Mean and Standard Deviation Score

	Green Practices Related to Green Procurement	Mean	Std. Deviation	Rank
Environmental Aspect	Compliance MS1525	3.42	1.019	9
	Green specification	4.13	.953	1
	Rating tools	4.12	1.083	2
	Eco-labelling guideline	3.93	1.053	5
	Basic environmental requirement	3.96	.999	3
	preliminary study on environmental impact	3.70	1.251	7
	IBS	3.84	1.048	5
	BIM	3.32	1.389	10
	Waste management plan	3.78	1.277	6
Economical Aspect	e-tendering	3.05	1.380	11
	value management	3.96	1.117	4
	Life cycle costing	3.28	1.272	12
Social Aspect	priority to green suppliers	3.47	1.165	8
	Public reporting	3.13	1.212	13
	Considering stakeholder feedback	3.08	1.261	14

The Key Points on the Green Procurement Practices for Construction Industry

As mentioned earlier in this article, green procurement for a construction project is coined to incorporate the concerns on protecting the natural environment in every component of construction project delivery. Construction procurement divided into five stages. This article has highlighted the green practices adopted in all five procurement stages to shift the current procurement practices to the more environmentally-friendly procurement delivery. Incorporating these green practices into procurement delivery is the value-add to the existing procurement method adopted, such as traditional or design and build. The green specification identified are significantly related to green procurement practices. The project team needs to decide on the which building material or process contributed higher to the environmental degradation process as early as during the inception stage and think of a way to minimize the impact, for instance, by specifying the minimum environmental requirement for the selected building materials in the project specification.

CONCLUSION

There is a call for the project stakeholders in the construction industry to shift their purchasing preferences towards greener alternatives. This call for the project stakeholders in the construction industry to shift their preference and to recognise the importance for a project to produce a project’s environmental criteria is to help the stakeholders in making a decision. These environmental criteria also send a signal to the project team on how and to what extent that project greenness is required. The list of green practices is based on the existing Malaysian construction practices indicated that the green practices has been adopted in the construction industry, and by identifying the most relevant green practices towards the green procurement implementation will help to push forward the introduction of green procurement in the construction industry. The green procurement for construction project can be effective communication tool to highlight the needs for a green project delivery to all procurement stakeholder and also providing benefits to all internal and external stakeholder. This changes requires more attention by the stakeholder that hold the decisive power and also commitment from all stakeholder. It is suggested that the awareness campaign should be conducted to spread widely the benefits of the green procurement for construction industry. Thus the next stage of this study is to examine the key success factors that promote the green procurement in the construction industry.

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EXPLORING AGILE PROJECT MANAGEMENT IN THE MALAYSIAN CONSTRUCTION INDUSTRY

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Abstract
Agile project management is widely adopted in recent years to counter the dangers of traditional, front-end planning methods which often lead to downstream development pathologies. However, little research has been conducted with regards to the appropriateness of the agile project management application in the Malaysian construction industry. Therefore, the aim of this preliminary study is to explore the feasibility in applying agile project management by the construction practitioners. Online questionnaire surveys distributed and were developed based on literatures review undertaken to facilitate the data collection and analysis of this study. Based on the total 152 returned responses received, four hypothesis tests were conducted. The study has hypothesized four values, 70 practices, 15 knowledge areas and 16 benefits of agile project management by using median test. The result indicated that all the respondents are inclined towards the agile values of project management and all the current project management practices are indeed expected in the agile project management. The respondents also responded positively on agile practices which can be applied to all the 15 knowledge areas and the 16 benefits of agile project management. The questionnaire survey also found statistically significant result on the group who has yet to decide on applicability of agile project management in construction project, tends to be more consistent on their perception rather than those who affirmed the applicability. This research concluded that there are positive responds to the agile approach of project management and most of the project management practices are align with the agile project management.

Keywords: *Agile; project management; construction industry (keywords)*

INTRODUCTION

Every year, there is about US10 trillion in construction-related spending globally, equivalent to 13 percent of the global GDP. This makes construction one of the largest sectors of the world economy. The sector employs 7 percent of the world's working population (Barbosa et al., 2017). However, construction has suffered from remarkably poor productivity relative to other sectors for decades. In contrast, manufacturing's productivity has nearly doubled over the same period, and continuous improvement has been the norm. A variety of factors account for poor productivity and cost outcomes. These problems are serious, systemic, and all too common (Tan and Taib, 2018; Changali et al., 2015):-

- Poor organization - Decision-making and procurement processes do not have the speed and scale required.
- Inadequate communication - Inconsistencies in reporting mean that subcontractors, contractors, and owners do not have a common understanding of how the project is faring at any given time.
- Flawed performance management - Unresolved issues stack up due to lack of communication and accountability.
- Contractual misunderstandings - The procurement team typically negotiates the contract, and this is almost always dense and complicated. When a problem crops up, project managers may not understand how to proceed.

- Missed connections - There are different levels of planning, from high-end preparation to day-by-day programs. Schedulers need to know if a daily work is incomplete, which enables them to update he priorities in real time. Yet, most often than not, they are not informed on this.
- Poor short-term planning - Companies are generally good at understanding what needs to be done in the next two to three months, but not nearly so much at grasping the next week or two. This may result in the necessary equipment not in place.
- Insufficient risk management - Long-term risks get considerable consideration; the kinds that crop up on the job not nearly as much.
- Limited talent management - Companies defer to familiar people and teams rather than asking where they can find the best people for each job.

Construction companies willing to improve their business performance and in achieving sustainable competitive advantage in global markets. Hence, there is a need to look for new management paradigms that lead to real improvement in their business capability. The agile paradigm has values that can enhance the business capability of construction companies (Serrador and Pinto, 2015; Dybå and Dingsøyr, 2008). Agile paradigm is deemed more suitable to uncertainty and changing circumstances than the traditional waterfall approaches (Nakanishi and Komai, 2017). It is claimed that agile paradigm radically improves the success rate of projects. However, very few construction companies are aware of the agile paradigm (Owen and Koskela, 2006).

Agile is an umbrella term for a vast range of methodologies and techniques, sharing the principles and values but differ in their emphases, areas of use and distinctive features (AltexSoft, 2016). There are three most popular forms and the contexts in which each works best. They include scrum, lean development and kanban. Scrum emphasizes creative and adaptive teamwork in solving complex problems; while lean development, focuses on the continual elimination of waste (Kamarudin and Nakanishi, 2017). As for kanban, it concentrates on reducing lead times and the amount of work in process (Rigby et al., 2016).

Little research has been carried out into agile project management in the Malaysian construction industry. Therefore, the main objective of this paper is to explore agile project management in the Malaysian construction industry. This paper is organized by describing the importance of construction industry and agile project management, and the main objective of this research. Followed by a description of agile project management. The research processes and the design of online questionnaire survey will be explained as well. The major findings of the online survey will be presented and discussed, and lastly the conclusions of this study.

LITERATURE REVIEW

In February, 2001, a group of 17 computer gurus, software developers, and managers held a retreat to discuss lightweight software development methods. They formed the *Agile Alliance* and the discussions of their meetings later resulted in a *Manifesto for Agile Software Development*. The Manifesto was authored by Fowler and Highsmith (2001) which was then signed by all participants to establish the basic guidelines for any Agile method. The purpose of *The Agile Manifesto* was laid out as follows (SCRUMstudy, 2017; Fowler and Highsmith, 2001):

> *"We are uncovering better ways of developing software by doing it and helping others do it. Through this work we have come to value:*
> - *Individuals and interactions over processes and tools*
> - *Working software over comprehensive documentation*
> - *Customer collaboration over contract negotiation*
> - *Responding to change over following a plan*
>
> *That is, while there is value in the items on the right, we value the items on the left more."*

The value of agile manifesto embraces the following four features in project management: (1) Individuals and interactions over processes and tools. Although processes and tools help in completing a project successfully, it is the individuals who undertake, participate in, implement a project, and determine which processes and tools to use. The key actors in any project are therefore individuals, hence the emphasis should be on them and their interactions, rather than complicated processes and tools (Layton, 2020a; SCRUMstudy, 2017; Eby, 2016). (2) Working software over comprehensive documentation. While documentation is necessary and useful for projects, many teams focus on collecting and recording qualitative and quantitative descriptions of deliverables, when the real value delivered to the customer is primarily in the form of working software. Therefore, the Agile focus is on delivering working software in increments throughout the product lifecycle rather than detailed documentation (Layton, 2020b; Wagenaar et al., 2018; Fowler and Highsmith, 2001). (3) Customer collaboration over contract negotiation. Traditionally, customers as external players are involved mainly at the start and end of the product lifecycle and the relationships were based on contracts and fulfilment. Agile believes in a shared value approach in which customers are seen as collaborators instead. The development team and customer work together to evolve and develop the product (ProductPlan, 2021; Layton, 2020c; SCRUMstudy, 2017). (4) Responding to change over following a plan. In the current market, customer requirements, available technologies, and business patterns are constantly changing. It is essential to approach product development in an adaptive manner that enables change incorporation and fast product development lifecycles rather than emphasizing on following plans formed with potentially outdated data (ProductPlan, 2021; Layton, 2020d; Fowler and Highsmith, 2001).

The principles of the Agile Manifesto are: (1) Our highest priority is to satisfy the customer through early and continuous delivery of valuable software. Customer satisfaction is crucial to a product's early and ongoing success. This principle emphasizes the importance of a continuous cycle of feedback and improvement. A minimum viable product is released to the market and the response informs future releases (Fowler and Highsmith, 2001; Eby, 2016; Keita, 2020). (2) Welcome changing requirements, even late in development. Agile processes harness change for the customer's competitive advantage. Development teams react to issues and change the product to satisfy customer needs. Strategies and processes may be reconsidered to safeguard the product's quality (SCRUMstudy, 2017; ProductPlan, 2021b; Airfocus, 2021). (3) Deliver working software frequently, from a couple of weeks to a couple of months, with a preference for the shorter timescale. Work on achieving goals on smaller scales, ultimately contributing to the product's overall completion. Teams have tighter structures and more concrete goals to work towards (Alexander, 2018; Keita, 2020; ProductPlan, 2021b). (4) Business people and developers must work together daily throughout the project. Agile principles unify different departments, prioritizing regular collaboration and communication to share information and resources (Fowler and Highsmith, 2001; Eby, 2016; ProductPlan, 2021b). (5) Build projects around motivated individuals, give them the environment and support they need and trust them to get the job done. Appointing the right people with the right skills to the right roles is vital to achieving success with agile principles. They should be trusted to do their job properly, without disruptive micromanagement (Alexander, 2018; ProductPlan, 2021b; airfocus, 2021). (6) The most efficient and effective method of conveying information with and within a development team is face-to-face conversation. This emphasizes the importance of ongoing collaboration and idea-sharing, with daily meetings, sprint planning, demos, and more (SCRUMstudy, 2017; Eby, 2016; Keita, 2020).

The remaining agile principles are: (7) Working software is the primary measure of progress. Development teams work on minimum viable features instead of trying to perfect complete feature sets. Idea testing should be fast, as useful products released now are better than those released a year down the line (Fowler and Highsmith, 2001; Eby, 2016; airfocus, 2021). (8) Agile processes promote sustainable development. The sponsors, developers and users should be able to maintain a constant pace indefinitely. It is vital for product teams to have realistic goals and manageable expectations during sprints. This aids morale and prevents staff from becoming burned out (Alexander, 2018; ProductPlan, 2021b; airfocus, 2021). (9) Continuous attention to technical excellence and good design enhances agility. Products should be reviewed after each iteration to ensure real improvement is taking place (Keita, 2020; ProductPlan, 2021b; airfocus, 2021). (10) Simplicity, the art of maximizing the amount of work not done is essential. Agile is about keeping processes simple and streamlining the entire cycle. Even the most minor distractions or unnecessary tasks can slow progress. Embrace automation tools whenever possible (SCRUMstudy, 2017; Eby, 2016; Keita, 2020). (11) The best architectures, requirements and designs emerge from self-organizing teams. Teams should be autonomous and capable of acting faster, without having to secure permission on every little task (Fowler and Highsmith, 2001; Eby, 2016; Keita, 2020). (12) At regular intervals, the team reflects on how to become more effective, then tunes and adjusts its behaviour accordingly. Teams should be encouraged to reflect on their progress and make changes to the product, rather than moving ahead blindly (Alexander, 2018; Keita, 2020; ProductPlan, 2021b).

A Guide to the Project Management Body of Knowledge (PMBOK® Guide) is PMI's flagship publication and is a fundamental resource for effective project management in any industry. Over the years, business has changed considerably, but projects remain critical drivers of business success (PMI, 2017). PMBOK® Guide is not technically a methodology but rather an industry framework that incorporates best practices in project management. It is often associated with the Waterfall methodology, which aligns project stages in a sequential approach, but it is also compatible with newer methodologies such as Agile. The PMI does not advocate for a particular methodology as the processes of PMBOK® Guide can be tailored to suit a variety of project management situations and managers select what they need for their respective companies (Wrike, 2021). Fifteen construction project management knowledge areas which covers the ten knowledge areas in the PMBOK Guide and the five additional areas in the Construction Extension to the PMBOK Guide, namely integration, scope, schedule, cost, quality, resource, communications, risk, procurement, stakeholder, health, safety, security, environmental, and financial.

According to the 14th Annual State of Agile™ Report by Digital.ai (2020), the benefits of adopting agile practices are ability to manage changing priorities, project visibility, business/IT alignment, delivery speed/time to market, team morale, increased team productivity, project risk reduction, project predictability, software quality, engineering discipline, managing distributed teams, software maintainability, and project cost reduction. Some of the key benefits of using Scrum as one of the agile methods, in any project are adaptability, continuous feedback, continuous improvement, continuous delivery of value, sustainable pace, early delivery of high value, efficient development process, motivation, faster problem resolution, effective deliverables, customer centric, high trust environment, collective ownership, high velocity and innovative environment (SCRUMstudy, 2017). However the results of Scrum Alliance (2016) survey indicated that respondents reported that fulfilling customer satisfaction and improving time to market / reducing cycle time are the most important business priorities for Scrum projects. Then followed by meeting budget, time, and scope constraint, completing projects that will drive innovation and market share, adding new features and functionality, and improved quality.

RESEARCH METHODOLOGY

This preliminary research was based on a survey conducted using an online questionnaire. It was achieved through the following processes:

1) Population and sample of respondents. The data collection exercise were held in Malaysia from July 2020 until the end of December 2020. Stratified random sampling was used for this study as stratified sampling involves the use of stratum or a subset group of the target population wherein the members possess one or more common attributes. A nine-page structured questionnaire was distributed to the four target groups (developers, consultants, contractors and suppliers) through LinkedIn professional networking.

2) Questionnaire Design. This is exploratory research as a questionnaire was designed to explore the feasibility in applying agile project management by the Malaysian construction practitioners. Following a thorough literature search, a total of four (4) agile values, seventy (70) agile practices, fifteen (15) agile knowledge areas, and sixteen (16) agile benefits were consolidated. All these factors were then assembled into a questionnaire that was distributed among three target groups who were connected with the construction industry. The respondents were required to identify, from the list of factors, to what extent they agreed to the appropriateness of the agile project management application in the Malaysian construction industry by responding on a five-point Likert rating scale was 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree and 5 = strongly agree. The survey instrument was divided into 5 sections:-

    - Section A consists of 4 questions about agile values for respondents to rate the inclination for construction project management.
    - Section B comprises 70 questions pertaining to agile practices for respondents to rate the level of agreement based on construction projects completed lately or ongoing construction projects.

- Section C consists of 15 questions for respondents to rate the level of agreement on the construction project management knowledge areas, which agile practices could be applied in.
- Section D contains 16 questions for respondents to rate the level of agreement on the benefits through the application of agile practices in construction projects.
- Section E comprises 7 questions about respondents' demographic information to ensure they are the targeted respondents for the research.

3) Data analysis and interpretation. The collected data were analysed and interpreted using quantitative analysis, which both descriptive and inferential statistics would be used typically to draw generalisation. In 2 or more independent groups, when the dependent variable is ordinal and the independent variable is nominal, the mean values between the groups cannot be compared. However, the medians between the groups can be compared by using median test in SPSS (Subedi, 2016). All the values, practices, knowledge areas and benefits of agile project management are regarded as dependent variables which are ordinal variables. Similarly, application of agile project management in the construction projects is regarded as independent variable with the three groups "yes", "may be", and "no" which is a nominal variable (Berg, 2020). Therefore median test was used as inferential analysis for this study to compare the medians for the three groups to find out if they are different (Glen, 2021).

    - The null hypothesis for this test is that the medians are the same for three groups.
    - The alternate hypothesis for the test is that the medians are different for three groups.

Like most hypothesis tests, the results will include a p-value and an alpha level (usually 5% or 0.05) (Glen, 2021).

- If the p-value is less than or equal to alpha, the medians are different and reject the null hypothesis that they are the same.

Besides this, boxplots were used to support the explanation for the result of median test. Box plots are a useful way to visualize the dispersion or differences among different groups. They manage to provide a lot of statistical information, including medians, ranges, and outliers (McLeod, 2019).

RESULTS AND DISCUSSION

The online questionnaire was sent out to construction practitioners through LinkedIn. Only 152 respondents out of approximately 1000 construction practitioners or 15.2% answered the online questionnaire. Fryrear (2020) mentioned that external survey will generally receive a 10% - 15% response rate on average, and Hill (1998) suggested that 10-30 respondents for pilots in survey research will be sufficient for reporting the findings of the study. Table 1 summaries the respondents' demographics.

Table 1. Respondents' Demographics

Descriptions	Number of Respondents	Percentage
Nature of company business		
Construction business	76	50.0
Construction material, plant & equipment merchant	17	11.2
Consultancy	36	23.7
Property development	23	15.1
Profession		
Architecture	7	4.6
Engineering	31	20.4
Quantity Surveying	58	38.2
Project Management	42	27.6
Interior Design	8	5.3
Others	6	3.9
Construction industry working experience		
Less than 2 years	28	18.4
2 – 5 years	38	25.0
6 – 10 years	40	26.3
11 – 20 years	31	20.4
More than 20 years	15	9.9
Designation		
C-Suite / Chief Executive Officer / Chairman / President / Managing Director	5	3.3
Vice President / Departmental Director / General Manager	7	4.6
Senior Manager / Departmental Senior Manager / Senior Project Manager	21	13.8
Manager / Departmental Manager / Project Manager	40	26.3
Executive / Departmental Executive / Project Executive	67	44.1
Others	12	7.9
Types of projects involved mostly		
Commercial	49	32.2
Industrial	13	8.6
Infrastructure	31	20.4
Residential	45	29.6
Renovation	4	2.6
Others	10	6.6

Hypothesis Test No.1: Values of Agile Project Management

Null hypothesis, Ano: There is no significant difference on agile values (An) between the respondents who agreeing agile project management could be applied in the construction project and those disagree or unsure.

Alternative hypothesis, Ana: There is significant difference on agile values (An) between the respondents who agreeing agile project management could be applied in the construction project and those disagree or unsure.

The following Table 2 indicates that as a whole, the respondents incline towards the agile values with median of 8 for A1, A2 and A4, and A3 at 7.

Table 2. The Median Score and Asymptotic Significance of Agile Values (A_n)

Agile Values (A_n)	Median*	Sig
Communication between clients and teams (A_1)	8	.319
Practical deliverables of a project (A_2)	8	.049
Constant collaboration of clients (A_3)	7	.627
Preparedness for project changes (A_4)	8	.278

Note:
*Linear scale of A_n:
1 = Towards processes and tools; 10 = Towards individuals & interactions
1 = Towards comprehensive documentation; 10 = Towards practical project delivery
1 = Towards contract negotiation; 10 = Towards client collaboration
1 = Following a plan; 10 = Responding to change

The results also indicated there is statistically significant difference between the group who answer 'yes', 'no' or 'may be' to 'agile project management could be applied in the construction project' on comprehensive documentation or practical deliverables of project. The post hoc test was conducted, and it indicated that the only pairwise comparisons show significant results is 'yes-may be' in Table 3. Although the median score and 25th percentile to 75th percentile of 'yes' and 'may be' group are the same (i.e. median=8, 25th percentile = 6, 75th percentile =9) , but the 'yes' group has rated a wider range of 2-10 while the 'may be' group rated 3-10 (Figure 1). This result infers that the 'Yes' group has relatively more differ than 'may be' group in the value of practical deliverables of project.

Table 3. Pairwise Comparison on Agreeing 'Agile Project Management could be Applied in The Construction Project' and 'Practical Deliverables of Project'

Values	Agile could be Applied in The Construction Project	Test Statistic	Sig
Practical Deliverables of Project	Yes - May be	4.625	0.032
	May be – No	0.362	1.000
	Yes – No	1.984	0.477

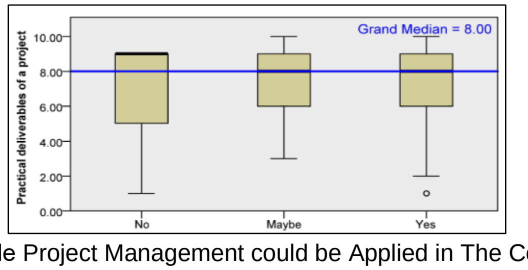

Figure 1. Boxplot of 'Agile Project Management could be Applied in The Construction Project' and 'Practical Deliverables of Project'

Hypothesis Test No.2: Practices of Agile Project Management

Null hypothesis, Pno: There is no significant difference on agile practices (Pn) between the respondents who agreeing agile project management could be applied in the construction project and those disagree or unsure.

Alternative hypothesis, Pna: There is significant difference on agile practices (Pn) between the respondents who agreeing agile project management could be applied in the construction project and those disagree or unsure.

The following Table 4 indicates that as a whole, the respondents incline towards the agile practices with median of 4 for all Pn, except P11 at 3.

Table 4. The Median Score and Asymptotic Significance of Agile Value (P_n)

Agile practices (P_n)	Median*	Sig
Progressive delivery of project (P_1)	4	.141
Early delivery of project (P_2)	4	.282
Work closely with the key stakeholders (P_3)	4	.692
Take advantage of changes (P_4)	4	.104
Support delivery of project (P_5)	4	.166
Support good technical design (P_6)	4	.774
Communicate face to face (P_7)	4	.490
Measure progress of work done (P_8)	4	.042
Maintain project performance (P_9)	4	.097
Practise simplicity (P_{10})	4	.745
Practise autonomy (P_{11})	3	.532
Reflect regularly (P_{12})	4	.840
Supports in getting job done (P_{13})	4	.283
Define deliverables progressively (P_{14})	4	.268
Gain consensus just-in-time (P_{15})	4	.798
Tailor processes on team experience (P_{16})	4	.022
Tailor processes on project characteristics (P_{17})	4	.241
Tailor processes on organizational characteristics (P_{18})	4	.520
Follow sequence of work (P_{19})	4	.247
Limit cycle time (P_{20})	4	.558
Solicit client feedback (P_{21})	4	.141
Prioritize through stakeholders' collaboration (P_{22})	4	.391
Balance both project delivery and risk reduction works (P_{23})	4	.645
Reprioritize requirement to reflect project environment changes (P_{24})	4	.096
Reprioritize requirements to reflect changes on project stakeholder needs (P_{25})	4	.172
Conduct frequent inspections (P_{26})	4	.907
Conduct frequent testing (P_{27})	4	.527
Engage with project stakeholders (P_{28})	4	.640
Share information frequently (P_{29})	4	.203
Sign contract agreement for all project involvement (P_{30})	4	.195
Assess project changes to maintain stakeholder involvement (P_{31})	4	.667
Use collaborative decision making (P_{32})	4	.144
Use collaborative conflict resolution (P_{33})	4	.014
Share project vision (P_{34})	4	.460
Understand project success criteria (P_{35})	4	.326
Transparent in decision making (P_{36})	4	.310
Perform forecast planning (P_{37})	4	.333
Develop ground rules (P_{38})	4	.329
Develop interpersonal skills (P_{39})	4	.708
Develop technical skills (P_{40})	4	.166
Encourage generalized specialists (P_{41})	4	.460
Encourage emergent leadership (P_{42})	4	.403
Understand factors of motivation (P_{43})	4	.723
Communicate via co-location (P_{44})	4	.655
Communicate via collaboration tools (P_{45})	4	.520
Reduce distractions (P_{46})	4	.452

Agile practices (P_n)	**Median***	**Sig**
Measure team performance (P_{47})	4	.572
Plan progressively (P_{48})	4	.204
Make planning transparent (P_{49})	4	.055
Increase commitments progressively (P_{50})	4	.065
Adjust planning on project characteristics (P_{51})	4	.326
Adjust planning on project performance (P_{52})	4	.144
Adjust planning to reflect project conditions changes (P_{53})	4	.380
Size deliverables progressively (P_{54})	4	.391
Adjust project capacity progressively (P_{55})	4	.326
Create rough estimates at the beginning of project (P_{56})	4	.291
Refine estimates progressively (P_{57})	4	.222
Evaluate the estimates for the remaining project work (P_{58})	4	.415
Perform project reviews progressively (P_{59})	4	.117
Seek feedback progressively (P_{60})	4	.683
Seek feedback via site mock-up (P_{61})	4	.559
Create continuous learning project environment (P_{62})	4	.100
Reduce waste (P_{63})	4	.356
Share good practices (P_{64})	4	.066
Share lesson learnt (P_{65})	4	.457
Open to reveal project problems (P_{66})	4	.052
Engage project members in resolving project issues (P_{67})	4	.017
Resolve issues with the assistance from pertinent project members (P_{68})	4	.204
Maintain a visible list of project issues to track ownership (P_{69})	4	.052
Maintain a visible list of project issues to communicate resolution status (P_{70})	4	.196

Note:
*Linear scale of P_n:
1 = Strongly Disagree; 2 = Disagree; 3 = Neutral; 4 = Agree; 5 = Strongly Agree

The results also indicated there is statistically significant difference between the group who answer ‘yes’, ‘no’ or ‘may be’ to ‘agile project management could be applied in the construction project’. The post hoc test was conducted, and it indicated that the only pairwise comparisons show significant results is ‘yes-may be’ for measure progress of work done, tailor processes based on team experience, use collaborative conflict resolution, and engage project member in resolving project issues in Table 5. Although the median score of ‘yes’ and ‘may be’ group is the same (median=4), but from the box plot of measuring progress of work done, found that there is difference between yes-group and may be-group as yes-group has an extreme outliner, 1.00 or strongly disagree. On tailor processes based on team experience, the yes-group rated disagree to strongly agree, while the may be-group rated neutral to agree (Figure 3). It indicates that the yes-group has a wider range of difference compare to the may be-group who is more concurred on their agreement in tailoring processes based on team experience. For collaborative conflict resolution, the yes-group rated disagree to strongly agree, while the may be-group rated agree only (Figure 4). It shows that the yes-group has a wider range of difference compare to the may be-group who is more concurred on their agreement in using collaborative conflict resolution. On engage project members in resolving project issues, the yes-group rated neutral to strongly agree, but the may be-group rated agree only (Figure 5). It shows that the yes-group has a wider range of difference compare to the may be-group who is more concurred on their agreement in engaging project members for resolving project issues.

Table 5. Pairwise Comparison on Agreeing ‘Agile Project Management could be Applied in The Construction Project’ and ‘Measure Progress of Work Done’, ‘Tailor Processes based on Team Experience’, ‘Use Collaborative Conflict Resolution’, ‘Engage Project Member in Resolving Project Issues’

Practices	Agile could be Applied in The Construction Project	Test Statistic	Sig
Measure Progress of Work Done	Yes - May be	5.517	0.019
	May be – No	0.181	0.671
	Yes – No	0.924	0.337
Tailor Processes based on Team Experience	Yes - May be	7.092	0.088
	May be – No	-	-
	Yes – No	0.635	0.426
Use Collaborative Conflict Resolution	Yes - May be	7.924	0.015
	May be – No	-	-
	Yes – No	0.713	0.398
Engage Project Members in Resolving Project Issues	Yes - May be	7.165	0.007
	May be – No	0.181	0.671
	Yes – No	1.110	0.292

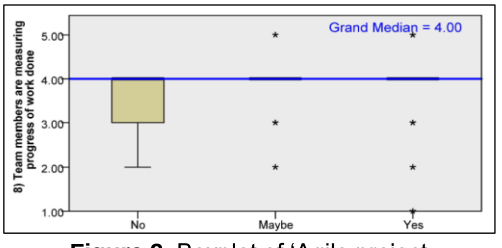

Figure 2. Boxplot of ‘Agile project management could be applied in the construction project’ and ‘Measure progress of work done’

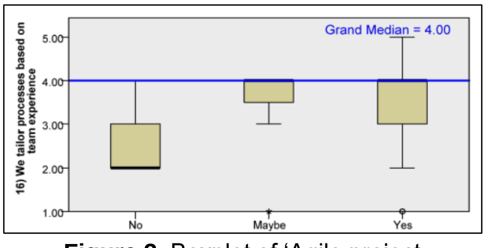

Figure 3. Boxplot of ‘Agile project management could be applied in the construction project’ and ‘Tailor processes based on team experience’

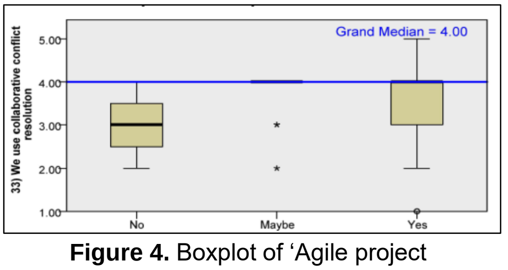

Figure 4. Boxplot of ‘Agile project management could be applied in the construction project’ and ‘Use collaborative conflict resolution’

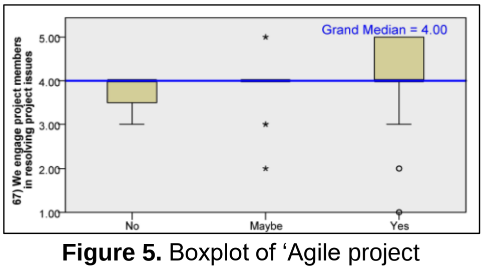

Figure 5. Boxplot of ‘Agile project management could be applied in the construction project’ and ‘Engage project member in resolving project issue’

Hypothesis Test No.3 - Knowledge Areas of Agile Project Management

Null hypothesis, Kno: There is no significant difference on agile knowledge areas (Kn) practiced between the respondents who agreeing agile project management could be applied in the construction project and those disagree or unsure.

Alternative hypothesis, Kna: There is significant difference on agile knowledge areas (Kn) practiced between the respondents who agreeing agile project management could be applied in the construction project and those disagree or unsure.

The following Table 6 indicates that as a whole, the respondents incline towards the agile knowledge areas with median of 4 for K1 to K15.

Table 6. The Median Score and Asymptotic Significance of Agile Knowledge Areas (K_n)

Agile Knowledge Areas (K_n)	Median*	Sig
Project communication management (K_1)	4	.007
Project cost management (K_2)	4	.108
Project environmental management (K_3)	4	.775
Project financial management (K_4)	4	.513
Project health management (K_5)	4	.603
Project integration management (K_6)	4	.117
Project procurement management (K_7)	4	.129
Project quality management (K_8)	4	.373
Project resource management (K_9)	4	.166
Project risk management (K_{10})	4	.457
Project safety management (K_{11})	4	.247
Project schedule management (K_{12})	4	.011
Project scope management (K_{13})	4	.080
Project security management (K_{14})	4	.222
Project stakeholder management (K_{15})	4	.571

Note:
*Linear scale of K_n:
1 = Strongly Disagree; 2 = Disagree; 3 = Neutral; 4 = Agree; 5 = Strongly Agree

The results also indicated there is statistically significant difference between the group who answer ‘yes’, ‘no’ or ‘may be’ to ‘agile project management could be applied in the construction project’. The post hoc test was conducted, and it indicated that the only pairwise comparisons show significant results is ‘yes-may be’ for project communication and schedule management in Table 7. Although the median score of ‘yes’ and ‘may be’ group is the same (median=4), but from the box plot of project communication management, the yes-group rated neutral to strongly agree, while the may be-group rated agree only (Figure 6). It indicates that the yes-group has a wider range of difference compare to the may be-group who is more concurred on their agreement in project communication management. For project schedule management, the yes-group rated neutral to strongly agree, while the may be-group rated agree only (Figure 7). It shows that the yes-group has a wider range of difference compare to the may be-group who is more concurred on their agreement in project schedule management.

Table 7. Pairwise Comparison on Agreeing ‘Agile Project Management could be Applied in The Construction Project’ and ‘Project Communication Management’, ‘Project Schedule Management’

Knowledge Areas	Agile could be Applied in The Construction Project	Test Statistic	Sig
Project Communication Management	Yes - May be	8.572	0.003
	May be – No	0.383	0.536
	Yes – No	1.789	0.181
Project Schedule Management	Yes - May be	7.648	0.006
	May be – No	0.383	0.536
	Yes – No	1.661	0.197

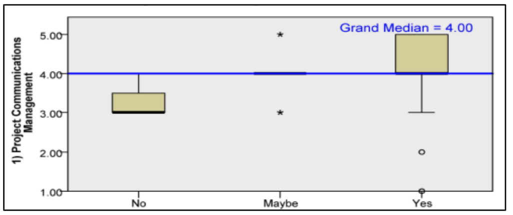

Figure 6. Boxplot of 'Agile Project Management could be Applied in The Construction Project' and 'Project Communication Management'

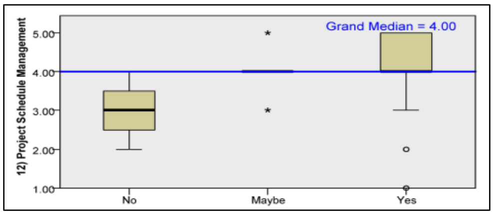

Figure 7. Boxplot of 'Agile Project Management could be Applied in The Construction Project' and 'Project Schedule Management'

Hypothesis Test No.4 - Benefits of Agile Project Management

Null hypothesis, Bno: There is no significant difference on agile benefits (Bn) between the respondents who agreeing agile project management could be applied in the construction project and those disagree or unsure.

Alternative hypothesis, Bna: There is significant difference on agile benefits (Bn) between the respondents who agreeing agile project management could be applied in the construction project and those disagree or unsure.

The following Table 8 indicates that as a whole, the respondents incline towards the agile benefits with median of 4 for B1 to B16.

Table 8. The Median Score and Asymptotic Significance of Agile Benefits (B_n)

Agile Benefits (B_n)	Median*	Sig
Adaptability (B_1)	4	.295
Collective ownership (B_2)	4	.628
Continuous delivery of project value (B_3)	4	.295
Continuous feedback (B_4)	4	.195
Continuous improvement (B_5)	4	.072
Customer centric (B_6)	4	.196
Early delivery of project value (B_7)	4	.166
Effective deliverables (B_8)	4	.009
Efficient development process (B_9)	4	.018
Faster problem resolution (B_{10})	4	.007
High trust environment (B_{11})	4	.052
High velocity (B_{12})	4	.204
Innovative environment (B_{13})	4	.172
Motivation (B_{14})	4	.055
Sustainable pace (B_{15})	4	.044
Transparency (B_{16})	4	.029

Note:
*Linear scale of B_n:
1 = Strongly Disagree; 2 = Disagree; 3 = Neutral; 4 = Agree; 5 = Strongly Agree

The results also indicated there is statistically significant difference between the group who answer 'yes', 'no' or 'may be' to 'agile project management could be applied in the construction project'. The post hoc test was conducted, and it indicated that the only pairwise comparisons show significant results is ‘yes-may be’ for effective deliverables, efficient development process, faster problem resolution, sustainable pace and transparency in Table 9. Although the median score of ‘yes’ and ‘may be’ group is the same (median=4), but from the box plot of effective deliverables, the yes-group rated neutral to strongly agree, while the may be-group rated neutral to agree (Figure 8). It indicates that the yes-group has a wider range of difference compare to the may be-group who is more coincided on their agreement in effective deliverables. On efficient development process, the yes-group rated neutral to strongly agree, while the may be-group rated disagree to strongly agree (Figure 9). It indicates that the may be-group has a wider range of difference compare to the yes-group who is more coincided on their agreement in efficient development process. For faster problem resolution, the yes-group rated neutral to strongly agree, while the may be-group rated agree only (Figure 10). It indicates that the yes-group has a wider range of difference compare to the may be-group who is more coincided on their agreement in faster problem resolution. For sustainable pace, the yes-group rated neutral to strongly agree, while the may be-group rated agree only (Figure 11). It indicates that the yes-group has a wider range of difference compare to the may be-group who is more coincided on their agreement in sustainable pace. For transparency, the yes-group rated neutral to strongly agree, while the may be-group rated neutral to agree (Figure 12). It indicates that the yes-group has a wider range of difference compare to the may be-group who is more coincided on their agreement in transparency.

Table 9. Pairwise Comparison on Agreeing ‘Agile Project Management could be Applied in The Construction Project’ and ‘Effective Deliverables’, ‘Efficient Development Process’, ‘Faster Problem Resolution’, ‘Sustainable Pace’, ‘Transparency’

Benefits	Agile could be Applied in The Construction Project	Test Statistic	Sig
Effective Deliverables	Yes - May be	8.232	0.004
	May be – No	0.279	0.597
	Yes – No	1.481	0.224
Efficient Development Process	Yes - May be	6.903	0.009
	May be – No	0.279	0.597
	Yes – No	1.314	0.252
Faster Problem Resolution	Yes - May be	8.696	0.003
	May be – No	0.279	0.597
	Yes – No	1.539	0.215
Sustainable Pace	Yes - May be	5.272	0.022
	May be – No	0.279	0.597
	Yes – No	1.110	0.292
Transparency	Yes - May be	6.068	0.014
	May be – No	0.279	0.597
	Yes – No	1.210	0.271

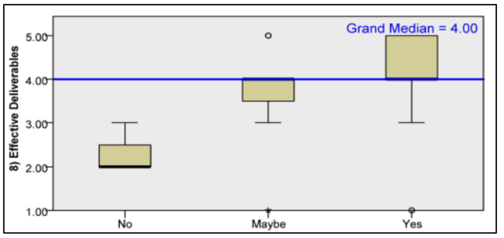

Figure 8. Boxplot of 'Agile project Management could be Applied in The Construction Project' and 'Effective Deliverables'

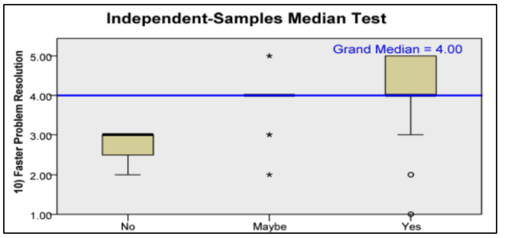

Figure 10. Boxplot of 'Agile Project Management could be Applied in The Construction Project' and 'Faster Problem Resolution'

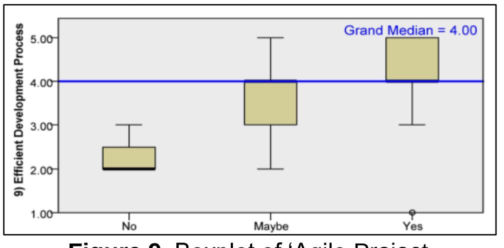

Figure 9. Boxplot of 'Agile Project Management could be Applied in The Construction Project' and 'Efficient Development Process'

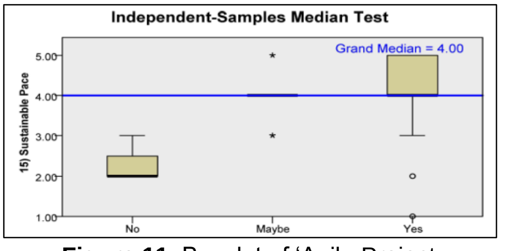

Figure 11. Boxplot of 'Agile Project Management could be Applied in The Construction Project' and 'Sustainable Pace'

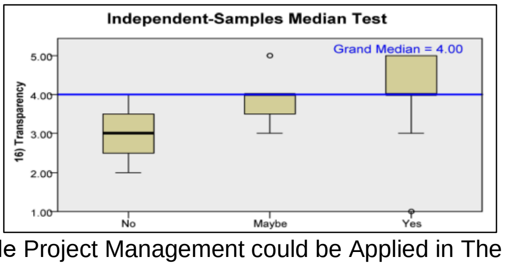

Figure 12. Boxplot of 'Agile Project Management could be Applied in The Construction Project' and 'Transparency'

CONCLUSION

The aim of this preliminary study is to explore the feasibility in applying Agile project management by the construction practitioners. Based on the total 152 returned responses received, four hypothesis tests were conducted. The study has hypothesized four values, 70 practices, 15 knowledge areas and 16 benefits of Agile project management on the success of construction project delivery. The result indicated that all the respondents are inclined towards the agile values of project management. A statistically significant result is found on the group who has yet to decide on the applicability of agile project management in construction project, to be more consistent on their perception than those who affirmed the applicability. Consistently, similar results could be found where the respondents are inclined towards the practices, knowledge areas and benefits of agile project management whereby statistically significant result is found on the group who has yet to decide on the applicability of agile project management in construction project tends to be more consistent on their perception than those who affirmed the applicability. This research concluded that many of the agile practices indeed are already being carry out by the construction industry practitioners, however quite a number of the practitioners are lack of understanding what agile project management is. This is evidenced by the may be-group lack of confidence to answer agile practices can be applied in the construction project management. Therefore the knowledge of agile approach of project management needed to be enhanced in the construction industry.

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ANALYSIS OF MOTIVATION FACTORS ON JOB SATISFACTION AND VOLUNTARY TURNOVER AMONG GENERATION Y QUANTITY SURVEYOR GRADUATES IN MALAYSIAN CONSULTING QUANTITY SURVEYING PRACTICE

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Abstract
Job satisfaction and voluntary turnover were some of the issues among Generation Y employees. These issues were raised by employers because employees from this cohort are crucial in building up the firm and they are the workforce in the upcoming years. There were studies being carried out for motivation factors with regards to these two issues. However, previous literatures had failed to explore in depth in terms of impact level, frequency level as well as prioritization level associated with motivation factors towards job satisfaction and voluntary turnover among Generation Y Quantity Surveyor graduates at Klang Valley. Hence, the ultimate aim of this research was to establish the priority score of motivation factors as well as comparing both intrinsic and extrinsic factors in accordance to Herzberg's Two-Factor Theory of Motivation. This study applied quantitative method through questionnaire and was analysed using content and multi-attribute analysis. Upon data collection, there were approximately 47% response rate for this study. Findings in terms of overall priority score had revealed that extrinsic factors had a greater significant effect towards job satisfaction and voluntary turnover rate among Generation Y Quantity Surveyor graduates in their firms. Hence, employers were recommended to prioritize salary and relations with superior in order to address job dissatisfaction and high voluntary rate.

Keywords: *Voluntary turnover, job satisfaction, motivation, Generation Y, Quantity Surveyors.*

INTRODUCTION

Salary remains at the top ranking for factor of job dissatisfaction (Azizan, 2017). Besides that, it was highlighted in the Labour Force Statistics that younger generation had covered 34% of the total workforce population and approximately 40% of employees would be out from the workforce over the years as they would be reaching the retirement age (Lai & Comeau, 2014). Hence, this demographic shift had come to a realization that the working cultures perceptions of Generation Y employees should be not be overlooked as they would dominate the workforce over the years. For that reason, the stereotype about Generation Y who was inclined to job hop was creating a concern to many employers in many industries because voluntary turnover which more often can be a dysfunctional turnover. Therefore, this study showed a purpose to improve job satisfaction and reduce voluntary turnover rate among Generation Y Quantity Surveyor graduates at Consulting Quantity Surveying Practice in Malaysia. This study had further analysed motivation factors in terms of impact index, frequency index and priority score towards both job satisfaction and voluntary turnover in order for employer to prioritize the motivation factors according to the ranking.

LITERATURE REVIEW

Voluntary turnover among Generation Y Quantity Surveyor graduates was detrimental to the Gross Domestic Product (GDP) of the country as the construction industry contributes an overall of 3% to 6% to the nation economy (Essays UK, November 2018). Besides that, 78% of Malaysian employees had expressed a sense of job dissatisfaction in the JobStreet.com survey (The Malaysian Reserve, 2017). Mahalingam (2013) reported in "The Star" online news article in 2013 that 26.5% of the respondents had ranked salary as the most important source of job satisfaction. Therefore, based on the problems which arose in the recent years, it had led to the significance of carrying out this research whereby motivation factors based on Herzberg's Two-Factor Theory were analysed in order to determine the impact and priority of these factors as well as distinguishing whether intrinsic or extrinsic have a greater effect towards job satisfaction and voluntary turnover among Generation Y Quantity Surveyor graduates. Furthermore, one of the key reason to carry out the study in the context of Generation Y Quantity Surveyor graduate is because previous study conducted by Goh (2018) did not specifically analyse on this population group and also the research sampling was limited to Selangor. Moreover, there was also another study pertaining to employee turnover of quantity surveying firms in the context of Malaysia (Sheikh Ilmi et al., 2019). In Sheikh Ilmi et al. (2019) study, factors of employee turnover among Consultant Quantity Surveyors were analysed and ranked in eight aspects namely salary, employment opportunity, working environment, workload and stress level, benefits, challenges, spouse being transferred to another state as well as opportunity to practice religious beliefs. However, Sheikh Ilmi et al. (2019) did not categorized the aspects into distinctive categories such as intrinsic and extrinsic factors. On top of that, Sheikh Ilmi et al. (2019) study was carried out across Malaysia quantity surveying consultancy. Aside from that, van Eck's (2016) thesis was pertaining to the job satisfaction among Generation Y Quantity Surveyors in South Africa. Thus, it is required to analyse the factors which significantly impact Generation Y Quantity Surveyor graduates in Klang Valley. Therefore, this study aims to present the findings for both aspects which are job satisfaction and voluntary turnover among Generation Y Quantity Surveyor graduates in Consulting Quantity Surveying Practice at Klang Valley.

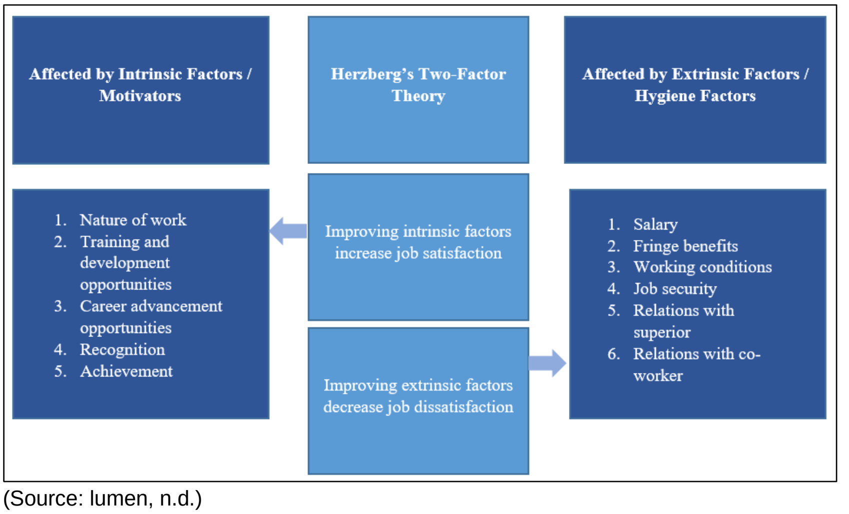
GENERATION Y

Generation Y is also referred as Millennium Generation which covers the largest portion of young adults in the world (Comeau & Lai, 2013). Considering that there were different year ranges of Generation Y being proposed by several authors, this study was conducted based on the year range between 1980s until 1990s. Hence, the criteria for the age group of Generation Y at this present date is between 22 and 41 years. For that reason, Generation Y is the selected respondents instead of Generation Z because Generation Y is currently in the working industry. According to the Department Statistics Third Quarter 2020, Malaysia, there was no exact percentage of the Generation Y population, however, it showed 7.59 million, 22.79 million and 2.32 million for the age group of 0 to 14 years, 15 to 64 years and 65 years and above respectively. Thus, the largest population of 22.79 million for the age group of 15 to 64 years acts as a reference which showed that Generation Y is still the largest population group (Department of Statistics Malaysia, 2020).

QUANTITY SURVEYORS AS THE KEY PLAYERS IN CONSTRUCTION INDUSTRY

The profession as a Quantity Surveyor is governed by Quantity Surveyors Act (Amendment) 2015 as well as regulations promulgated in terms of the Act. As a fresh graduate with a degree in Bachelor of Quantity Surveying which has been recognized by the Board of Quantity Surveyor Malaysia (BQSM) and Royal Institution of Surveyors Malaysia (RISM) shall be entitled on application to be registered as a Provisional Quantity Surveyor. Hence, Professional Quantity Surveyor and Consultant Quantity Surveyor can only be addressed upon going through the BQSM 1st – tier registration and 2nd – tier registration respectively. In short, fresh graduate can pursue to be a Registered Quantity Surveyors in Malaysia by undergoing two years of industrial experience in the quantity surveying firm under the supervision of a Registered Quantity Surveyor and also pass the Professional Competence Test conducted by BQSM. In actual practice, Quantity Surveyors had a significant role in the construction industry because they are involved from feasibility study to pre-contract stage which involved controlling the cost, reviewing the design, analysing the cost implication for the design proposed by design team, preparing Bills of Quantities based on the latest tender drawings issued by design team (Goh, 2018). During tender stage, Quantity Surveyors would prepare pre-tender estimate in advance in order to carry out a comparison with tenderers' submission during tender evaluation. As for post-contract stage, Quantity Surveyors are very involved in monthly site valuation in order to ensure contractor is paid based on work done on site before the recommendation of interim certificate (Van Eck & Burger, 2017) as well as preparing final account.

HERZBERG'S TWO-FACTOR THEORY OF MOTIVATION



(Source: lumen, n.d.)

Figure 1. Herzberg's Two-Factor Theory

Herzberg's Two-Factor Theory of Motivation by Frederick Herzberg in 1959 claimed that intrinsic factors contribute in greater job satisfaction whilst extrinsic factors merely contribute to job dissatisfaction (van Eck, 2016). Upon reviewing previous authors opinions towards Herzberg's 1959 theory, there were many criticisms disagreeing with the traditional concept of Herzberg's theory because Golshan et al. (2011) asserted that job dissatisfaction is not a direct consequence of the deficiency of extrinsic factors as well as can be derived from either intrinsic or extrinsic factors. Aside from the criticism with regards to the theory itself, the theory was criticized in terms of not being relevant to a specific generation (van Eck, 2016). Based on the criticisms, it was notable that Herzberg's theory was not tested in different aspect that is in the context of voluntary turnover.

KEY FINDINGS OF LITERATURE REVIEW

Table 1 and Table 2 shows the key findings from previous authors with regards to motivation factors towards job satisfaction and voluntary turnover.

Table 1. Authors' Findings of Intrinsic Factors Towards Job Satisfaction and Voluntary Turnover

Intrinsic Factors	Job Satisfaction	Voluntary Turnover
Nature of work	Moderate impact between nature of work and job satisfaction among Quantity Surveyors (Jongo et al., 2019).	Nature of work impacted employees' turnover intention in a banking department at Kenya (Chelangat et al., 2018).
Training and development opportunities	A linear relationship between training and development opportunities and job satisfaction at Uganda Management Institute (UMI) (Picho, 2014).	Significant impact between training and development opportunities and turnover intention among healthcare employees in Pakistan (Imran, 2017).
Career advancement opportunities	Job satisfaction is directly impacted by career advancement packages among Research and Development employees (Chen et al.,2004).	Opportunities along a career pathway had an inverse relationship with turnover intention (Weng & McElroy, 2012).
Recognition	Quantity Surveyors in Gauteng province had high preference for recognition as a source of job satisfaction (van Eck, 2016).	Recognition was revealed as the second factor to have an impact on turnover intention (Imran, 2017).
Achievement	Achievement orientated employees would be motivated to commit provided that achievement needs were given by employers (Aloysius, 2012).	Employees who experienced low achievement from the organization would more likely to resign voluntarily (Raza et al., 2015).

Table 2. Authors' Findings of Extrinsic Factors Towards Job Satisfaction and Voluntary Turnover

Extrinsic Factors	Job Satisfaction	Voluntary Turnover
Salary	Wages being less important towards employees' job satisfaction level at Zenith Corporation (Mohd Said et al., 2017).	Study found that 10% increase of base wages causes 1.5% increase in the probability of employees to remain in the organization (Chamberlain, 2017).
Fringe benefits	60% of employees who rated fringe benefits was ranked as the third factor for job satisfaction in 2015 (Society for Human Resource Management, 2016)	Fringe benefits were not limited to health care services (Janzer, 2018). Thus, it creates an added value to an individual's annual salary.
Working conditions	95.2% of Quantity Surveyors agreed that the working environment with a mean score of 4.55 as the key factor affecting job satisfaction (Jongo et al., 2019).	35% of Quantity Surveyors were reported to overwork due to tight deadline and that it was difficult to balance between work and life (Bowen et al., 2013).
Job security	From the perspective of Consultant Quantity Surveyors in Sri Lanka, job security was ranked in third position for influencing job satisfaction (Samarasinghe, 2016).	Job security problem was a prime reason for voluntary turnover (Dwyer, 2012).
Relations with co-worker	67% of employees agreed that respectful treatment by co-workers was very important for their job satisfaction (Society for Human Resource Management, 2016).	Finding showed that bad relations with colleagues can affect turnover intention which was mediated by the level of job satisfaction (Azam et al., 2017).
Relations with superior	Relations with superior is an important factor for employees' job satisfaction (Samarasinghe, 2016).	Lack of supervision or guidance from superior may influence employee to leave the organization (Carter, 2018).

RESEARCH AIM AND OBJECTIVES

Research Aim: To improve job satisfaction and reduce voluntary turnover rate among Generation Y Quantity Surveyors in Malaysian Consulting Quantity Surveying Practice.

Table 3. Research Gaps, Research Question and Research Objectives

No.	Research Gaps From Previous Studies	Research Questions Towards Job Satisfaction and Voluntary Turnover	Research Objectives Towards Job Satisfaction and Voluntary Turnover
1.	Impact level of motivation factors in terms of impact index was not emphasized.	What is the impact level of motivation factors among Generation Y Quantity Surveyor graduates?	To identify the impact level of motivation factors among Generation Y Quantity Surveyor graduates.
2.	Priority level of motivation factors was not determined.	What is the priority score of motivation factors among Generation Y Quantity Surveyor graduates?	To determine the prioritization levels associated with motivation factors among Generation Y Quantity Surveyor graduates.
3.	Motivation factors were not studied in the context of Generation Y Quantity Surveyor graduates in Consultant Quantity Surveying Practice at Klang Valley.	Does extrinsic or intrinsic factors result a greater significant effect among Generation Y Quantity Surveyor graduates?	To establish whether extrinsic or intrinsic motivation factors have more significant effect among Generation Y Quantity Surveyor graduates.

CONCEPTUAL FRAMEWORK

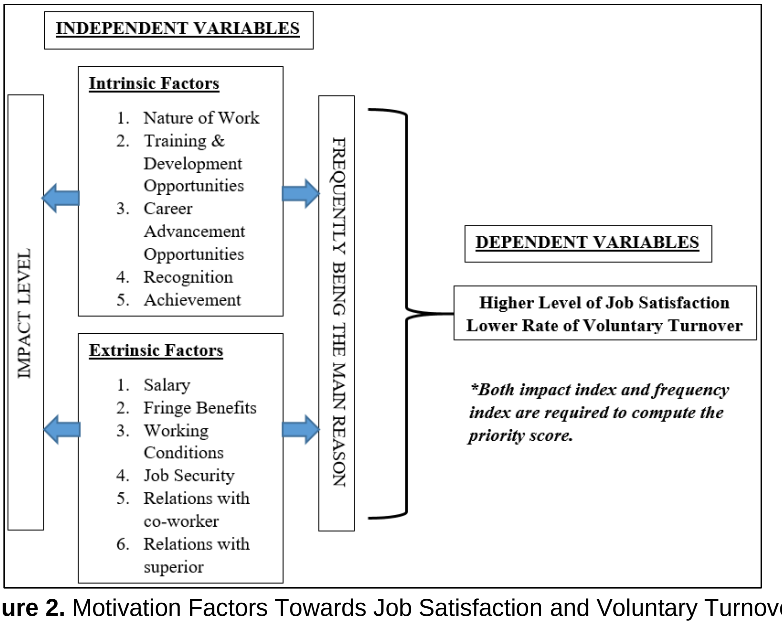


Figure 2. Motivation Factors Towards Job Satisfaction and Voluntary Turnover

The conceptual framework as shown in Figure 2 above illustrates both independent variables comprising of intrinsic and extrinsic factors towards both dependent variables in terms of job satisfaction and voluntary turnover. The independent variables are derived from motivation factors that were opined to have an impact towards both job satisfaction and voluntary turnover among Generation Y Quantity Surveyor graduates in Consulting Quantity Surveying Practice at Klang Valley. Motivation factors were further categorized in terms of intrinsic and extrinsic factors in order to analyse the impact level, frequency level and priority of each sub-factors. By doing so, the study can further justify and confirm whether employers should give more attention to intrinsic or extrinsic factors. The reason being is that the priority score of factors will be dependent on the impact index and frequency index of factors. In short, the higher the impact index and frequency index, the higher the value of the priority score which influence the ranking among the factors.

RESEARCH METHODOLOGY

Generally, the target population were Quantity Surveyor graduates because the research aims to cover all Provisional Quantity Surveyor, Professional Quantity Surveyor, Consultant Quantity Surveyor as well as Quantity Surveyor graduates who were not registered with BQSM. Besides that, the study population was Quantity Surveyor graduates who were working in Consulting Quantity Surveying Practice at Klang Valley. Also, the sampling population had focused on Generation Y Quantity Surveyor graduates. Therefore, quantitative method was used in order to get a greater response from Quantity Surveyor graduates, specifically Generation Y who were working in Consulting Quantity Surveying Practice at Klang Valley. For instance, convenience sampling was utilised to enhance the collected data from random sampling. Generally, majority of the questionnaire were responded by Quantity Surveyor graduates. According to the Board of Quantity Surveyors Malaysia official website in 2020, there were a total population of 243 quantity surveying consultancy firm in Klang Valley, however, this number did not reflect the total population of Generation Y Quantity Surveyor graduates in Consultant Quantity Surveying Practice at Klang Valley. The sampling size computed to be 149 upon inputting the necessary data in the sampling size formula as shown below.

$$S = \frac{X^2NP(1-P)}{d^2(N-1) + X^2P\,(1-P)}$$

where:

- S = Sampling size
- X^2 = Table value of chi square for one degree of freedom at the desired confidence level (3.841)
- N = Population size
- P = Population proportion (assumed as 0.50 to provide maximum sample size)
- D = Degree of accuracy expressed as a proportion of 0.05

The questionnaires were distributed to the employees in the form of Google Form through email. These respondents would answer the structured questions based on the five-point Likert scale in order to record and measure the Impact Index (II) and Frequency Index (FI). As for data analysis, content analysis and multi-attribute analytical technique were used to analyse the respondents' rating based on the formulas shown in Figure 3.

Mean Rating of Impact and Frequency (Impact Index or Frequency Index)

$$MR_t = \sum_{k=1}^{5}(R_{ptk} \times \%R_{tk})$$

MR_t = Mean Rating for attribute t

R_{ptk} = Rating point k (ranging from 1-5)

$R_{tk\%}$ = Percentage responses to rating point k, for attribute t

Priority Score

$$PS_i = II_i \times FI_i$$

II_i = Impact Index of the criterion

FI_i = Frequency Index of the criterion

Relative Impact Index or Relative Frequency Index

**RFI also applied the same formula as shown below*

$$RII_i = \frac{M_i}{\sum_{i=1}^{N} M_i}$$

Overall Priority Score

$$OPS = \frac{\sum_{i=1}^{N} PS_i}{N}$$

$N\ (denominator)$ = Number of factors involved in the subset

Figure 3. Formulas for Data Analysis

KEY FINDINGS AND DISCUSSION OF INTRINSIC FACTORS IN RELATION TO RESEARCH OBJECTIVE 1 AND 2

Based on the collected data, there were approximately 47% response rate out of the sampling size of 149. Table 4 shows the results of five intrinsic factors towards two aspects which are job satisfaction and voluntary turnover based on content and multi-attribute analysis.

Table 4. Results of Intrinsic Factors Towards Job Satisfaction and Voluntary Turnover

	Intrinsic Factors	Impact Index		Frequency Index		Priority Score		Priority Ranking	
		JS	VT	JS	VT	JS	VT	JS	VT
1	Nature of work	4.029	3.800	4.014	3.686	16.172	14.006	1	3
2	Training and development opportunities	3.786	3.543	3.743	3.443	14.169	12.198	5	5
3	Career advancement opportunities	3.986	3.957	3.957	3.914	15.772	15.498	3	1
4	Recognition	3.886	3.729	3.843	3.686	14.932	13.742	4	4
5	Achievement	4.029	3.857	4.014	3.786	16.172	14.602	1	2

Discussion of Intrinsic Factors Towards Job Satisfaction

Based on the Table 4, the priority ranking was similar to impact ranking upon taking into account of the frequency index. Nature of work was seen to be in the top impact ranking was in accordance to Samarasinghe's (2016) study whereby job content has a significant relationship towards job satisfaction among employees. Achievement being in the top for both impact and priority ranking had lent credence to Aloysius's (2012) findings because achievement needs were demanded by higher achiever employees as compared to lower achiever employees. Third impact and priority ranking was also career advancement opportunities which had further supported Chen et al. (2004) finding who only discussed this factor to have an impact on research and development employees' job satisfaction level. The finding of 31% of Generation Y who consented that this factor being in the top five factors in choosing an employment by Hays plc. and Cullens (2013) was in line with the current finding.

Discussion of Intrinsic Factors Towards Voluntary Turnover

On the subject of voluntary turnover, the top intrinsic factors in terms of impact and priority ranking were similar as in the context of job satisfaction but the sequence seemed to be different because career advancement opportunities was ranked first, then followed by achievement and third in ranking was nature of work. Career advancement opportunities were seen as the top in the impact and priority ranking. In terms of impact, it was in consistence with Weng and McElroy (2012) who revealed that career pathway that was promised by the organization had lower the rate of turnover intention. Second priority ranking was achievement which had substantiated Raza et al. (2015) who had found a relationship between achievement motivation and voluntary turnover but did not analysed in terms of priority. Nature of work being in the third ranking showed that this factor had different level of impact towards voluntary turnover. Anyhow, this factor which had a higher impact as compared to training and development opportunities and recognition had showed agreement with Chelangat et al. (2018) who established that nature of work had impacted lower turnover intention among employees in banking department at Kenya.

DISCUSSION OF EXTRINSIC FACTORS IN RELATION TO RESEARCH OBJECTIVE 1 AND 2

Table 5 shows the results of six extrinsic factors towards two aspects which are job satisfaction and voluntary turnover based on content and multi-attribute analysis.

Table 5. Results of Extrinsic Factors Towards Job Satisfaction and Voluntary Turnover

	Extrinsic Factors	Impact Index		Frequency Index		Priority Score		Priority Ranking	
		JS	VT	JS	VT	JS	VT	JS	VT
1	Salary	4.129	4.143	4.071	4.143	16.809	17.163	2	1
2	Fringe benefits	3.986	3.986	3.971	3.829	15.829	152.26	4	3
3	Working conditions	3.943	3.914	3.929	3.814	15.490	14.930	5	4
4	Job security	3.814	3.857	3.857	3.743	14.712	14.437	6	6
5	Relations with co-worker	4.114	3.929	3.986	3.786	16.398	14.872	3	5
6	Relations with superior	4.214	4.200	4.114	3.943	17.339	16.560	1	2

Discussion of Extrinsic Factors Towards Job Satisfaction

Both impact and priority ranking for extrinsic factors were similar upon taking into consideration of frequency index. Relations with superior was regarded to be the first seemed to corroborate with Samarasinghe (2016) research who pointed out that this factor was important for employees' job satisfaction level especially when employees were treated democratically by superior. Having said that salary had highly impact on job satisfaction among respondents, however, Mohd Said et al. (2017) had found salary to have lower impact on job satisfaction among property developer. Acknowledging that relations with co-worker was only in the third leading factor in terms of impact and priority, the results had accorded with the report from Society of Human Resource Management (2016) whereby 67% of workers agreed that this factor is significant to increase job satisfaction.

Discussion of Extrinsic Factors Towards Voluntary Turnover

The top three extrinsic factors in the context of impact and priority ranking for voluntary turnover were different with job satisfaction because it seemed that fringe benefits were being prioritized greatly as compared to relations with co-worker in the decision making of leaving a quantity surveying firm. Relations with superior being the top impact on voluntary turnover was in accordance to the earlier finding of Carter (2018) who claimed that insufficient supervision had a greater cause to voluntary turnover. Salary being the second impact ranking for Generation Y Quantity Surveyor graduates had further confirmed the results of Chamberlain (2017) whereby 10% increment in salary causes 1.5% increase in employee retention. On top of that, salary as the top priority in the context of voluntary turnover had verified Carter (2018) discussion pertaining to salary being an effective source of lowering the turnover rate among employees. Despite that fringe benefits were viewed to be lower in priority as compared to salary and relations with superior, however, this factor is helpful in retaining employees as it is an added value for the employees because it was no longer confined to health insurance (Janzer, 2018).

DISCUSSION OF MOTIVATION FACTORS IN RELATION TO RESEARCH OBJECTIVE 3

Table 6. Overall Priority Score of Motivation Factors on Job Satisfaction and Voluntary Turnover

	Motivation Factors On Job Satisfaction		**Motivation Factors On Voluntary Turnover**	
Independent Variables	Overall Priority Score	Remark	Overall Priority Score	Remark
Intrinsic factors	15.443	High	14.007	Moderate
Extrinsic factors	19.315	High	15.537	High

According to the Table 6 with regards to the significant effect of motivation factors towards job satisfaction, it was obvious that extrinsic factors had scored a higher overall priority score as compared to intrinsic factors. This implied that extrinsic factors had a greater effect on respondents' job satisfaction level in the context of priority. Hence, finding had supported Ringer and Garma (2006) as cited by Tan and Yusoff (2012) finding which mentioned that Millennials employees were more favourable towards extrinsic factors as compared to older generation. In the case of voluntary turnover, it was apparent that extrinsic factors were more likely to be considered or prioritized based on the overall priority score which was remarked as high in overall as compared to overall priority score of intrinsic factors were in the moderate category. This had addressed that intrinsic factors had a smaller effect on voluntary turnover as compared to the effect on job satisfaction among Generation Y Quantity Surveyor graduates in Consulting Quantity Surveying Practice at Klang Valley.

CONCLUSION

As a whole, extrinsic factors had the greatest impact towards both aspects that include job satisfaction and voluntary turnover among Generation Y Quantity Surveyors in Consulting Quantity Surveying Practice because extrinsic factors scored higher for priority score in total as compared to intrinsic factors. Not to mention, intrinsic factors which were merely being remarked as moderate for priority score had proven that extrinsic factors had a greater significant effect towards voluntary turnover among respondents in the area of

Klang Valley. Having said that both intrinsic and extrinsic factors should not be overlooked by management or employer, they should give more emphasis for extrinsic factors.

The findings from this study had provided insights for further research. It was recommended for future researcher to utilize qualitative method by carrying out interview for the purpose of comparing their opinions with the quantitative results that were discussed. Apart from that, future studies had to be pursued in order to determine whether the top three motivation factors were applicable to the entire country of Malaysia. Future researcher could also study in depth with regards to the approach to be implemented and how would employer address the salary and relations with superior in the organization in order to improve the job satisfaction level and reduce the voluntary turnover rate among Generation Y Quantity Surveyor graduates in Consulting Quantity Surveying Practice. Furthermore, future study can be carried out in the context of Generation Y Quantity Surveyor graduates who are in the contractor firm since their scope of work is different, hence, their perspectives may vary with this study.

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EMPLOYABILITY OF QUANTITY SURVEYING STUDENTS IN MALAYSIA: PERCEPTIONS OF EMPLOYERS AND STUDENTS

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Abstract
Quantity Surveyor is in high demand in the construction industry in this rapidly growing era, but the question of quantity surveyor graduate's unemployment still persists. The diversity of employment opportunities leads to the need of Quantity Surveyors being equipped with employability skills in order to stand a chance in the current competitive industry. This research paper seeks to identify the challenges faced by graduates, analyze the disparities between education and employability skills required by the employer and establish practical solutions for Quantity Surveyor students. This research paper have adopted a survey methodology in which questionnaires are send to students and employers to determine the perceptions of both the concept of employability. The feedbacks are collected and analyzed in order to find out practical solutions that can be applied to improve employability of Quantity Surveyor graduates in the construction sector. It was concluded that an effort must be made between the two parties to overcome the divide. Employability capabilities will therefore be defined to reduce unemployment soon.

Keywords: *Graduate's unemployment; challenges; employability skills; practical solutions; Quantity Surveying students; employers.*

INTRODUCTION

Construction industry development in Malaysia has been on the rise over the last decade (Ibrahim, Roy, Ahmed, & Imtiaz, 2010). This leads to significant growth in student education in construction careers, especially in Quantity Surveying (Cartlidge, 2002). As this career is highly demanded, more and more people have enrolled in this undergraduate. Nevertheless, more students also indicated more fresh graduates which lead to a highly competitive market.

The scope of work of a Quantity Surveyor has diversified. Demand of Quantity Surveyor has been high as construction works have increased in volume and complexity over the past decades (Chong, 2014). Notwithstanding this, students struggled in the real working world to secure a position (Robinson, 2019). The concern about student' unemployment has been highlighted. However, the current education line does not necessarily produce students that meet the private sector's requirements (Organisation for Economic Co-operation and Develop, 2003). Such capability gap has resulted in a rising number of unemployed fresh graduates. Students of Quantity Surveyor must therefore equip themselves with numerous excellent qualifications and competences.

Students entering the real world of work in this 21st century are expected not only to be employable, but also to maintain their employability by keep on updating their skills and knowledge in order to catch up the new trends in the construction industry (Mbachu & Phipps, 2013). It is a waste of talent if they were not discovered by related firms. To archive Malaysia Wawasan 2020, labours must be completely utilized in this competitive industry.

Through improving knowledge and skills, this can be achieved. According to Hasmawati and Johan (2006), students must adapt to changing work patterns. We are living in a rapidly evolving environment, we must adapt ourselves to the changes learn more skills continuously.

According to Chartered Institute of Building (2009), it highlighted the problem where there is a shortage of skills in the construction industry due to the industry's shortage of hires. There are a large number of students graduated from different university every year, but the issue of students who failed to secure a place in this high demanded work field, however, still exists. Many employers believe that the main factors are because there is a mismatch between student's skills and market requirements (Lowden, Hall, Elliot, & Lewin, 2011). Students from institutions have struggled to develop market-compliant knowledge and skills (Sani, 2019). According to Jayamathan and Rameezdeen (2006), skill is essential in determining future success and growth of professions. Competency, on the other hand, is an action, behaviour and outcome where an individual can demonstrate in the field of work (Holmes, 2011). It proves that skills should come along with competencies and can be improved with personal qualities. Therefore, employers mainly target those with good degree level, transferable skills and personal attributes while recruiting employees due to competitive nature in the industry.

There is a great concern in the number of students entering the industry. In Malaysia, Omar and Rajoo (2016) conducted a research on the rate of unemployment among students, noting that the unemployment rates among graduates is directly linked to the economics of developing country. According to Bank Negara Malaysia, it was estimated that the youth unemployment rate in Malaysia hit 10.7% in 2015, which is more than three times the national unemployment rate of 3.1%. In addition, among the overall unemployed labours, there is 6.7% of graduates are reported as unemployed. For the sake of the economy, the issue of unemployment should be adequately addressed to investigate on why undergraduates are not being hired. Many believe that graduate candidates pursued by organizations are those equipped with, for example, communication skills, not only academic skills, but also different skills and competencies (Shafie, Khuzzan, & Mohyin, 2014). Students must have element of soft skills to measure abilities in communication, critical thinking, problem solving, team player and leadership qualities (Shafie, Khuzzan, & Mohyin, 2014). However, former education does not teach the acceptance of soft skills. In accordance with Carol et al. (2011), Malaysia acknowledges the high importance of English but most of the students from Malaysia's universities face challenges in speaking, writing, reading, and listening in the English language for job-related tasks at the workplace. According to Wei S. L (2011), there are 50 private companies in Selangor and Perak recruitment of employees depends on their command of fluent in English language. Therefore, students nowadays should master their soft skills as they are a key employable ability.

Additionally, employers prefer applicants with more work experience compared to those highly qualified or technically experienced fresh graduates (Omar & Rajoo, 2016). Employers' perceptions in favour of experienced applicant have culminated in unemployed fresh graduates (Kaur, 2017). This situation causes many of the students graduated from university do not have the opportunities to try out as many employers say that they will not bear the risk of failure due to the lack of experience of students (Pearl, 2004). Employers believe that experienced workers do not have to undergo extra trainings and courses because they are already equipped with required skills and knowledge which help reduces the cost borne by the employer (Marsh & Flanagan, 2000). However, such action by most of the employers indirectly caused negative losses to the country as it is a waste of talent if the skilled labours in our country are not fully utilized (Kaur, 2017). Furthermore, the perception of fresh graduates asking for salaries and scope of work was inaccurate. We see that there are many fresh graduates with degree or higher qualifications, but they also start from a low-level salary (Shen & Li, 2003). Therefore, students should not only choose the salary because in the future the experience gained is more significant.

PROBLEM STATEMENT

The construction industry is always changing and evolving. There is a significant change in Quantity Surveyor positions to suit the growing construction industry (Ochieng, 2016). Therefore, employers will turn head to students who possess better skills and competencies.

Chartered Institute of Building (2009) highlighted the demand for Quantity Surveyor is high but unemployment issue still exist. It is believe that there is a mismatch between student's skills and market requirements (Lowden, Hall, Elliot, & Lewin, 2011). Students from institutions have struggled to develop market-compliant knowledge and skills (Sani, 2019).

Bank Negara Malaysia (2015) stated that youth unemployment rate hit 10.7%, which is more than three times the national unemployment rate of 3.1%. Among the overall unemployed labours, there is 6.7% of graduates are unemployed. It is believe that graduate candidates pursued by organizations are those not only equipped with academic skills but also different skills and competencies (Shafie, Khuzzan, & Mohyin, 2014). However, former education does not teach the acceptance of skills.

The lack of industrial training provided by institutions does not allow students to take on industry challenges (Ashworth, 2008). This situation causes the work quality of the students after graduated cannot meet the requirement set by outside (Darus, 2009). The competitiveness of this students is poor compared to other institutions that offering industrial training (Omar & Rajoo, 2016).

Also, employers favour of experienced applicant have culminated in unemployed fresh graduates (Kaur, 2017). It causes fresh graduates do not have the opportunities to try out as many employers don't want to bear the risk of failure due to lack of experience (Pearl, 2004).

It is apparent that ignorance of these vital skills and challenges has hampered student's employability (Karunasena, Niroshan, & Perera, 2015). As result, this paper aims at analyse the required employability skills and establish practical solutions in order to reduce unemployment rate of students of Quantity Surveyor in Malaysia.

RESEARCH OBJECTIVE AND DESIGN

Table 1. Table of Research Objective and Design

Research Objectives	Types of Data	Source of Data	Method of Collection
1. Identify the challenges faced by Quantity Surveyor graduates in the current construction industry.	List out all the challenges faced by Quantity Surveyor graduates in the current construction industry.	Journal Dissertation Internet Articles	Questionnaires Reading Document analysis
2. Analyse the disparities between the quality of education and the employability skills required by the employer.	List out the disparities between the quality of education and the employability skills required by the employer.	Journal Dissertation Internet Articles	Questionnaires Reading Document analysis
3. Establish practical solutions for Quantity Surveyor students to address the expectations of employer.	List out practical solutions for Quantity Surveyor students to address the expectations of employer.	Journal Dissertation Internet Articles	Questionnaires Reading Document analysis

LITERATURE REVIEW

Challenges Faced by Graduate

After several findings, the following challenges are the top significant challenges that the graduates of Quantity Surveyor faced in the current construction industry.

Table 2. Challenges Faced by Quantity Surveyor Graduate

Challenges	Issues
Severe Fee Competition	Market competitiveness has compelled Quantity Surveyors to make reduced unreasonable fee offers (Cruywagen & Snyman, 2006).
Professional Indemnity Insurance (PII)	Insurance premiums have risen over the past few years from 100% to 800% for Quantity Surveying companies (Johnson & Dracoulis, 2007).
Technology Advancement	Software such as BIM and CAD become a major threat to Quantity Surveyor's technical role (Smith, 2004).
Conservatism	Quantity surveying profession is more conventional than others profession in terms of Information Technology (Marsh and Flanagan, 2000).
Competition from others professions	Competition from other professions that offer significantly similar services that focused on construction and property-based services (Frei, 2009).
Poor Marketing	QS was poorly represented, and the piece-meal approaches have not been of any great benefit to the profession (Low & Kok, 1997).
Opinion on quality of Graduates	Employers dissatisfied with the graduate's performance in the workplace (Andrews & Derbyshire, 1993).
Lack of interest from school leavers	Declining level of interest in the profession uncovered by school leavers (Lay, 1998).
Basic Functions	Architect was not pleased with the Quantity Surveyor's services which include estimating, variation and finalising accounts (Hiew & Ng, 2007).
Management of Contract	Lack of knowledge on procurement and management of contract (Davies & Watson, 2007).

Employer's Requirements

In order to identify employer's expectation on fresh graduates, several studies are identified to conclude the exact employability skills, competencies and soft skills that employers required.

Table 3. Employability Skills, Competencies and Soft Skills that Employers Required

Requirements	Descriptions
	Employability Skills (Bhanugopan & Fish, 2009)
Business Skills	Time management, written, listen, communication, leadership, problem solving, organizational capability.
Technical Skills	Quality & project management, resource planning, cost-benefit analysis, spread sheet applications, word processing.
Personal Attributes	Intelligent, extrovert, rational, confident, flexible, cautious, creative, controversial, responsible, aggressive, motivated.
	Competencies (RICS, 1998)
Basic	Personal & interpersonal skills, business & professional practice, law, measurement, mapping, data, information technology.
Core	Construction contract practice, technology services, economics of construction, procurement & financial management.
Optional	Development appraisal, dispute resolution, project & facilities management, insolvency, valuation.
	Soft Skills (Archer & Davidson, 2008)
Soft Skills	Communication, critical thinking, problem solving, lifelong learning, teamwork, entrepreneurial skills, moral, professional ethics.

Practical Solutions

Academics involved in such professional programmes have to counter-balance the demands of employers with the need to achieve broader educational aims that will prepare students for not just the immediate work-entry years but for a life-long career with suitable skills that will allow students to adapt to changing work practices and market-skills needs. Hence, the following practical solutions for Quantity Surveyor student from several researches are proposed in order to address the expectation of employer.

Table 4. Practical Solutions to Address Expectations of Employer

Solutions	Descriptions
Maintain and Develop Professional Expertise in Core Competencies	To have enough professional knowledge in the profession's core competencies and continue to improve these abilities (Smith, 2004).
Resources/ Invest in Necessary Technology	To be developed, trained and displayed so that full flexibility exists to enable QS to perform well in workplace (Odeyinka & Doherty, 2008).
Continuing Professional Development (CPD), Education, Training, Research and Mentorship	The true continuity of the practitioner's education and learning to help and improve their clinical practice (RICS, 1998).
Stay Competency through Practical	Gain competencies by established practical methods, such as go through Work Shadow, Foster Firm schemes, Year Out Period and Realistic Work Experience (Nkado & Meyer, 2001).
Strategies for Developing Student Attributes	Focus on tasks and events that were of real-life significance or were in any way authentic such as group assignment or having business connection (Zou, 2005).
Partnering Employers and Universities to Enhance Employability	Raise awareness, provide visibility, and increase graduate's employability. It operate hand-in-hand with employers and tertiary education, primarily with the goal of preparing students for jobs (Omar & Rajoo, 2016).
Improve Soft Skills	Increase their awareness on the value of soft skills and the implications of deficiencies in this respect. A formal approach to the issue will be to integrate soft skills subjects into the curriculum of a programme (Schulz, 2008).

The concepts of employability have changed from interest drove specialized abilities to a broader perspective of graduate attributes which incorporate non-exclusive, transversal, transferable, delicate skills and fundamental abilities, connected to subject-specific knowledge and skills (Yusof & Jamaluddin, 2015). Employability is not just about the fundamental advancement in education and employment. It is additionally grounded in having an inquiring mind and a passion for lifelong learning, something that is demonstrable in many meanings of employability (Yeo, 2018).

Students' academic qualification is not only the product of choosing their employability, but also the ability of the students to convey specific skills such as leadership, management, subject knowledge, problem solving and business sharpness. Moreover, effective communication, demonstrating initiative and efficiency, and vitally the part of state of mind and individual attributes in the push to achieve wanted employment. Metacognition and efficacious beliefs about one's personal identity and self-worth also form part of the components (Knight & Yorke, 2004).

RESEARCH METHODOLOGY

Data Collection Method

Quantitative approach is deployed in this study as it suitable for gathering mass information that needed in a short period. The data collected is in numerical form and can be measured and analysed statistically. There are two methods to deliver questionnaire either personal delivery or by post (Ndukwu, 2020). In this study, postal questionnaire has been chosen. Combination of closed-ended and open-ended questionnaire has been used in the research study for the collection of data.

The target for this research study will be narrowed down to the consultants Quantity Surveyors in the construction industry and final year students of Quantity Surveying in the private university around Klang Valley. 2 questionnaires were prepared to Students and Employer to collect their perceptions and opinions. Both questionnaires were designed into three sections to be distributed out to the public, which are the general information of respondent, employability skills of students and practical solution for students to improve their performance.

Data Analysis Method

Frequency Analysis

Frequency analysis is applied when there is large amount of data, thus dividing them into categories or classes (Stephanie, 2011). The data that retrieved from the responses of respondents can be presented in various type of form such as tabulation, bar chart, pie chart or graph. The formula below shown how the percentage of frequency is calculated:

$$\text{Percentage (\%)} = (n/N) \times 100\%$$

n = frequency of respondents
N = total number of respondents

Relative Importance Index Analysis

Relative Importance Index (RII) analysis was used to rank the parameters by their relative importance (Gunduz, Nielsen, & Ozdemir, 2013). The respondents will be required to answer the question through likert scale from 1 to 5 (1 as “strongly disagree” while 5 as “strongly agree”). The formula is shown as follows:

$$\text{RII} = \frac{\sum W}{A * N}$$

W = Weighting stated by the respondents and ranging from 1 to 5
A = The highest weight (i.e. 5 in this case)
N = Total number of respondents

Questionnaire survey method was adopted for this research study. Questionnaire method requires each participant to respond to the same set of questions in a pre-determined order thereby providing uniformity and the responses collected can be considered to be objective (Pahwa, 2019). Moreover, by remaining anonymous the respondents are more inclined to provide honest responses. In this research, 2 different questionnaires were prepare to Students and Employer to collect their perceptions and opinions. Both questionnaires were designed into three sections to be distributed out to the public. All questions were design in structured so that a logical result of the quantitative analysis can be generated.

Besides, both questionnaires for this research consists of 3 sections which are the general information of respondent, employability skills of students and practical solution for students to improve their performance.

In first section, the student’s questionnaire has been designed to collect the information of the respondents which includes the respondent’s gender, ages, way of seeking employment, challenges in employment and perception on their tertiary education and chances of finding a job. Employer’s questionnaire has been designed to collect the information of their name of organization, their position in the organization, years of working experience in the company, highest level of education, perception on fresh graduates.

The second section is related to the employability skills of students in perception of students and employers. Statement basis and Likert Scale method have been used in both questionnaires. For employer’s questionnaire, respondents are asked to satisfy or not satisfy with the graduates and also important or not important on the skills of the graduates. For student’s questionnaire, respondents are asked to agree or disagree on the statement stated. In Likert Scale method, in the example level of agreement, it was leveled as strongly agree, agree, neutral, disagree and strongly disagree (Stephanie, 2015).

The last section will be questions for opinions and solutions from the respondents on the ways to improve the employability of Quantity Surveying students in Malaysia. Likert Scale method is used in this section to collect the perceptions of students and employer on practical solutions that has been proposed to address the expectation of the employer.

Finally, last question is designed as the open-ended question to allow the respondent to speak out their suggestions. There is no right and wrong answer for this type of question.

RESEARCH FRAMEWORK

The research framework defines the research method adopted to attain the results needed to fulfill the objectives of this study. The research strategies, design and process, sample frame and size as well as method of data collection are included in this research framework.

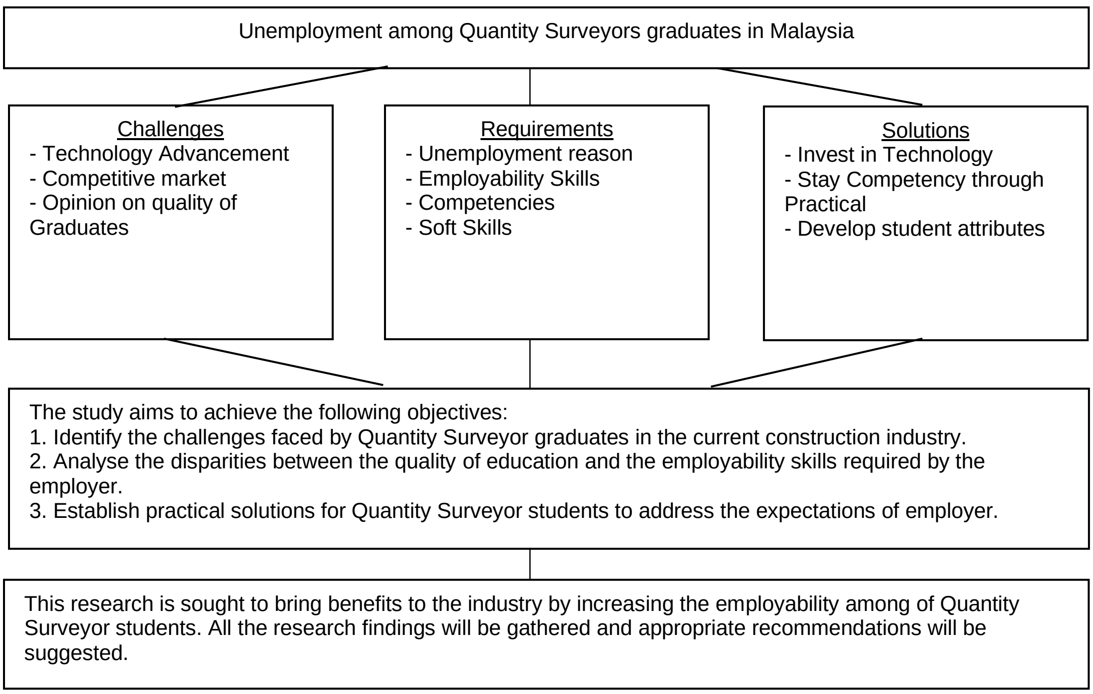

Figure 1. Research Framework

DISCUSSION & KEY FINDINGS

Student Questionnaire Analysis

Background of Respondent

The sampling size of the BQS final year students from private university in Klang Valley is 186 respondents. A total of 137 responses were recorded which is a response rate of 74%. A few of question are asked to identify the student’s challenges in work life, the result is show as below Table 5.

Table 5. Student's Feedback

Questions	Results	Reference
Do you think the knowledge and skills you gained at university prepare you for professional work life?	59% - NO 41% - YES	Aligned to research done by Yeo (2018), stated that students nowadays felt insecure in employment.
Do you think your university was providing effective career guidance?	62% - NO 38% - YES	Aligned to research done by Xavier (2015), stated that students didn't maximuse resources they had to hunt a job.
What is your biggest challenge in employment?	37% - lack of contemporary skill 35% - lack of working experience 16% - lack of soft skill 12% - lack of technical skill	Aligned to research done by Nagarajan (2011), stated that students always felt they lack of competencies and working experiences thus they felt they were not competitive enough to compete with another.

Employability Skills

Basic employability skills rating were prepared for the respondents, respondents thus had to rate themselves to evaluate whether they had those skills or not. From this information, respondent's current standard and skills level will be analysed to examine whether the quality of the students today were able to meet employer's expectation or not, the result is show as below Table 6.

Table 6. Student's Employability Skills

What Attributes and Skills do you have?	
Extensive practical knowledge	40 respondents have it.
Computer literate	100 respondents have it.
Able to update professional knowledge	70 respondents have it.
Reading skills	130 respondents have it.
Listening skills	128 respondents have it.
Communication skills	119 respondents have it.
Written skills	121 respondents have it.
Gather and interpret information	74 respondents have it.
Define and solve problems	73 respondents have it.
Adaptable and flexible to cope with changing work environment	59 respondents have it.
Work autonomously	120 respondents have it.
Work cooperatively as a team member	125 respondents have it.
Be creative and accept responsibility	81 respondents have it.
Work ethic and Accountability	57 respondents have it.
Exercise professional judgement	41 respondents have it.
Do you feel you developed most of these attributes and skills at the university level?	61% - NO 39% - YES

Most of the respondent felt they had enough skills level in Reading, Listening, Communication, Written, Work Autonomously and Work Cooperatively As A Team Member, which is aligned to the research done by Griffin and Annulis (2013), stated that students nowadays were believed to have enough skill level in these relevant skills.

Next, Computer Literate, Update Professional Knowledge, Gather And Interpret Information, Define And Solve Problems and Creative And Responsibility were the skills that respondent felt there were improvements that still can be made, aligned to the research done by Holmes (2011), stated that the school should appoint a professional to share their experience and apply knowledge to help the students.

Also, Extensive Practical Knowledge, Adaptable And Flexible To Cope With Changing Work Environment, Work Ethic And Accountability and Exercise Professional Judgement, respondents stated that they were lacking of these variable skills. This result matches the researcher's theory that students does not have enough real-working experience practice in their education, the universities were advised to provide more real practices so the students able to act and perform in the future workplace (Knight & Yorke, 2004).

Lastly, it deduced that 61% of them does not feel they developed all these employability skills at the university, aligned to the research done by Smith (2004) stated that students felt these skills only can be learn in workplace.

Practical Solutions

Respondents were asked to rate some of the practical solutions for Quantity Surveying students proposal, result is show as below Table 7.

Table 7. RII of Practical Solutions for Quantity Surveying Students

Practical Solution	Remark	RII	Rank
Education must emphasise on student's soft skills.	Strongly Agree	0.966	1
Maintain and develop Professional expertise in core competencies	Strongly Agree	0.917	7
Resources/ Invest in necessary technology to train the students	Strongly Agree	0.942	2
Continuing Professional Development (CPD), education, training, research and mentorship	Strongly Agree	0.926	6
Stay competency through practical	Strongly Agree	0.927	5
Strategies for developing student attributes	Strongly Agree	0.933	3
Partnering employers and universities to enhance employability	Strongly Agree	0.928	4

The solution that has the highest RII is Education Must Emphasis On Student's Soft Skills with the RII of 0.966. This result is aligned with the research done by Omar and Rajoo (2016) where they agreed the education should emphasis putting soft skills practice into teaching process. Next, Resources/Invest In Necessary Technology To Train The Students ranked at second with RII of 0.942, matched with the resulted done by Grant (2004), stated that students must be developed and trained so they can perform in using these technologies for the future workplace. Strategies For Developing Student Attributes is the third ranked with the RII of 0.933, Zou (2005) believed that student's attributes need to be improved to prepare them for the workplace.

Partnering Employers And Universities To Enhance Employability is the fourth ranked with the RII of 0.928. Omar and Rajoo (2016) indicated that this method able to let students understand employer's expectation, therefore cooperation between the parties is a must to produce quality students. Stay Competency Through Practical is the fifth ranked with RII of

0.927 which aligned with the research done by Simpson (1996), stated that Realistic Work Experience, Role Play and Problem-based practice enable the students to think outside the box and is a good way to gain relevant competencies.

Continuing Professional Development (CPD), Education, Training, Research And Mentorship is the sixth ranked with the RII of 0.926. Darus (2009) said that this practice is a common practice to produce high-quality workforce performance. Lastly, Maintain And Develop Professional Expertise In Core Competencies has the RII of 0.917. Smith (2004) stated that it is important to make sure students have enough professional knowledge in the profession's core competencies and they have to keep improving these abilities as well so they were always be updated and able to work in different environments.

Employer Questionnaire Analysis

Background of Respondent

The sampling size of the consultant quantity surveying firm in Klang Valley is 105 respondents. A total of 52 responses were received which is a response rate of 49.5%. A few of questions have been asked regarding the graduates they employ and their on-the-job performance, the result is show as below Table 8.

Table 8. Employer's Feedback

Questions	Results	Reference
Does your organisation actively recruit graduates?	54% - NO 46% - YES	Aligned to research done by Smith (2004), stated that employers prefer experienced employees.
Do you think graduates you employ are well equipped for the workplace?	52% - NO 48% - YES	Aligned to research done by Smith (2004), stated that employers don't give much chances to students.
Is your company involved in any collaborative activities with higher education?	54% - NO 46% - YES	Aligned to research done by Shen and Li (2003), stated that most of the companies does not collaborate with education
Do you think the abilities that newly graduates have match your expectations?	54% - NO 46% - YES	Aligned to research done by Frei (2009), stated that employers were dissatisfied with the students they employ.

Employability Skills

Employer respondents were asked to rate their satisfaction on the graduate's employability skills nowadays. From this information, employer's satisfaction and expectation will be known to minimize the gap between student's abilities and employer's expectation in order to improve employability skills of students.

Most of the employers slightly satisfied with the student's ability to Working In A Team, Numeracy Skills, Proficiency In Different Language, Written Communication Skills, Computer Literacy, Technical Ability and Ability To Handle Large Amounts Of New Information, aligned to the research done by Bhanugopan and Fish (2009), highlighted that these different types of employability skills were mainly the skills sought by different employer but student's nowadays does not maximise these skill during their tertiary education.

Table 9. RII of Satisfaction on Student's Employability Skills

Practical Solution	Remark	RII	Rank
Prior work experience	Neutral	0.677	9
Knowing the organization	Neutral	0.669	11
Ability to interpret given tasks	Neutral	0.688	8
Ability to find and access new information	Neutral	0.677	9
Ability to handle large amounts of new information	Slightly Satisfied	0.708	7
Proficiency in different language	Slightly Satisfied	0.723	3
Working in a team	Slightly Satisfied	0.735	1
Social networking skills	Neutral	0.596	13
Oral presentation skills	Neutral	0.665	12
Written communication skills	Slightly Satisfied	0.719	4
Numeracy skills	Slightly Satisfied	0.731	2
Computer literacy	Slightly Satisfied	0.712	5
Technical ability	Slightly Satisfied	0.712	5

Following to the Neutral category, Ability To Interpret Given Tasks, Prior Work Experience, Ability To Find And Access Information, Knowing The Organisation, Oral Presentation Skills and Social Networking Skills. These skills were interrelating with each other as some employers found out that some of the students were introvert, shy and timid which cause the students not able to mix around and join the culture of the company. Lack of confidence in speaking weaken the student's social network skills and oral skill (Omar & Rajoo, 2016).

Practical Solutions

Employer respondents were asked to rate some of the practical solutions for Quantity Surveying student's proposal, result is show as below Table 10.

Table 10. RII of Practical Solutions for Quantity Surveying Students

Practical Solution	Remark	RII	Rank
Education must emphasise on student's soft skills	Strongly Agree	0.965	1
Maintain and develop Professional expertise in core competencies	Strongly Agree	0.919	7
Resources/ Invest in necessary technology to train the students	Strongly Agree	0.927	6
Continuing Professional Development (CPD), education, training, research and mentorship	Strongly Agree	0.954	2
Stay competency through practical	Strongly Agree	0.954	2
Strategies for developing student attributes	Strongly Agree	0.942	4
Partnering employers and universities to enhance employability	Strongly Agree	0.935	5

From the result shown, Education Must Emphasise On Student's Soft Skills has the highest RII of 0.965. Ministry of Higher Education (2006) stated that employer will be hired students who have variety of soft skills such as communication, entrepreneurial, moral and more. Continuing Professional Development (CPD), Education, Training, Research and Mentorship and Stay Competency Through Practical ranked at second with the RII of 0.954.

This result is in line with Nkado and Meyer (2001) where they stated that there is a competencebased evaluation of professional quantity surveying to ensure the quantity surveyors giving excellent service. Strategies For Developing Student Attributes ranked at fourth with the RII of 0.942 which is aligned to the research done by Zou (2005) where most of the employers suggested that education should give more practical practice to develop the attributes of the students.

Next, Partnering Employers And University To Enhance Employability ranked at fifth with the RII of 0.935, which is aligned to the research done by Omar and Rajoo (2016), stated that employers want the education offer a program that is seek to accomplish raise awareness, provide visibility and improve employability to prepare students for works. Resources/ Invest in Necessary Technology ranked at sixth with the RII of 0.927, This result is in line with Simpson (1996) where this skill is one of the skills that has been most emphasised by the employers.

Lastly, seventh ranked is Maintain And Develop Professional Expertise In Core Competencies with the RII of 0.919 which matched the research done by Hasmawati and Johan where they stated that employability is not just to get a job but he or she must respond and always updated themselves by develop their professional so they won't get eliminated in the future.

Summary of Additional Suggestions Collected from Open-End Question

Table 11 below is a summary table of additional suggestions that has been collected from respondents in the open-end question. Results is show as below and all these suggestions are aligned and supported by few researches, these suggestions are believed to be helpful in improving the education framework.

Table 11. Summary of Additional Suggestions for Quantity Surveying Students

No.	Summary of Additional Suggestions	Reference
1	Increase and extend the duration of practical industrial training to students of Quantity Surveying	Aligned to the research done by Davies and Watson (2007)
2	Education must communicate with employers to find out their wants and expectation every year	Aligned to the research done by Verster (2004)
3	All parties have to help the school design courses, programmes and services to support students move from university to workplace.	Aligned to the research done by Holmes (2011)
4	Provide tasks that allow students to exhibit their managerial skills, encourage community practices which will increase productivity and function in teams.	Aligned to the research done by Robinson (2019)
5	Have site visit and trip to introduce students to the industry style and standards out there.	Aligned to the research done by Cruywagen and Snyman (2006)
6	University should offer student enrol in technical classes or workshops for technical and business communications.	Aligned to the research done by Babbie (2010)

CONCLUSION

This research study has been set out to investigate employability of Quantity Surveying students in the perceptions of employers and final year private university students around Klang Valley.

Confusion arises as employability is not just about getting a job, but also being able to work in that job in a very long time. Students claim they have been able to cope with the challenges of the workplace over time, while employers expected that they would be capable of fresh and able to meet their expectation after they graduated. It was recommended to take out more of such research to understand the problem in a broader perspective and for better solutions and recommendations.

In conclusion, findings in the research carried out that there is a correlation between students, education and employers. When analysing the results, practical training was found not to be a topic implemented in the Quantity Surveying course in the school. Nevertheless, students felt that the duration of the practical training was not enough. This results that students were not easy to seek jobs from companies where practical work could be undertaken. It leads to research opportunities in finding ways to add realistic training to the education program, as well as working with different companies to ensure it approach works. This will improve student's employability and graduateness. With a better-quality workforce performance from the students, construction industry will become a successful sector in order to achieve the plan of Vision 2020.

RECOMMENDATION

The research study has been conducted on identify the challenges of graduates and analyse the gap between the students, education and employer. The purpose of this research is to improve student's employability that can meet employer's expectation. However, there will be further improvements for this study in future as stated below:

1. The location can increase to whole of Malaysia instead of in Klang Valley.
2. To perform the same research on public university, whether or not in Klang Valley only.

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A STUDY OF CRITICAL SUCCESS FACTORS FOR BIM-FM IMPLEMENTATION AMONG FACILITY MANAGERS IN MALAYSIA

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Abstract
Due to the fragmented nature of the construction industry, there are important communication gaps occurring between the project phases and among the various stakeholders. After construction, the building owner does not just obtain a new building, but also a wide range of information in paper and electronic form. Often, Facility Management (FM) Service providers face problems due to the difference between the FM contract amount awarded and the final cost of the service by the end of the contract period. The facilities management information system (FMIS) could be optimized through the integration of Building Information Modelling (BIM) data into Computer-Aided Facilities Management (CAFM) software which is referred to as BIM-FM Implementation. Thus, the numerous advantages of BIM could increase the quality and productivity of the FM-teams. The objectives of this research are to study the critical success factor for BIM-FM system implementation among FM service-providing companies in Malaysia and to find evidence about the level of efficiency in terms of performance of the BIM-FM system. Quantitative data analysis is used to calculate the level of effectiveness for each critical success factor which contributes to the overall efficiency of the system performance. This study shows that the level of the overall efficiency of the BIM-FM system in Malaysia is at the "*adequate*" level. Evaluation of the relationship between each success factor in terms of strength and influence on the overall efficiency of system performance shows the usefulness of manual has the strongest influence and stability is the weakest factor to the overall performance. The findings of this study guide different stakeholders to enhance the effectiveness of BIM-FM implementation in Malaysia.

Keywords: *Building Information Modelling (BIM); Computer-Aided Facilities Management (CAFM); Facility Management (FM).*

INTRODUCTION

Due to the fragmented nature of the construction industry, there are important communication gaps occurring between the project phases and among the various stakeholders such as architects, engineers, surveyors, contractors, sub-contractors, facility operators, and asset managers. During the operation and maintenance phase of the project, these gaps are much more evident. By completing the project, the building owner does not obtain just a new building, but also a wide range of information and data in paper and electronic form. According to Khoshnevis (2004), information technology has influenced the construction industry, but it has brought only partial benefits from the advantage of innovation and digital technology to the construction industry.

As Aziz (2016) articulated, Computer-Aided Facilities Management (CAFM) still relies on conventional methods based on tabulated data in a spreadsheet and two dimensional (2D) drawings. By adopting a three-dimensional (3D) capability and the advantage of the integration of Building Information Modelling (BIM) into CAFM, the way of facilities management information system (FMIS) will be optimized. BIM influences construction projects on the common way of collaboration including all the stakeholders who involve in construction projects from the pre-contract stage up to the post-construction stage (Yii et al., 2019). As Gnanarednam, & Jayaseba (2013) acknowledged, Maintenance Management is more about data and managing information rather than engineering. Sufficient, adequate, and proper information is the pre-request for any maintenance work.

CAFM is the tool in order to reach this objective. Managing a wide range of information through a spreadsheet is very difficult and it will not be efficient without utilizing CAFM. According to Subki and Mahzir (2019), Building Information Modelling can enhance the performance of the building during the operation phase.

The aim of this research is to enhance the effectiveness of BIM-FM implementation in Malaysia. The objectives of this research are to study the critical success factor for BIM-FM system implementation among FM service-providing companies in Malaysia and to find evidence about the level of efficiency in terms of performance of the BIM-FM system.

LITERATURE REVIEW

BIM has an enriched capability to improve the various process of operation and maintenance management during the whole life cycle (Motamedi et al., 2018). BIM and Facility Management (FM) are modernizing the way built environment behave and they are changing the construction industry efficiently and effectively (Mehala Gnanarednam & Jayaseba, 2013). An in-depth discussion of main trends in this domain will identify the current status of BIM-FM implementation, key success factors, and research gaps.

Computer-Aided Facilities Management (CAFM) and 7D-BIM

As the US National Building Information Model Standard Project Committee defines, "*Building Information Modeling (BIM) is a digital representation of physical and functional characteristics of a facility. A BIM is a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle; defined as existing from earliest conception to demolition*". Application of BIM brings better, faster, more coordinated, and more accurate information and project experience.

BIM involves the construction of a model that contains information about a building from all phases of the building life cycle (ISO 16757-1: 2015). As the American Institute of Architects (2008) defines, Building Information Modelling (BIM) is a model-based technology consisting of project information data. It's a digital and data-rich representation of the building which contains building information as an approach to store and convey the data. The application of BIM brings better and faster coordination to a project (Tang et al, 2019).

7D-BIM is a data-enrich model that contains all information on the project life cycle. 7D BIM model is usually delivered to the building owner, operation manager, or facility manager as an as-built model. The as-built model is being used by the Facility Manager to be integrated into CAFM (Montiel-Santiago et al, 2020).

Montiel-Santiago (2020) explained a 7D-BIM Model or as-built model delivered to a Facility Manager can be integrated into CAFM solutions to have more efficient data management and FM works.

According to TabsCAFM (2020), CAFM solutions are consisting of the following modular:

- Maintenance Systems (CMMS)
- Resource Booking Systems
- Health and Safety Systems
- Finance Systems
- Support Systems

In order to utilize models for operation use, they are evaluated and validated based on a few key criteria. According to AREO (2016), the most important items are: Correct geolocation information and data, all BIM models including architectural, structural, mechanical, electrical, and plumbing (MEP) models must be aligned correctly in 3D-space, follow the BIM Execution Plan (BEP) for type naming, space naming, and equipment naming, being able to identify the location of equipment, all doors and windows must be in association with their location, all building elements, spaces, and component need be classified according to BEP or building owner's requirement and to check if adequate properties have been used.

Critical Success Factor for BIM-FM Implementation

According to Mehdipoor (2018), the majority of building professionals in Malaysia are aware of the importance of BIM during the operation and maintenance stage. Easy and fast access to building data for emergency purposes is the most important success factor for BIM-FM Implementation (Mehdipoor, 2018). Analysis of previous studies of critical success factors in the literature shows that the most frequent factors are: Top management commitment and support, training, and education, change management, and product information sharing (Misron et al., 2018). Key success factors for BIM-FM (also referred to as BIM-enabled CAFM) in employer's information requirements categorized into the following key topics: FM or Client-oriented EIR, guidance on the use of EIR and BIM Guideline, Implementation of existing BIM standards, Level of definition (LOD), BIM visualization and understanding of the model and Asset data (Ashworth et al., 2018). These factors are interpreted to the usefulness of the manual of the BIM-FM solution as one of the important success factor shown in Table 4.

Implementation of Defect Management is one of the key modules of the BIM-FM procedure. Hashim (2018) identified eight key factors that have significant contributions in this domain such as coordination, compliance, training, work procedure, best practice, top management support, technical skill, competency, and monitoring.

METHODOLOGY

The research questionnaire was sent to the organizations consisting of facility management (FM) companies and various organizations that have FM departments. The scope of the sample group is limited to the organization with In-house FM service and FM consultant companies in Malaysia. Sample of this research selected from the Malaysian Association of Facilities Management (MAFM) database. In order to generate accurate and most reliable information and data, the only relevant professions were asked to participate in the survey. Respondents selected their predetermined job title which best described their job function i.e. Director or Head of FM, Operation /Manager, Office Manager, Business Development, Senior FM, Regional or Multi-site FM, Single site FM, or Facilities Assistant. Any job position not related to FM service was excluded. The questionnaire was developed using Survey Monkey. The purpose was to collect data on each factor's importance through a questionnaire in order to capture their assessments of the verified factors. In this step, a scoring system (1: Poor, 2: Ineffective, 3: Adequate, 4: Effective, 5: Very effective) was implemented to compute the importance of each factor. The scoring system was in line with the statistical data analysis method used in this research.

Statistical Data Analysis consisting of Pearson's correlation technique and Univariate Analysis of Variance (ANOVA) deployed to analyze the relationship between the importance of each factor. Statistical techniques are considered as the main tools for data analysis in research, but multivariate techniques have a common limitation i.e. each technique can be used to only investigate one relationship at a time (Hair et al, 2006). To achieve the objective of this research, several methods of statistical analysis have been deployed.

To set up the hypotheses tests for this study, Pearson product-moment correlation and Univariate Analysis of Variance (ANOVA) were implemented. Analysis of Variance (ANOVA) is often used as the best statistical technique where there is an approach to compare the group of cases for differences in their mean. According to Field (2009), ANOVA is a statistical technique when two or more population means are significantly different from each other (Field, 2009). The testing was deployed to evaluate the BIM-FM system implementation success perceived by different groups. The effect to each group implementing the BIM-FM was tested using one-way ANOVA which is the method of choice when there is a need to do testing for differences between multiple groups. Data gathered from the questionnaire analyzed by the Statistical Package for Social Sciences (SPSS). The main aim of using the ANOVA statistical technique is to avoid using a single criterion for implementation success measurement. The respondents were asked to evaluate the level of BIM-FM effectiveness for the validated construct based on Five-point Likert Scale, where one symbolizes (poor), two (ineffective), three (adequate), four (effective), and five (very effective). By using ANOVA-One Factor data analysis the variance within the groups of respondents and between groups of respondents are evaluated to determine if there is any difference between different types of BIM-FM system (also referred to as BIM-enabled CAFM) shown in Table 1&2.

In order to measure the extent to which two variables are associated with a single summarizing measure, there are several statistical techniques. A correlation coefficient is often referred to as such a measure of relationship which is to reflect the strength and the direction of the association between the variables including the degree that one variable can be predicted from the other variable (Nachmias 2008). As Nachmais (2008) articulated, "It ranges from +1 to -1. A correlation of +1 means that there is a perfect positive linear relationship between variables, a correlation of -1 means that there is a perfect negative linear relationship between variables, and finally, a correlation of 0 means that there is no relationship between variables.

The final step in the relationship analysis procedure is to use the data to examine if there is any significant correlation between the importance levels of factors. Pearson correlation analysis is deemed the most appropriate method to achieve this objective as correlation analysis tests whether a relationship exists between two variables" (Nachmias, 2008).

DATA ANALYSIS

Status of BIM-FM System Implementation

For this research, 300 questionnaires were distributed, and 81 valid responses were collected, therefore the percentage of responses is considered as 27%. The respondents are categorized into three groups in terms of the status of implementation of the BIM-FM system in their organization as presented in Table 1. According to the results, almost half of the respondents are yet to implement the BIM-FM system into their organization, and they prefer to use conventional methods such as spreadsheets rather than implement any BIM-FM solution. Data analysis shows a quarter of the respondents started implementing third-party commercial BIM-FM systems in their organization (25%) and 19% of the respondents indicated using their own customized/bespoke system.

Table 1. Respondent's Group Scheme

Group	Status	Percentage
G1	Already started implementing our own customized/bespoke system	19%
G2	Already started implementing third party commercial system	25%
G3	Not using any BIM-FM system	56%

Respondents in G1 and G2 were asked to determine the type of BIM-FM system used by their organization. As shown in table 2, 31% of the respondents were using a customized or bespoke system, while the rest were using third party commercial system such as TOMMS System (37%) and FM:System (32%).

Table 2. Type of System

Group of Respondents	Type of System	Percentage
T1	Customized/Bespoke system	31%
T2 (a)	TOMMS System	37%
T2 (b)	FM:System	32%

BIM-FM System Critical Success Factor for Performance Efficiency

In order to examine the effectiveness of the BIM-FM system in terms of performance, the respondents were asked to rate the efficiency of each critical success factor on a scale of five i.e. Poor (1), Ineffective (2), Adequate (3), Effective (4), and Very effective (5) in Table 3.

Table 3. Scale of Efficiency

1	2	3	4	5
Poor	Ineffective	Adequate	Effective	Very Effective

According to the literature review and previous studies on the critical success factor in this domain such as Ashworth's factors (2018) related to BIM guideline and Implementation of existing BIM standard which interpreted to the factor of usefulness of the manual, and Mehdipoor's factors (2018) regarding easy and fast access to building data which led to factors of speed and stability; the total 14 factors of stability, speed, online help, support by manufacture during installation, support by manufacture during operation, support by the manufacturer for further development, usefulness of the manual, user-friendliness of the overall system, functionality of the overall system, user acceptance, support of FM-processes in daily business, feasibility of individual customization, reporting of existing data, and assessment of cost-value ratio were defined to be rated according to the user's satisfaction in order to calculate the mean of overall efficiency. The results of the survey do produce a remarkable statement in terms of the overall system efficiency as per figure 1. The user-friendliness of the overall system and functionality of the overall system factor ranked as very effective. Pearson's Correlations analysis was implemented in order to determine the relationship between the efficiency of BIM-FM implementation success factors based on the null hypothesis (H0) and the alternative hypothesis (H1).

Null hypothesis (H0): There is no association between the efficiency level of each CAFM implementation factor and the extent to which the overall CAFM system efficiency has been implemented. This null hypothesis is evaluated against the alternative hypothesis.

Alternative hypothesis (H1): There is an association between the efficiency level of each BIM-FM implementation success factor and the extent to which the overall BIM-FM system efficiency has been implemented.

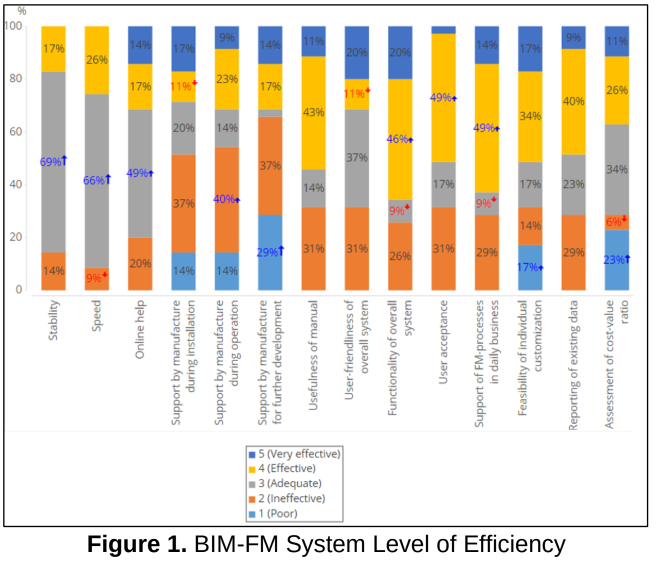

Figure 1. BIM-FM System Level of Efficiency

According to the used methodology, a correlation is significant at 0.05.
DV. 5-Point Scale, 1 score indicates poor and 5 scores indicate very effective.
IV. 5-Point Scale, 1 score indicates poor and 5 scores indicate very effective.

Overall Implementation success factor: 3.12,
Overall Efficiency level is considered as Adequate based on Table 3.

P-value for all 14 factors is less than 0.05 which means the Null Hypotheses test (H0) is rejected therefore there is a relation between the efficiency level of each factor and the overall efficiency of the system.

In order to evaluate the relationship in terms of strength between each success factor such as stability, speed, online help, etc, regression analysis is deployed to calculate the Multiple R-value.

Multiple R ranges from -1 to +1, and this indicates the strength of the relationship between the variables as per table 4. For this study, fourteen constructs as the independent variables (iv) are evaluated against dependent variables (dv) as the overall efficiency of the BIM-FM system.

Table 4. Success Factor

Success Factor	Means	N	*r*	*p*
Stability	3.02	35	0.46	<0.05
Speed	3.17	35	0.62	<0.05
Online help	3.25	35	0.76	<0.05
Support by manufacture during installation	2.80	35	0.61	<0.05
Support by manufacture during operation	2.71	35	0.68	<0.05
Support by manufacture for further development	2.51	35	0.81	<0.05
Usefulness of manual	3.34	35	0.82	<0.05
User-friendliness of overall system	3.20	35	0.79	<0.05
Functionality of overall system	3.60	35	0.82	<0.05
User acceptance	3.22	35	0.63	<0.05
Support of FM-processes in daily business	3.48	35	0.78	<0.05
Feasibility of individual customization	3.20	35	0.85	<0.05
Reporting of existing data	3.28	35	0.68	<0.05
Assessment of cost-value ratio	2.97	35	0.81	<0.05

Table 5. Scale of Relation

-1	-0.7	-0.5	-0.3	0	0.3	0.5	0.7	1
Very Strong	Strong	Medium	Weak	Null	Weak	Medium	Strong	Very Strong

Table 6. Level of Relation

Success Factor	*r*	Level
Stability	0.46	W
Speed	0.62	M
Online help	0.76	S
Support by manufacture during installation	0.61	M
Support by manufacture during operation	0.68	M
Support by manufacture for further development	0.81	S
Usefulness of manual	0.82	S
User-friendliness of overall system	0.79	S
Functionality of overall system	0.82	S
User acceptance	0.63	M
Support of FM-processes in daily business	0.78	S
Feasibility of individual customization	0.85	S
Reporting of existing data	0.68	M
Assessment of cost-value ratio	0.81	S

According to table 6, the minimum r factor for iv is calculated as 0.46 which is for stability and it is considered as the 'weak' relation with dv for overall importance. The maximum r factor calculated as 0.83 for iv as the usefulness of the manual and considered as the 'strong' relation with dv which is overall importance.

ANOVA-One Factor testing was deployed to evaluate the BIM-FM implementation success perceived by different respondent groups.

Hypothesis test:
Is there any variation in overall BIM-FM implementation success between the two groups of organization scheme format (T1 and T2)?

Null hypothesis (H0):
The Mean values of BIM-FM implementation success are the same across two groups of organization scheme grouping. This null hypothesis is evaluated against the alternative hypothesis.

Alternative hypothesis (H1):
The Mean values of BIM-FM implementation success vary across two groups of organization scheme grouping.

Table 7. ANOVA Summary Out-put

Group	T1	T2
Mean	3.08	3.14
Std. Dev	0.23	0.95
N	11	24

ANOVA: Single Factor

Groups	*Count*	*Sum*	*Average*	*Variance*
T1	11	33.92	3.08	0.05
T2	24	75.57	3.14	0.91

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P value*	*F crit*
Between Groups	0.03	1	0.03	0.04	0.82	4.13
Within Groups	21.66	33	0.65			
Total	21.69	34				

F crit (1,33) = 4.13 and P-value is significant at 0.05.

F is less than F crit (0.047 < 4.13) and also P-value is more than 0.05 (0.82 > 0.05), therefore the null hypothesis is accepted, which means there is no variance in the Overall Implementation success between the two groups of the organization, either by using customized/ bespoke system or third-party commercial system. Selection of BIM-FM solution depends on the nature of the project as well as the client's budget, therefore a user could decide to request for the development of a customized system or deploy a third-party commercial solution that has been used by others in the market and the cost of purchase or subscription is more economical. In both case scenario, there is no variance in the overall implementation success.

CONCLUSION

It is discovered that not many respondents were using BIM-FM system in their organization. Results show that the majority of respondents were utilizing a third party system consisting of TOMMS System and FM:System. This shows organizations prefer to purchase commercial BIM-FM system in the Malaysian Market. The quantitative analysis shows the overall efficiency of BIM-FM system is considered as the “Adequate” level while the once factor analysis concluded there is no difference between customized/bespoke system or third-party commercial system in terms of the influence of each success factor on the overall efficiency of system performance. Evaluation of the relationship between each success factor in terms of strength and influence on the overall efficiency of system performance shows the usefulness of manual has the strongest influence and stability is the weakest factor to the overall performance.

It is recommended that all relevant stakeholders especially facility managers and BIM-FM solution developers, focus more on the critical success factor identified in this research based on their level of importance regardless of the type of the BIM-FM system that they are using to increase the effectiveness of BIM-FM implementation in their projects. This study was limited to the application of BIM-FM by organizations registered with the MAFM. Further research needs to be done to explore BIM-FM implementation and its effectiveness by non-members of the MAFM.

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DOCTRINAL ANALYSIS ON INTEREST FOR LATE INTERIM PAYMENT FOR MALAYSIAN CONSTRUCTION WORKS CONTRACTS

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Abstract

The doctrinal analysis is a legal methodology adopted to understand a particular area of law's principles and practices. In the context where interest is used as a charge for late interim payment, related provisions in the Malaysian construction works contracts are confined by minimal details. Hence, this study aims to identify relevant legal provisions bearing the principles and practices of interest for a late interim payment for the Malaysian construction works contracts using the doctrinal analysis approach. Fifteen cases were selected from the Construction Industry Development Board (CIDB) Law Reports from 2015 until 2018 for the analysis. The doctrinal analysis was conducted in two stages; the first stage was to locate the law sources, and the second stage was to synthesis the findings of the analysis. Through the analysis, seven themes and nineteen sub-themes based on the case judgements and principles related to interest for late interim payment were developed. The findings were subsequently presented to legal experts for validation and comments. This study helps the employer and the contractor be more prudent in forming and treating contractual interest provisions for late interim payment. Also, a better understanding of the legal implications for the said provisions might reduce disputes between the contracting parties.

Keywords: *Doctrinal analysis; late interim payment; construction contracts.*

INTRODUCTION

A timely interim payment is essential to ensure an ongoing construction project runs smoothly. Failure to abide by the contractual obligations related to interim payment could lead to potential disputes between the contractor and the employer (Hamzah, Chen, Faizul Azli, Nurul Safwah, & Mohd. Suhaimi, 2015; Kenyatta, Alkizim, & Mbiti, 2015). Late payment of certified interim claims is typically considered a breach of warranty, which does not allow the contractor to terminate the contract (Amran, 2017). However, if the employer has developed a habit of constantly delaying the payment of the interim claims causing severe losses to contractor, it would serve as a ground for termination by the contractor due to the failure of the employer to fulfil his contractual obligation (Amran, 2017). Hence, the Malaysian Contract Acts 1950 (Act 646) section 74 illustration (n) allows for the contractor to claim the payment of interest in addition to the principal sum owed, as a monetary relief for the losses incurred due to the payment default. The practice of charging interest on late payment is a generic contractual remedy which also extends to construction contracts (Maritz & Robertson, 2012). Under the law, the award of interest is based on the general principles of damages that do not specifically tailor to construction matters (Fong, 2011).

Sundra Rajoo & Harban Singh (2012) has voiced concerns on the ignorance of the main stakeholders and parties in the local construction industry of the relevant legal requirements and principles that govern their specific projects. The increasing trend of adjudication cases registered with the Asian International Arbitration Centre (AIAC) (AIAC, 2017; Quratul Ain, Siti Suhaidah, & Zulhabri, 2019) proves that better legal understanding by the leading players of the construction projects, namely the contractor and the employer is highly needed. A common methodology used in law to understand legal issues is through doctrinal analysis. Doctrinal analysis analyses all relevant legislation and case laws concerning the legal facts relevant to the matter under investigation (Hutchinson, 2015).

Therefore, this study aims to identify relevant legal provisions bearing the principles and practices of interest for late interim payment for the Malaysian construction works contracts using the doctrinal analysis approach.

PROVISION OF INTEREST FOR LATE INTERIM PAYMENT IN THE MALAYSIAN CONSTRUCTION WORKS CONTRACTS

Late payment is often described as the failure of the employer to disburse payment of the full amount certified by the contract administrator within the Period of Honouring Certificate as stated in the contract (Hamzah, Chen, Faizul Azli, Nurul Safwah, & Mohd. Suhaimi, 2015; Siti Suhana, Nuremma, & Roselan, 2017). Period of Honouring Certificate is the period allocated for the employer to make due payment which starts running when the certificate is issued (Sundra Rajoo, Davidson, & Harban Singh, 2010). Therefore, failure of the employer to fulfil this obligation entitled the contractor to claim for interest on the delayed amount. This entitlement arises either as an agreement in the contract or under the applicable statute.

An express contractual agreement on the award of interest should incorporate details to enable the contractors in exercising the entitlement of interest accordingly. Common factors influencing the award of interest would be the formula, type, the duration of interest charges, and the procedural arrangements for the practice (Maritz & Robertson, 2012; Society of Construction Law, 2017; Sundra Rajoo et al., 2010).

Table 1 is the author’s compilation of details on the contractual provisions regarding the interest for late interim payment available in major standard forms of construction works contracts in Malaysia. In general, the contracts have expressly specified on the effects due to the employer's failure in making the necessary payment within the period agreed in the contract. The table also listed other details relevant to contractual interest for late interim payment such as the rate, formula, and duration of interest charges. It is noted that only the standard forms of construction works contracts for the private sector have incorporated the provisions of interest for late interim payment. As for the Government sector, the rights to claim for interest is reserved for legal deliberations under the relevant statute. Presently, there is no statute in Malaysia which makes it compulsory to include interest for late interim payment as a provision in the formation of a construction contract. The contractual effects of this lacuna are, the provision might be incomplete, exempted or amended. These effects would exclude or restrict one party’s liability or rights which may arise should that party be in breach of the contract (Farhah & Sakina, 2018).

Table 1. Provisions of Interest for Late Interim Payment in the Malaysian Construction Works Contracts

Types of Contracts	Brief Descriptions					
	Clause	**Default Rate**	**Formula**	**Contract Procedure**	**Conditions Precedent**	**Duration**
PAM Contract 2018 (with/without quantities)	Clause 30.17	Maybank BLR+1%	Simple interest	Not needed	Failure of Employer to pay the amount due in the interim certificate after the PoHC	Accrue from the date of default on delayed amount until payment is made
IEM Form of Contract for Civil Engineering Works (Second Ed., July 2011) (corrigendum No. 1)	Clause 58.3 (5)	6% (Appendix)	Simple interest	Not specified	Failure of Employer to pay the whole or part of the amount due in the interim certificate within the PoHC	Accrue from the date of default until the payment of the unpaid sum
CIDB Standard Form of Contract for Building Works (2000 Edition)	Clause 42.9 (b)	Maybank BLR+2% (Appendix)	Simple interest	Not specified	Failure of Employer to pay the amount of the interim certificate in full on or before the PoHC	Until settlement of payment
P.W.D Standard Form of Contract 203A (Rev. 1/2010)	None	Not applicable (N/A)	(N/A)	(N/A)	(N/A)	(N/A)

Notes: i. Period of Honouring Certificates (PoHC)
ii. Base Lending Rates (BLR)

THE DOCTRINES ON INTEREST FOR LATE INTERIM PAYMENT FOR THE CONSTRUCTION WORKS CONTRACTS

The word 'doctrine' comes from the Latin word of '*doctrina*' which means 'education, knowledge or learning' (Salim, Zuryati, & Zainal Amin, 2017). However, more common usage of the word doctrine is defined as a 'principle or position or the body of principles in a branch of knowledge or system of belief' (Merriam-Webster,n.d). The principles are developed through the consensus and practise by the practitioners (Coetsee & Buys, 2018).

According to the legal doctrine, the delayed amounts from a certified interim claim is categorised as debts (Akisinku, Emmanuel Olusegun Ajayi, 2016; Kenyatta et al., 2015). The claimant (contractor) has the burden of proving the existence of a debt and thereafter the burden shifts to the defendant (Employer) to prove that the debt has been discharged (Grose, 2016). In principle, debt does not entitle the contractor to additional payment apart from the principal amount. However, additional financial claims as a contractual remedy can be achieved for losses incurred due to the late interim payment if it fulfils the principles of damages outlined by the common law (Sundra Rajoo et al., 2010).

Damages are monetary compensation aim at putting the innocent party in the position he would have been if the contract had been performed accordingly (Robinson v Harman [1848] 1 Exch 850; 154 ER 363). The common law relies on the contractor to prove the following principles of damages as highlighted in Hadley v Baxendale ([1854] 9 Exch 341) as the primary case reference on the rights to receive the award of damages, which are:

i) the losses arise naturally according to the usual course of thing
ii) the losses are within the reasonable contemplation of the parties at the time of contract
iii) the losses must not be too remote

In the context of a claim for interest for late interim payment, the contractor may usually determine the measure of losses based on the claim for general damages or special damages. General damages measure losses based on convenience or efficiency rather than accuracy, which relieves the contractor of the burden on proving precise losses (Norlizah, 2015). In contrast, special damages require the contractor to provide precise detailing of the head of damages claimed (Chartered Institute of Arbitrators, 2011; Society of Construction Law, 2017).

In practice, the award of contractual interest or discretionary interest by the judge for late interim payment by the employer usually confer the rights of general damages for the contractor unless the measure of special damages is required. Therefore, pre-determined rate of contractual interest for late interim payment as agreed in the contract falls under the pretext of general damages as it does not require the contractor to provide the evidence of precise losses due to the late interim payment. The contractual rate of interest is mainly based on the notion that a late interim payment from the employer would normally cause the contractor to bear the increase in financing cost. However, Amran (2017) strongly opines that any losses suffered by the contractor due to the late interim payment by the employer should be measured based on the actual losses suffered. In which case, the quantum and period for interest would be further scrutinised to ensure fairness and justice to the contractor as well as the employer.

Nevertheless, despite having the provisions for the claims for interest on late interim payment incorporated in the contract, the contractor is still subjected to legal deliberations to determine the claims' validity. The primary piece of legislation that deals with payment-related disputes in the Malaysian construction industry is the Construction Industry Payment and Adjudication Act 2012 (CIPAA 2012). Alternatively, the disputing parties may also bring the matter to other dispute resolutions mechanisms such as negotiation, mediation, arbitration and adjudication or even litigation to obtain a decision from the court. However, as reported by King, Myzatul Aishah, Nurul Huda, Azrina, & Nabilla Hanim (2019), negotiation is the most preferred method of dispute resolutions by the contractor as it saves costs and time. Unfortunately, the terms and agreements made through negotiations may be not binding especially if no written evidence is included (Sundra Rajoo & Harban Singh, 2012).

If the provision of interest for late interim payment is absent from the contract, the interest may be awarded according to the judiciary's discretion (Nor Ainah, 2019; Sundra Rajoo & Harban Singh, 2012). The power to award interest by the judiciary can be in the form of pre-award interest (date of default until date of judgement) and post-award interest (date of judgement until date of payment) depending on the jurisdictions under which the matter of interest is to be judged. In addition, the date of these interest awards, are further subjected to the statute of limitations for the period of debt collection and payment. This means, the legal rights for the contractor to retrieve the debt and interest is bound by a specific period time and would cease after the period had lapsed.

RESEARCH METHODOLOGY

Research Approach

Doctrinal analysis is a qualitative research methodology that interprets, assesses, and develops the doctrines that serve as the basis to determine the concepts, rules, and principles for inquiry (Hutchinson & Duncan, 2012). The main concern of doctrinal analysis is regarding the law in a particular case. The analysis is done through rigorous library research focusing on uncovering the traditional legal sources, such as cases and outcome of cases (Salim et al., 2017).

Hutchinson and Duncan (2012) suggested a detailed step by step doctrinal analysis to comprise the following steps: (1) Assembling relevant facts; (2) Identifying the legal issues; (3) Analysing the issues to search for the law; (4) Reading background material (including legal dictionaries, legal encyclopaedias, textbooks, law reform and policy papers, loose-leaf services, journal articles); (5) Locating primary material (including legislation, delegated legislation and case law); (6) Synthesising all the issues in context; and (7) Coming to a tentative conclusion. However, for this study, these steps have been assigned under three major headings:

Step 1: Locate the Primary Source of the Law (Step 1- 5)
Step 2: Synthesis of Findings (Step 6)
Step 3: Validation of Findings (Step 7)

Primary Source and Sampling Process

Purposeful sampling is considered the best sampling method when dealing with a particular phenomenon (Creswell & Guetterman, 2019). Therefore, this study's primary source has been confined to the collection of the Construction Industry Development Board Malaysia (CIDB) Law Reports. The reason is to eliminate disputes on interest that is not relevant to the construction works contracts. The CIDB Law Report is published annually with commentaries from legal experts as an interpretation of the legal principles and practices of the legal issues towards the cases' decisions. To date, CIDB has produced four Construction Law Reports from the year 2015 until 2019.

The process of filtering the relevant cases to be analysed from the samples consisted of four (4) major keywords – (i) interest; (ii) late/delayed/unpaid payment; (iii) interim payment/progress payment/payment claims and (iv) employer/client/contractor. For a holistic perspective on the principles of interest, the cases selected have also included issues related to delay or non-payment of other types of payments claims such as the final payment claims or variation order claims. This is because these types of claims fall under the same doctrine on interest concerning payment of debt. The author relies heavily on the cases' narration in determining the most relevant cases to be analysed. Table 2 presents the number of cases selected for analysis after the completion of the filtering process.

Table 2. Selection of Cases for Analysis

Year	Cases in CIDB Construction Law Reports		
	No of Cases Compiled	No of Cases Selected	Percentage of Cases Selected
2015	88	2	2.27
2016	70	6	8.57
2017	68	6	8.82
2018	59	1	1.69
Total	285	15	5.26

Although the number of cases selected for the doctrinal analysis as reported in Table 2 is relatively small, the author believed that the selected cases have managed to provide an in-depth understanding of the doctrines of interest for late interim payment to achieve the aim of the study. According to Blaikie (2018), determining specific sample size for qualitative research that adopts a logic of inquiry should depend on the knowledge that evolves as an outcome of the iterative process. Also, Creswell & Guetterman (2019) opined that it is common that sample size would vary from one qualitative study to another. Small selection of sample size is further supported by Braun & Clarke (2016) who strongly believe that complex analyses for the qualitative study could also be developed from smaller samples.

ANALYSIS AND FINDINGS

Step One: Locate the Primary Source of the Law

This step is pertinent in identifying the legal provisions and principles relevant to the claiming and awarding of interest for late interim payment under the Malaysian statutes. The primary source on the law for this study comprises of legal issues and judgements made from relevant cases derived from the CIDB Law Reports. The CIDB Law Report is a compilation of construction disputes cases for a particular year published in the following year. Therefore, the reference year of the cases will be according to the year it is published. For example, the cases compiled in the CIDB Construction Law Report 2015 will have the reference year of 2016, and so on.

Table 3 has tabulated the analysis of fifteen law cases deemed relevant for the study. The analysis comprises the case reference, the type of court in which the decision is made, the legal issues from the disputes, the judgment of the cases, and the principles underlying the decision and the Malaysian statutes and/or contract clauses as cited in the reports. From these, the author has managed to develop seven themes and nineteen sub-themes explicitly addressing the issues of claims and awards of interest for late interim payment for the Malaysian construction works contract. The advantages of having a thematic analysis is the provision of a rich and complex identification of pattern and meaning across the data-set (Braun & Clarke, 2016).

Step Two: Synthesis of Findings

The purpose of synthesising the findings of research is to make connections between the parts identified in the analysis. The synthesis also aims to provide new knowledge, enabling the author to provide a deeper understanding of the analysis (Wyborn et al., 2018). For this study, the author has opted to synthesise between the main findings of the analysis, which are: the legal provisions consisting of statutes and contractual provisions related with the themes on interest for late interim payment. From the synthesis, it can be seen the issues of fairness and justice has the most connections with the legal provisions followed by quantum and period of interest as well as the power to award interest, respectively. The employer and the contractor's angle of knowledge produced by this synthesis can be used when deliberating on a dispute for interest for late interim payment.

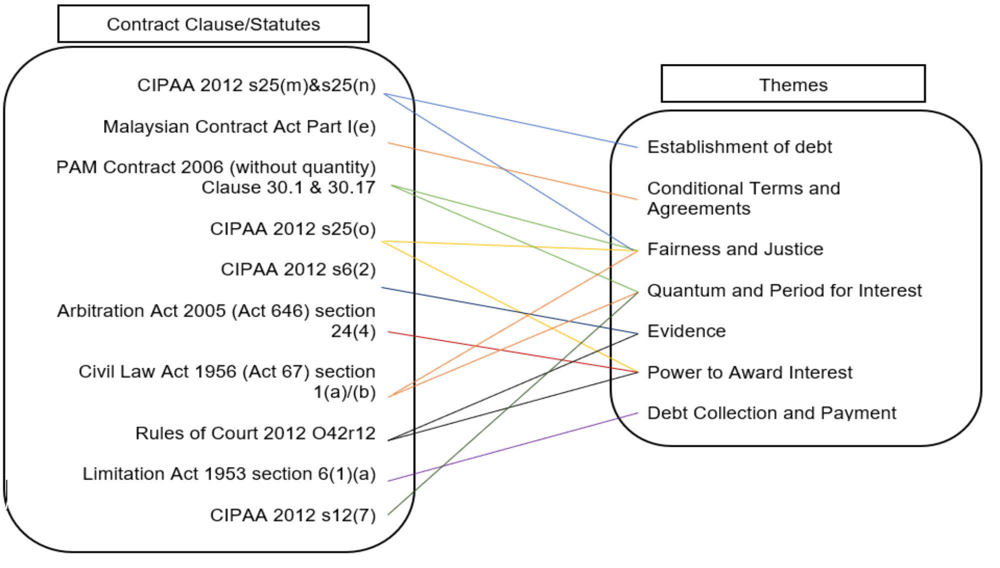

Figure 1. Synthesisation of Contract Clause and Statutes with the Themes on Interest for Late Interim Payment for the Construction Works Contracts

Table 3. Analysis of Selected Case Studies Related to Principles of Interest and Interest for Late Interim Payment from Construction Works Contracts

Cases	Court	Legal Issues	Judgement/Legal Principles	Statutes/Contract clauses	Themes	Sub-Themes
Bina Puri Construction Sdn Bhd. v Hing Nyit Enterprise Sdn Bhd. [2016] 1 CIDB-CLR 182	High Court (Sabah & S'wak)	Payment claim was premature due to no certification	Lack of certification for progress claim was not a bar to the adjudication process	CIPAA 2012 s25(m)&s25(n)	Establishment of debt	• Conditions precedent for rights to receive interim payment
Pembinaan BLT Sdn Bhd. v Debessa Development Sdn. Bhd. [2016] 1 CIDB-CLR 271	High Court	Request for waiver of 12 day's interest – settlement agreement between the parties	The binding agreement under the law is as expressed in the contract	Malaysian Contract Act Part I (e)	Conditional Terms and Agreements	• Modifications of rights • Consideration towards financial conditions of debtor (Employer)
BM City Realty & Construction Sdn Bhd. v Merger Insight (M) Sdn Bhd. & Another Case [2017] 1 CIDB-CLR 87	High Court	Quantum of award plus interest	Discretionary award by the judge needs to be fair and just	PAM Contract 2006 (without quantity) Clause 30.1 & 30.17	Quantum and Period for Interest	• Assessment of interest
				CIPAA 2012 s25(o)	Fairness and Justice	• Based on discretionary empowerment
Econpile (M) Sdn Bhd. v IRDK Ventures Sdn. Bhd. & Anor. [2017] 1 CIDB-CLR 116	High Court	Award of interest for unpaid progress payment - no claim for interest was made	Interest stated in the contract shall take precedence being a binding contract between the contracting parties	PAM Contract 2006 (without quantity) Clause 30.1 & 30.17	Quantum and Period for Interest	• Rate of interest • Interest formula • Assessment of interest • Limitation for quantum of interest
					Fairness and Justice	• Based on contractual agreement
Rimbunan Raya Sdn Bhd. v Wong Brothers Building Construction Sdn Bhd & Anor. [2017] 1 CIDB-CLR 151	High Court	Reliability of the interest rate provided	In the absence of evidence to the contrary produced, the interest provided is accepted based on balance of probabilities	CIPAA 2012 s6(2)	Evidence	• Burden of proof
				PAM Contract 2006 (without quantity) Clause 30.1 & 30.17	Quantum and Period for Interest	• Rate of interest • Interest formula • Assessment of interest • Limitation for quantum of interest

Table 3. Analysis of Selected Case Studies Related to Principles of Interest and Interest for Late Interim Payment from Construction Works Contracts (continued)

Cases	Court	Legal Issues	Judgement/Legal Principles	Statutes/Contract clauses	Themes	Sub-Themes
Asean Bintulu Fertilizer Sdn Bhd. v Wekajaya Sdn Bhd. [2017] 1 CIDB-CLR 234	High Court	Jurisdiction to grant pre-award interest – interest upon interest	Interest may be claimed as head of damages when one has been kept out of one's monies or bear additional charges i.e., financing interest - double interest is prohibited under the law	Arbitration Act 2005 (Act 646) section 24(4)	Power to Award Interest	• Statutes • Doctrine of stare decisis
				Civil Law Act 1956 (Act 67) section 11(a)	Quantum and Period for Interest	• Assessment of interest • Limitation for quantum of interest
Kerajaan Malaysia v Kumpulan Sekata Sdn. Bhd. [2017] 1 CIDB-CLR 262	High Court	Jurisdiction in law to allow interest on the amount awarded	The doctrine of *stare decisis* or binding precedent applies	Arbitration Act 2005 (Act 646) section 24(4)	Power to Award Interest	• Statutes • Doctrine of stare decisis
Kerajaan Malaysia v Tasja Sdn Bhd. [2017] 1 CIDB-CLR 262	High Court	Jurisdiction in granting 'pre-award interest'	Both the judicial decorum and discipline would require the court to follow the ratio laid down by a higher court	Arbitration Act 2005(Act 646) section 24(4)	Power to Award Interest	• Statutes • Doctrine of stare decisis
Fairview School Berhad v Merger Insight (M) Sdn. Bhd. [2018] 1 CIDB-CLR 61	Court of Appeal	Decision of High Court omitting to award certain interest	A holistic approach ought to be taken on interest based on the contract, the construction law and practice, and the powers and/or discretion of the court to do the same	Rules of Court 2012 O42r12	Evidence	• Sufficiency of evidence
Asean Bintulu Fertilizer Sdn Bhd. v Wekajaya Sdn. Bhd. & Anor. [2018] 1 CIDB-CLR 223	Court of Appeal	Jurisdiction to grant pre-award interest	The loss for use of money at the market rate is rightful to the notions of justice	Arbitration Act 2005 (Act 646) section 24(4) Rules of Court 2012 O42r12	Power to Award Interest	• Statutes • Doctrine of stare decisis • Reference body
Menta Construction Sdn. Bhd. v SPM Property and Management Sdn. Bhd. & Anor. [2018] 1 CIDB-CLR 301	High Court	Time bar for progress claims - rate of interest entitled under the construction agreement	So long as the debt is clearly identified, and the acknowledgement of indebtedness is clear and unequivocal - fresh acceptance of debt	Limitation Act 1953 section 6(1)(a)	Debt Collection and Payment	• Claim of interest as part of judgement • Payment of interest as part of judgement • Waive of interest from debt judgement
			Interest is granted in due consideration for the delay incurred	Civil Law Act 1956 (Act 67) section 11(b)	Fairness and Justice	• Based on discretionary empowerment

Table 3. Analysis of Selected Case Studies Related to Principles of Interest and Interest for Late Interim Payment from Construction Works Contracts (continued)

Cases	Court	Legal Issues	Judgement/Legal Principles	Statutes/Contract clauses	Themes	Sub-Themes
Milsonland Development Sdn. Bhd. v Macro Resources Sdn. Bhd. & Anor. [2018] 1 CIDB-CLR 305	High Court	Award of interest for unpaid progress payment - no claim was made for interest	Interest may be regarded as consequentially and naturally flowing from the amount claimed	CIPAA 2012 s25(o)	Power to Award Interest	• Statutes
					Fairness and Justice	• Based on discretionary empowerment
SQA Builder Sdn. Bhd. V Luxor YRM Sdn. Bhd. & Anor. [2018] 1 CIDB-CLR 319	High Court	Amount entitled to be set-off by the employer from the Contractor's Interim Payment Certificates - period of interest awarded	The rights to award interest from the period deemed fair and reasonable having regard to the contractual provisions of the contract	CIPAA 2012 s25(o)	Quantum and Period for Interest	• The rights to set-off disputed amount from certified interim claims • Duration of interest
Vital Talent Sdn. Bhd. V Harmony Teamwork Construction Sdn. Bhd. [2018] 1 CIDB-CLR 349	High Court	Corrective Decision (CD) for rate of interest	The CD had to be set aside due to gap in the Adjudicator's Original Decision	CIPAA 2012 s12(7)	Quantum and Period for Interest	• Calculation of interest
Milsonland Development Sdn. Bhd. v Macro Resources Sdn. Bhd. & Anor. [2019] 1 CIDB-CLR 214	Court of Appeal	Error in law for the award of interest – interest as an item of claim	The power to award interest was a consequential power to the power to award claim	CIPAA 2012 s25(o)	Power to Award Interest	• Statutes

Step Three: Validation with Experts

Validation of findings requires the author to employ strategies to ensure that the findings are accurate and credible (Creswell & Guetterman, 2019). As the author is not trained in law, validations from the law experts are highly needed to ensure that the methodology of doctrinal analysis was conducted accordingly, and the analysis and synthesis were appropriately evaluated.

Two law experts were selected based on their vast experiences in dealing with construction law disputes. Notably, the extent of their knowledge on cases about interests for late interim payment. From the validation process, both experts have agreed with the study's findings with minor comments that have already been incorporated in Table 3 and Figure 1.

DISCUSSIONS OF FINDINGS

Establishment of Debt

It is a common practise that the standard forms of construction works contracts require the interim claims from the contractor to be duly verified and issued by the contract administrator. The certified interim claim is considered as a condition precedent to the entitlement of the interim payment (Tuck Sin Engineering & Construction Sdn Bhd v Yee Heng Manufacturing (M) Sdn Bhd [2007] MLJU 416). Nevertheless, under CIPAA 2012, the Adjudicator is given the powers to revise and review any certificate issued or to be issued (s25(m)), as well as to decide on matters where no certificate has been issued (s25(n)), deemed relevant to the dispute. The amount of payment in a certificate that the Adjudicator decided as being delayed will be categorised as debt. Hence, entitled the contractor to claim for interest.

Conditional Terms and Agreements

In the Malaysian Contracts 1950 (Act 136), Act Part I(e) – Preliminary, stated that every promise forming consideration for each other is considered an agreement. However, the matter in dispute is whether the disputing parties' conditional agreements through the waiver on the part of the interest awarded have superseded the Adjudicator's entire decision. To determine this issue, the judge has asked on the contracting parties' intention by referring to the principles of the construction contract. Without the contracting parties' intention to make the conditional agreement legal, it will only be considered a mutual understanding but not enforceable by the court (Sundra Rajoo & Harban Singh, 2012). The contractor's decision to consider the request for waiver of interest based on the employer's financial conditions in discharging his debt is within his discretion and not binding by the law.

Quantum and Period of Interest

In line with the general rules of assessing damages, the contractor should be placed in the position that as far as possible, he would have been if the employer had made timely payment. The losses of receiving timely payment are related to the loss of monetary value at market rate (SQA Builders Sdn. Bhd. v Luxor YRM Sd. Bhd. & Anor. [2018] 1 CIDB-CLR

319). In practice, the interest awarded for the contractor will be according to the rate of interest agreed in the contract, or within the discretion of the judge. As the quantum of interest awarded on late interim payment is relatively dependant on the amount of established debt from the interim certificates, the employer's rights to set-off any amount expressly allowed by the contract from the interim certificate must be first identified. It is statutory that the discretionary award for the pre-award interest will not exceed the rate of post-award interest specified under the Rules of Court (O42 r12) which is currently set at an annual rate of 5% annum (Bar Council Malaysia, 2012). The judge's decision on the quantum of discretionary interest will be based on the reasonable amount of compensation for the contractor to receive based on the facts presented (Chain Cycle Sdn Bhd v Kerajaan Malaysia [2016] 1 CIDB-CLR 158). The period determined for the award of interest is dependant on the type of interest, whether it is a pre-award or a post-award interest. Pre-award interest is calculated from the date when the cause of action arose until the judgment date. In comparison, post-award interest is calculated from the date of the judgement until payment has been made in full. It is important to note that the award of double interest or interest upon interest is prohibited under s11 of the Civil Law Act 1956 (Act 67). It is also customary that all interest awarded shall be of simple interest unless otherwise agreed by the contracting parties.

Evidence

It is trite law that the burden of proof is on the person who claims. Therefore, the contractor who is claiming interest on late interim payment must bear the burden on proving the default on each item of the claimed based on the balance of probabilities (Aneka Melor Sdn Bhd v Seri Sabco (M) Sdn Bhd [2016] 1 CIDB-CLR 156). However, the proof must be sufficient for the judge to make a holistic decision regarding the interest to be awarded. Legally, written evidence is easier to prove than verbal or oral evidence (Sundra Rajoo & Harban Singh, 2012). In practice, the express terms in the contract shall take precedence being a binding contract between the contracting parties (Econpile (M) Sdn Bhd. v IRDK Ventures Sdn. Bhd. & Anor. [2017] 1 CIDB-CLR 116).

Power to Award Interest

The Malaysian statutes have specified the jurisdictions in which the award of interest could be made. The power to award interest is regarded as a consequential power to the power to make decision on the payment claimed. Under s25(o) CIPAA 2012, the Adjudicator only has the power to decide on a post-award interest. The Arbitration Act 2005 (Act 646) section 24(4) had previously allowed the Arbitrator to decide only on pre-award interest. However, the Act has been amended for the Arbitrator to be vested with the power to award both pre-award and post-award interest (Malaysian Arbitration (Amendment) (No 2) 2018 (Act A1569)(Section 33)). Because the decision made under the alternative dispute resolutions is legally binding but not final, the employer or contractor can bring the matter to the court for a judicial review. The existing statute provided the court with the power to order payment of interest on the judgement debt both for pre-and post-award interest under the Rules of Court (Amendment) 2018 (read together with Practice Note Circular No 165/2012 Dated 31 July 2012) (Order 42r12). Should any dispute arise on awarding pre- or post-award interest, the court would be compelled to follow the doctrine of *stare decisis* in which the *ratio decidendi* (reasoning) applied in precedents cases.

Fairness and Justice

The central idea of awarding interest is to put the aggrieved party in the position that he would have been should the contract was performed accordingly (Asean Bintulu Fertilizer Sdn Bhd. v Wekajaya Sdn Bhd. [2017] 1 CIDB-CLR 234) by referring to the principles of damages. Therefore, the judge who is considering the award of interest for late interim payment needs to determine the ground on which the entitlement for interest arises to ensure fairness and justice to the contracting parties as prescribed by the law. The interest could be legally awarded based on a contractual agreement or through discretionary empowerment allowed by the statute. The primary consideration would be to refer to the provisions of interest as agreed in the contract. Subsequently, if the provision of interest is not provided in the contract, the judge would refer to the relevant statutes.

Debt Collection and Payment

Limitation Act 1953 section 6(1)(a) has specified the time bar to bring the matter on claim for outstanding debt inclusive of interest to obtain court decision, is within six years from the date of the default action arose. Hence, regarding the discussion on evidence from the previous section, it is a prudent move by the contractor to ensure that notices for the demand of delayed interim payment and interest are issued to ensure the employer's indebtedness is duly acknowledged within the time range allowed. The same statute in section 6(3) further deliberated on the period applicable for a claim on full payment of a judgement debt (which consists of the principal sum and the interest awarded) to be within twelve years from the date of judgement. The entitlement to receive the payment of interest will expire within the first six years from which the payment of interest is due. The remaining six years only allowed for the claim of principal sum. In practice, the waiving of interest after a judgement has been decided is only applicable through a higher jurisdiction than the previous jurisdiction granting the award with a good and justifiable case.

LIMITATIONS OF STUDY

This study is limited to the purposeful sampling of the cases compiled in the CIDB Construction Law reports produced from 2015 to the year 2019 to identify the legal provisions bearing the principles and practices of interest for late interim payment for construction works contracts.

CONCLUSIONS AND RECOMMENDATIONS

The knowledge on the legal provision and the principles and practices regarding interest for late interim payment would help the contracting parties be more prudent during the formation of the contractual provisions of the construction works contracts. Thus, this study has identified significant legal provisions bearing the principles and practices of interest for a late interim payment for the Malaysian construction works contracts using the doctrinal analysis approach. It is hoped that disputes on interest for late interim payment in the construction works could be reduced through a better understanding of the contractual and legal rights due to late interim payment by the employer. It is recommended that further research in doctrinal analysis on interest for a late interim payment for the construction works contracts is conducted using the Computer Aided Qualitative Data Analysis Software

(CAQDAS) to incorporate more law cases for different scenarios of disputes on interest for late interim payment. It is also recommended that doctrinal analysis be made to study the legal principles and practises on interest for late interim payment between other stakeholders in the construction works.

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COLLABORATIVE LEARNING EXPERIENCE IN HIGHER EDUCATION: STUDENTS' PERSPECTIVE

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Abstract
Teamwork plays a critical role in determining the success and performance of a construction project. As such, it is one of the core competencies in Architecture, Engineering and Construction (AEC) related degree programmes at university level. A series of assessments have been designed to train and improve undergraduate students' collaborative skill and knowledge throughout the four years' degree programme at higher education institutions. However, experience and literature review showed that group assessments do not always guarantee a positive outcome on collaborative learning or learning outcomes. Further to this, past literature on university students' collaborative learning experience especially in the AEC related programme is not sufficient to provide information to educators on how to assure the effectiveness of the current collaborative assessments. This shed light on the need to further study on group assessments of higher education programmes in AEC disciplines at university level. As such, this study aims to explore students' collaborative learning experience at university level. Responses were collected based on convenient sampling method through questionnaire survey and targeted to university students in one of the Malaysian private higher education institutions. Based on the mean values, it was discovered that the critical issues in collaborative assessments were inactive team members, slow and poor decision making/problem solving and increased in uncertainties. The empirical findings of this study provide information to educators in higher education to take note on these issues in designing collaborative assessments in degree programmes as well as to improve the current teaching methods to ensure collaborative learning is taking place effectively at university level.

Keywords: *Collaborative assessment; collaborative learning; construction; group work; higher education; teamwork.*

INTRODUCTION

Architecture, Engineering, and Construction (AEC) industry is a complex industry. It is a project-oriented industry in which a project is a typical and symbolic business manner in the AEC industry. Professionals of various disciplines from different organizations will interact and work together to achieve project objectives and new team members and human relationship will take place whenever a new project starts. As a consequence, the success of a project relies heavily on knowledge input by different professionals within a project team. A project team refers to the combined effort and contribution of each individual team member to produce synergistic outcome (Olatunde et al., 2018). As such, teamwork contributes significant influence on the performance of a construction project (Yang et al., 2011). This makes teamwork plays a critical role in determining the success of a project (Kim et al., 2018).

Teamwork is not merely critical at project level, it also plays an important role at organizational level. As such, it becomes a core competency in AEC related degree programme. It is an important graduate attribute in higher education as well as employability skill (Shishavan & Jalili, 2020) especially in the AEC field. Students at higher education are expected to master the skills and knowledge of working in a collaborative environment. Hence, educators are required to design a series of group assessments throughout the entire study period to improve the collaborative skill and knowledge of AEC students. Educators could also witness the increase in collaborative assessments in some higher education programmes (Meijer et al., 2020).

In the AEC industry, professionals are required to work collaborative with different disciplines. As the world is moving toward industry resolution 4.0, technology such as building information modeling (BIM) and augmented reality (AR) require greater collaboration and better coordination among professionals of multi-disciplines (Zhang & Chen, 2019). According to Garbett et al. (2021), BIM requires collaboration of various actors of diverse disciplines in a project team. Hence, higher education is an important platform to train and instill collaborative skill and knowledge to students who will be working as the future architects, contractors, engineers, managers and surveyors.

Collaborative learning is an important skill in the 21st century (Laux et al., 2016). Past studies reported that collaboration foster diversity of ideas and thought through knowledge sharing (Laux et al., 2016). However, implementing group work in a unit's assessment does not assure an effective collaborative learning (Johnson & Johnson, 1996). One of the main issues is individual contribution in a group assessment. This will consequently affect the fair assessment of individual contribution (Friess & Goupee, 2020). The outcome of an assessment reflects the outcome of teamwork. In some cases, poor quality of assessment reflects poor teamwork quality. According to Shishavan and Jalili (2020), outcome of teamwork is critical in higher education especially in engineering programmes. As it demonstrates the quality of learning experience that students may experience as well as achievement of learning outcome in a unit.

In view of this, quality of group assessment in higher education has received considerable attention by academic scholars. Meijer et al. (2020) highlighted two main challenges of collaborative learning in group assessments, namely, the construct validity of collaborative assessments and behavioural misalignment with collaborative learning objective in group assessments. As such, the main concerns of the existing past studies are mainly on the quality of teamwork performance in a group assessment and methods of conducting a quality group assessment. For an example, Shishavan and Jalili (2020) focused on the peer assessment process to individualize group marks and to improve students learning experience. Also, Friess and Goupee (2020) proposed a weekly peer evaluation method to monitor individual's contribution as well as to improve individual performance in a teamwork project. Noguera et al. (2018) suggested the use of agile learning strategy in online higher education.

In addition, researchers have also proposed the usage of technology to improve teamwork performance in a group assessment such as GoogleDrive and Trello (Noguera et al., 2018). In regards of the innovative methods and tools proposed by the researchers, it is critical for educators to review the current issues faced by students in higher education. It is apparent that this research theme is captured little to no attention by current past studies. By understanding the current common issues in a group assessment face by undergraduates, a more effective and appropriate solution could be used by educators. As such, this study intends to fill in the knowledge gap of existing studies by revisiting the current issues faced in group assessment by undergraduates. Hence, the aim of this study was to explore students' collaborative learning experience at university level. The objective was to identify the critical issues in collaborative assessments experienced by undergraduate students from the AEC disciplines.

LITERATURE REVIEW

Collaborative assessments in undergraduate studies have received considerable attention by academic scholars. The main concern of most past studies was how to assure an effective collaborative learning process is taking place in performing a collaborative assessment. As such, teamwork in the collaborative assessment is a popular investigated research scope. Past studies addressed on the issue of individual contribution to optimize teamwork performance. Johnston and Miles (2004) investigated the effectiveness of using self- and peer evaluation as a means to improve the group assessment in psychology laboratory course. They concluded that peer assessment helps to improve students' learning experience in a group assessment. Shishavan and Jalili (2020) proposed peer assessment to individualize the teamwork score to assure a fair evaluation in a collaborative assessment. They found that students' appreciation to teamwork has increased and complains on teamwork issues have been reduced significantly. On the other hand, Friess and Goupee (2020) proposed the use of weekly peer evaluation of the contribution of each team member. It has discovered that this approach has weak positive correlation on individual grade and the students experienced difficulty in providing fair peer grade. While, Gueldenzoph and May (2002) suggested best practices of performing peer evaluation in a group assessment. Ko (2014) addressed on the rating method and suggest the use of iterative method to improve the Individual Weight Factor method by providing a fairer grade in peer assessment of a collaborative assessment.

Other than peer evaluation, Hernández-García et al. (2018) focused on log data-based indicators to improve teamwork performance in a group assessment. In addition, Iacob and Faily (2019) investigated the gaps between the expectations at the start and the reality at the end of software engineering group projects. This study has identified few teamwork-related issues, namely, lack of commitment of the team members, difficulty to manage and complete other coursework of other units at the same time, last minute attitude and time consumption on the discussion and generation of unrealistic plans at the beginning stage of the project. On the other hand, Hilliard et al. (2020) focused on exploring the experiences of part-time distance learners in an online group project. This study discovered that the part-time distance learners indicated their anxiety as they have to trust and work with someone unknown, fear of bad evaluation and fear of inactive group members. Nonetheless, this study also found that anxiety tends to facilitate participation and drive for better performance.

Some researchers explored the usage of technology tools to facilitate and improve collaboration among team members in a group assessment. Noguera et al. (2018) proposed the implementation of agile learning strategy with the use of technology tools such as Dropbox (a file sharing tool), GoogleDrive (a collaborative writing tool) and Trello (a team management app) to improve teamwork performance in an online group assessment. Han et al. (2021) explored the application of learning analytics dashboard to facilitate collaborative learning in face-to-face argumentation projects. They found that this technology enhances collaborative learning in terms of visualized feedback and adaptive support. Some researchers focused on the usage of social media to improve collaborative experience at higher education. For example, Hamadi et al. (2021) proposed the use of social media to support and improve cooperative learning at higher education. Caple and Bogle (2013) suggested the usage of wikis to improve and track individual contribution in a group assessment. They concluded that usage of technology has the potential to improve collaborative online assessment but there are few pitfalls that need to be alerted such as additional time is required by team members to familiarize with the technology.

While, Fatimah et al. (2021) explored on the influence of cultural and individual differences on the collaborative learning especially in classroom group activities and group discussion. This study focused on the Edmodo and Google Meet as technology-supported collaborative learning tools. Lyons et al. (2021) designed a web-based tool to support on collaborative learning. Other research areas included the influence of emotional aspect in collaborative learning in primary education (Mänty et al., 2020), methods to improve the thinking skill in a collaborative assessment (Schamber & Mahoney, 2006) and students' readiness on computer-supported collaborative learning environment at higher educational level (Khalifeh et al., 2020).

It is worth noting that different generations tend to have different characteristics that will result in differences in learning and teaching preferences (Monaco & Martin, 2007) as well as different issues in learning. Today's university is occupied by new generation which is referred as generation Z (1995-2009). This generation is knowns as "Digital Generation" with some unique characteristics, namely, individualism, reliance, prefer socialize in the virtual and internet environment (Berkup, 2014). In addition, with the emergence of new education pedagogies and educational technology tools, it is indeed a need for educators to review and identify current problems faced by this new generation in collaborative assessments.

This study also intended to fill in the region gap in Asian region as the research theme in collaborative assessment was mostly conducted in Western regions, namely, Australia (Caple & Bogle, 2013; Shishavan & Jalili, 2020), Spain (Hernández-García et al., 2018; Noguera et al., 2018), United Kingdom (Iacob & Faily, 2019), Finland (Mänty et al., 2020), United Stated (Friess & Goupee, 2020), New Zealand (Johnston & Miles, 2004). Finally, the outbreak of pandemic such as Covid-19, it alarms us the need to revisit the effectiveness of the existing collaborative assessments to ensure effective learning is taking place in different learning environment.

RESEARCH METHODOLOGY

The framework of the research methodology of this study and the timeline is presented in Figure 1. Six (6) critical processes were involved in this study. The first stage was desktop research to identify the research gap of existing studies. Based on the identified research gap, research aim, objectives and scope were developed at the stage 2. The third stage involved design of research which included identification of research methods, data analysis method, sampling method and population. Also, questionnaire design and application of ethical approval were conducted at this stage. Once the ethics has been approved, quantitative data collection was performed at stage 4 and followed by data analysis at stage 5. Lastly, the results of the study were discussed and conclusion were drawn out at stage 6.

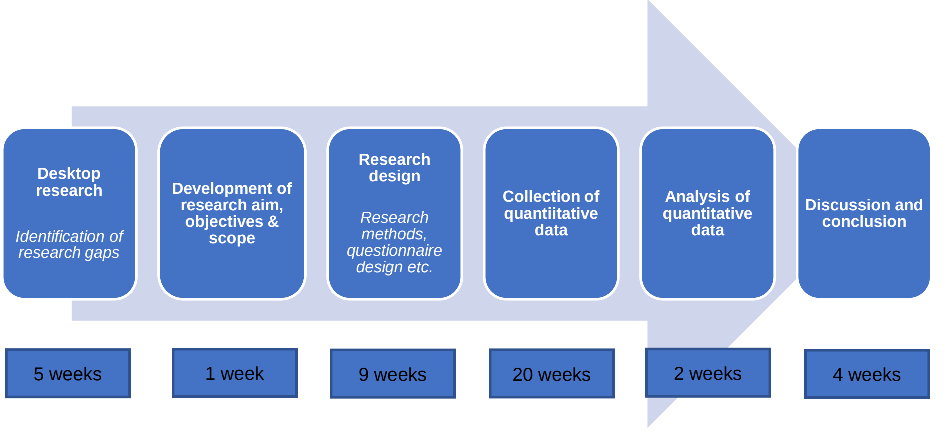

Figure 1. Research Methodology Framework of the Study

A cross-sectional quantitative research strategy has been conducted to explore the common issues occur in the group assessments. A closed-ended questionnaire has been designed to elicit data quantitatively in regards to students' collaborative learning experience in the group assessments. The questionnaire consisted of two main sections. The first section was designed to obtain demographic information of the respondents. While, the next section was concerned about the problems faced by undergraduate students in their group assessments. Instead of focusing on one aspect as in the past years, the problems in collaborative assessments were measured in three aspects, namely, learning, teamwork and personal emotion aspects. These aspects were rated by five-point Likert scale of agreement (1=Strongly disagree, 2=Disagree, 3=Neutral, 4=Agree, 5=Strongly agree) which is a common measurement scale in quantitative study. Variables of each aspect were presented in Table 1.

The sampling method of this study was convenience sampling method. This study was focused on the undergraduate students from the civil engineering, environmental engineering and construction management disciplines from first to fourth years, located at the Curtin University Malaysia. However, students at the first semester of the first academic year (also known as fresher) were not considered in this study as they are lack of collaborative experience at university level. These three disciplines are managed under the same department which is convenient to the researchers to do data collection. Architecture discipline was not covered in this study as this discipline is not offered in the respective university. The questionnaire was distributed to the respondents through face-to-face and email. For the face-to-face technique, the questionnaire was distributed and collected back in the units taught by the researchers. The respondents were given ten to twenty minutes to fill in and submit the questionnaire to the researchers during the class. While filling in the questionnaire, students were further sharing their thoughts with the researcher about their experience in collaborative assessment. In view of the Covid-19 pandemic, some of the respondents were approached through email. Mean was used to identify the most critical issues faced by university students in collaborative assessments. Cronbach alpha was used to identify the reliability of the internal consistency of the items. Microsoft Excel was used to perform the analysis tests.

Table 1. Variables of the study

Code	Variables	References
	Learning process	
L1	I had issue in learning in group projects compared to individual projects	Noguera et al. (2018)
L2	I could not learn effectively in group projects compared to individual projects	From the authors
L3	I learned few things or nothing in group projects compared to individual projects	From the authors
L4	I had difficulty in achieving the grade that I targeted in group projects compared to individual projects	From the authors
L5	Bad learning experience compared to individual projects	From the authors
L6	Group projects affected my overall satisfaction in that particular unit	Noguera et al. (2018)
L7	Group projects affected my interest to learn in that particular unit	Noguera et al. (2018)
L8	Group projects are only useful to students with lower grades	Noguera et al. (2018)
L9	Group projects provided little positive impact in stimulating me to learn	From the authors
L10	Confusion was greater in group projects compared to individual projects	From the authors
	Teamwork	
T1	Problem in communicate effectively with team members	Noguera et al. (2018)
T2	Difficulty in exchanging and sharing of ideas/knowledge	Noguera et al. (2018)
T3	Issue in performing the assigned role	Noguera et al. (2018)
T4	Difficulty in managing time effectively compared to individual projects	Noguera et al. (2018)
T5	Issue in coordinate well with other team members	Noguera et al. (2018)
T6	Unfair task distribution	Noguera et al. (2018)
T7	Inactive team members	From the authors
T8	Most/all team members acted passively	From the authors
T9	Issue in slow decision making/problem solving	Noguera et al. (2018)
T10	Issue in poor decision making/problem solving	Noguera et al. (2018)
T11	Issue in sharing the learning resource	Noguera et al. (2018)
T12	Conflict issue among team members	Noguera et al. (2018)
T13	Lacking of trust among team members	Noguera et al. (2018)
T14	Issue in having frequent communication with team members	Noguera et al. (2018)
T15	Feeling more helpless compared to individual projects	From the authors
T16	Lack of support among team members	From the authors
T17	Issue in accessing information/knowledge	From the authors
T18	Issue in planning the task effectively compared to individual projects	Noguera et al. (2018)
	Emotion	
E1	I feel demotivated in performing task compared to individual projects	Noguera et al. (2018)
E2	Feel anxiety in group projects compared to individual projects	Hilliard et al. (2020)
E3	Feel stress in group projects compared to individual projects	Hilliard et al. (2020)
E4	Feel frustrated in group projects compared to individual projects	Hilliard et al. (2020)
E5	Uncertainties are increasing in group projects compared to individual projects	Hilliard et al. (2020)
E6	Poor emotional support among team members	Hernández-Sellés et al. (2019)

RESULTS AND DISCUSSION

Demographic Information of the Respondents

With approximately of 250 students being approached, 75 responses were received and 67 valid responses were used in data analysis. This yielded a valid response rate of 26.8%. Table 2 presents the demographic information of the respondents. As indicated in Table 2, all the valid responses were participated by generation Z, with the age between eighteen (18) years old to twenty-five (25) years old. About 65.7% of the respondents was at their first and second academic years in the university. Also, 62.7% of the respondents was male. Majority of them (71.6%) was from the civil engineering discipline. This is because the degree programmes of construction management and environmental engineering are considered new programmes in the university compared to civil engineering programme as it has history of almost twenty years in the university.

Table 2. Demographic Information of the Respondents

Demographic Information	Frequency (No.)	Percentage (%)
Age (in years)		
18-19	3	4.5
20-21	49	73.1
22-23	12	17.9
24-25	2	3.0
Missing data	1	1.5
Academic year		
First year	15	22.4
Second year	29	43.3
Third year	19	28.4
Fourth year	4	6.0
Disciplines		
Construction management	7	10.4
Civil engineering	48	71.6
Environmental engineering	12	17.9
Gender		
Male	42	62.7
Female	25	37.3

Critical Issues in Collaborative Assessments

The reliability of the variables for the three aspects was proved as the Cronbach Alpha of learning (0.82), teamwork (0.91) and emotion (0.88) aspects were above 0.7, within the acceptable range. Figure 2 indicates the mean score of the overall results. Based on the Table 3, results of the questionnaire showed that the most critical issues experienced by respondents in the past collaborative assessments were: (1) inactive team members (T7, 3.4), slow decision making/problem solving (T9, 3.21), increased in uncertainties in group projects compared to individual projects (E5, 3.12) and poor decision making/problem solving (T10, 3.03). The most critical collaborative aspects in descending order were: teamwork (2.82), learning process (2.57) and emotion (2.66). These findings were congruent with a study done by Iacob and Faily (2019) in which lack of commitment of team members and unrealistic plan were issues found in software engineering group projects. Similarly, Hilliard et al. (2020) discovered that the part-time distance learners showed their anxiety and concern on teamwork-related issues in online collaborative projects such as trust and inactive team members.

As discussed in the literature review section, some researchers (Friess & Goupee, 2020; Gueldenzoph & May, 2002; Johnston & Miles, 2004; Ko, 2014; Shishavan & Jalili, 2020) have proposed the use of peer assessment to control or mitigate the issue of inactive team members many studies, this study found that inactive team members (T7, 3.4) was the main issue and concern from the undergraduate students. Some of the respondents commented that peer assessment is not an effective way to mitigate the issue of inactive team members as students are afraid that this method will affect peer relationship. In this regards, educators can use collaborative learning tools which are user friendly to monitor and improve teamwork performance. Nonetheless, Table 3 shows that the overall mean values of all the three aspects were less than 3. This indicated that students did not have significant problems in collaborative assessments.

In view of the differences in body of knowledge and skills of various disciplines, it is worth to investigate the critical issues in group assessments experienced by students in different disciplines. Figure 3 represents the mean scores based on 3 different educational disciplines. Refer to Table 3 and Figure 3, there is no variable has mean value of more than 3 in the construction management discipline. The construction management programme is a new programme which was offered in the mid of 2018 with less than 25 students in total. Some respondents commented their preference on group assessments compared to individual assessments although they have experienced some issues in the group assessments. Some explained that they preferred group assessments as they can learn from others and help each other to complete an assessment. Also, with a smaller number of students in construction management discipline, the students might have closer relationship among the team members, which in turns have a conducive learning environment, and hence facing less issues in the group assessments.

For the civil engineering discipline, the most critical issues experienced by the respondents in group assessments were: inactive team members (T7, 3.63), slow decision making/problem solving (T9, 3.29), poor decision making/problem solving (T10, 3.10) and increased in uncertainties (E5, 3.04). Some of the respondents highlighted that the critical issues in group assessment depending on the behaviour of team members. As such, some students prefer to choose their team members instead of assigned by the instructors/lecturers.

While, for the environmental engineering, the highest mean value was 3.58 (E5, increased in uncertainties), followed by 3.33 (T9, slow decision making/problem solving), 3.25 (T4, Difficulty in managing time effectively compared to individual projects; T14, Issue in having frequent communication with team members; E3, Feel stress in group projects compared to individual projects), 3.17 (T18, Issue in planning the task effectively compared to individual projects) and 3.08 (L10, Confusion was greater in group projects compared to individual projects; T5, Issue in coordinate well with other team members; T7, inactive team member; T10, poor decision making/problem solving). This group of environmental engineering students gave their questionnaire feedbacks during the Covid-19 pandemic outbreak, therefore, it is proved that their teamwork capability was limited as they were unable to have face-to-face discussion among their group members. As a prevention of the pandemic outbreak, student learning mode was shifted from face-to-face learning to full on line learning. With this change of learning mode, students' preference could be changed, they would prefer individual projects compared to group projects.

Table 3. Mean Scores of The Variables based on Discipline and Academic Years

Aspects & Variables	Types of Disciplines						Academic Years				Overall	
	Civil Engineering		Environmental Engineering		Construction Management		First Half (1^{st} & 2^{nd} year)		Second Half (3^{rd} & 4^{th} years)			
	Mean	Group Mean	Mean	Group Mean	Mean	Group Mean	Mean	Group Mean	Mean	Group Mean	Mean	Group Mean
Learning process		2.56		2.72		2.34		2.61		2.48		2.57
L1	2.67		2.75		2.43		2.77		2.43		2.66	
L2	2.42		2.58		2.57		2.52		2.35		2.46	
L3	2.13		2.17		2.43		2.25		2.00		2.16	
L4	2.88		3.00		2.43		2.84		2.87		2.85	
L5	2.25		2.83		2.14		2.39		2.26		2.34	
L6	2.75		2.83		2.29		2.84		2.48		2.72	
L7	2.35		2.67		2.29		2.43		2.35		2.40	
L8	2.50		2.33		2.29		2.30		2.74		2.45	
L9	2.77		3.00		2.43		2.95		2.43		2.78	
L10	2.88		**3.08**		2.14		2.82		2.87		2.84	
Teamwork		2.86		2.94		2.33		2.84		2.78		2.82
T1	2.69		2.83		2.43		2.70		2.65		2.69	
T2	2.77		2.83		2.57		2.84		2.62		2.76	
T3	2.63		2.67		2.43		2.59		2.65		2.61	
T4	2.96		**3.25**		2.57		2.91		**3.09**		2.97	
T5	2.71		**3.08**		2.43		2.80		2.65		2.75	
T6	2.98		2.75		2.57		2.98		2.74		2.90	
T7	**3.63**		**3.08**		2.43		**3.36**		**3.48**		**3.40**	
T8	3.00		2.83		2.43		2.86		3.00		2.91	
T9	**3.29**		**3.33**		2.43		**3.18**		**3.26**		**3.21**	
T10	**3.10**		**3.08**		2.43		2.98		**3.13**		**3.03**	
T11	2.58		3.00		2.00		2.61		2.57		2.60	
T12	2.60		2.58		1.86		2.57		2.43		2.52	
T13	2.96		2.83		2.43		2.95		2.74		2.88	
T14	2.94		**3.25**		2.29		2.91		2.96		2.93	
T15	2.38		2.83		2.14		2.52		2.26		2.43	
T16	2.56		2.92		2.00		2.57		2.57		2.57	
T17	2.63		2.67		2.00		2.64		2.43		2.57	
T18	3.00		**3.17**		2.43		**3.07**		2.78		2.97	
Emotion		2.61		3.03		2.33		2.75		2.47		2.66
E1	2.21		2.42		1.86		2.27		2.09		2.21	
E2	2.65		2.00		2.57		2.84		2.43		2.70	
E3	2.67		**3.25**		2.14		2.91		2.35		2.72	
E4	2.69		3.00		2.57		2.84		2.52		2.73	
E5	**3.04**		**3.58**		2.86		**3.23**		2.91		**3.12**	
E6	2.40		2.92		2.00		2.41		2.52		2.45	

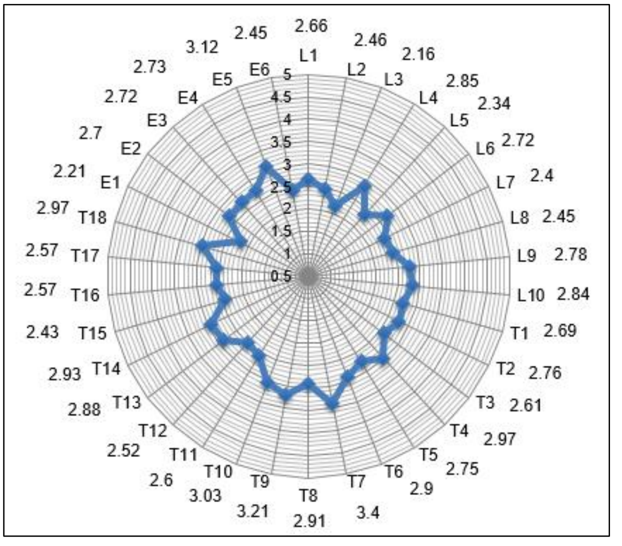

Figure 2. Overall Results

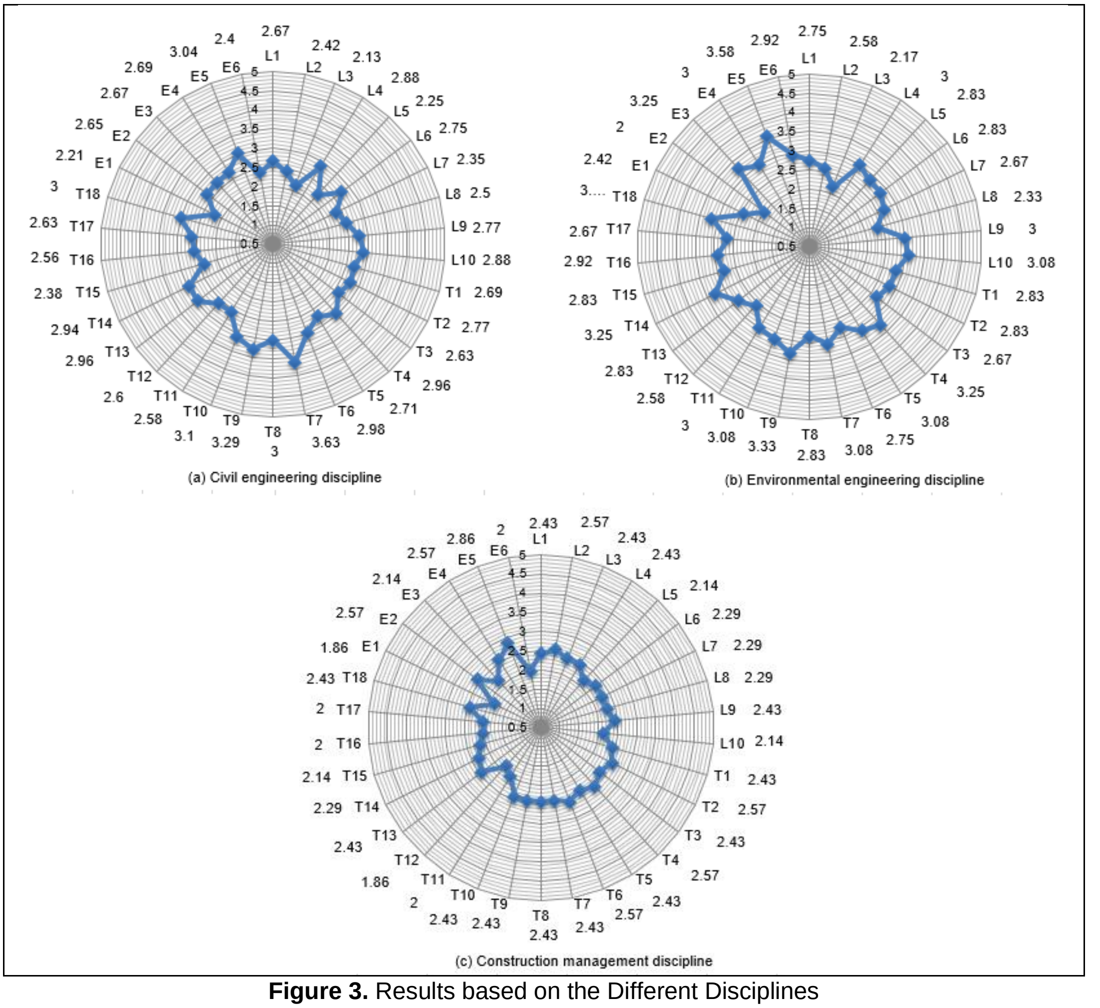

Figure 3. Results based on the Different Disciplines

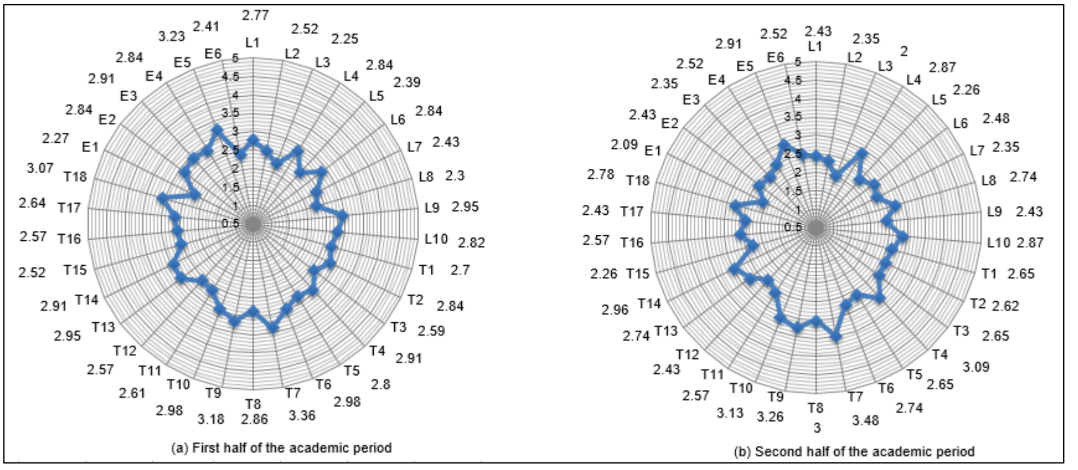

Figure 4. Results based on the Different Academic Period

As students' maturity and exposure in collaborative assessments are different, this study also intended to investigate the critical issues in group assessments experienced by students in different academic year. Figure 4 indicates the mean scores based on different academic period. For the first half of the four-year programme, the most critical issues in group assessments were: inactive team members (T7, 3.36), increased in uncertainties (E5, 3.23), slow decision making/problem solving (T9, 3.18) and issue in planning the task effectively compared to individual projects (T18, 3.07). For the second half of the four-year degree programme, the most critical issues in group assessments were: inactive team members (T7, 3.48), slow decision making/problem solving (T9, 3.26), poor decision making/problem solving (T10, 3.13) and difficulty in managing time effectively compared to individual projects (T4, 3.09).

CONCLUSION AND RESEARCH IMPLICATIONS

The aim of this study was to explore university students' collaborative experience in AEC-related disciplines. This study discovered that the most critical issues in collaborative assessments were inactive team members, slow and poor decision making/problem solving and increased in uncertainties. Inactive team members will lead to unfair contribution of team members which will then affect relationship and interaction among team members. This could consequently affect grading of that particular group assessment or the assessments of other units. Although many studies have proposed ways to deal with the issue in unfair contribution of team members, but most of them were focused on peer evaluation. Educators can consider to integrate technology tools and project management strategies to improve students' collaborative learning experience. The findings of this study could be useful to educators in the AEC fields who are running and managing collaborative assessments to have better knowledge and awareness of the current collaborative assessments issues. Consequently, educators could provide strategies as well as identify appropriate technology-related collaborative learning tools to mitigate the impact of critical issues by ensuring students are able to master and acquire teamwork skill effectively in performing a collaborative assessment.

LIMITATIONS AND RECOMMENDATIONS OF FURTHER STUDIES

In view of the data collection was conducted during the outbreak of Covid-19 pandemic, the researchers would like to recommend future research to consider larger sample size and other disciplines. Further research can also consider to investigate the influence of cultural values in collaborative experience based on the types of universities and races. As this study was focused on one private higher education institution in Malaysia, future study can broaden the research samples by considering public universities and other private higher education institutions to have a more reliable and concrete finding on the collaborative experience of generation Z.

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EDUCATION FOR SUSTAINABILITY IN QUANTITY SURVEYING PROGRAM IN HIGHER EDUCATION

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Abstract
Sustainability have been gaining the attention of construction industry professionals but higher education institutions seems not to widely incorporate sustainability into the construction related program. Without the incorporation of sustainability into the education, sustainable development seems not be able to procure. This study aims to investigate the level of sustainability incorporation in a Quantity Surveying program offered in University College of Technology Sarawak, Malaysia, by using both content analysis and questionnaire survey. Content analysis was conducted to analyze the course synopsis, learning outcomes and topics, to determine the sustainability components in the existing quantity surveying program. The results showed that most of the sustainability components are included as part of a small topic in one course, rather than as an add-on course. The sustainability topics that covered in the program are comparatively broad, including the environmental issues, social issues and technology aspect. Results of questionnaire survey showed that students are quite optimistic with sustainability measures in their future career. This study showed that the students reckoned themselves having quite good knowledge in relation to sustainability. This study addresses the needs of incorporating sustainability elements into the existing course structure, to ensure that the students could have better knowledge and understanding with regards to sustainability. This study could serve as an advising document to the university management to incorporate more sustainability elements into the future quantity surveying syllabus and fills in the knowledge gap within Malaysian education sector.

Keywords: *Higher education; knowledge; quantity surveying; sustainability; syllabus.*

INTRODUCTION

The world's population growth is increasing rapidly with 1.1% per year growth rate in year 2019 (The World Bank Group, 2020). This significantly high number of populations led to the increase in building demand. In the midst of Covid-19 pandemic outbreak, world Gross Domestic Product (GDP) is expected to shrink by 3%, but construction industry alone, is expected to grow by 0.5% in 2020 (Deloitte Global, 2020). Such growth in the construction industry could signify its contribution towards greenhouse gases emission (GHG), waste generation and global warming (Arcadis, 2019). For example, the construction industry sector along with buildings work were accountable for 39% of emissions along with both its carbon and operational usage (World Green Building Council, 2019). To reduce the GHG emissions and environmental impact from construction, construction stakeholders are encouraged to embed sustainability features in the building design and resilience business strategy into construction project (Arcadis, 2019; Shams et al., 2018).

In Malaysia, the policy of sustainability in the social, environment and economic aspects, is still not reaching the maturity level as other developed countries (Jamaludin et al., 2018). Therefore, there has been no apprehension against the dawdling pace in achieving sustainability due to insufficient expertise and presumed high initial cost by the developers (Ha et al., 2020).

Other countries such as Australia, South Africa and United Kingdom (UK) had looked into the embedment of sustainability components in the quantity surveying program in higher education, and most of the findings stated that the embedment of sustainability is considered minimal with low level of sustainability knowledge among the students (Akinshipe & Aigbavboa, 2018; Tan et al., 2017; Xia et al., 2016). In Malaysia, the higher education institutions had conducted research on the incorporation of sustainability components in the field of engineering, science, and social science (Reza, 2016). In the built environment field, Keumala et al. (2016) reported that architectural students would incorporate certain level of sustainability components in the pre-design assessment. None of the studies conducted in Malaysia are specifically related to the quantity surveying program. It seems to prove that Malaysia is lacking in the research of sustainbility embedment in quantity surveying program.

It is vital that construction industries practice sustainable construction. Since 1820, the roles of a quantity surveyor (QS) slowly changed to adapt various changes happening in the construction industry rather than providing advices solely in costing and procurement matters (Chamikara et al., 2020; Kamarazaly et al., 2019). Haron et al. (2017) stressed that the integration between the core practices of QS with sustainable construction knowledge allows the awareness of green elements, hence paving a path as a dominant in ushering the change. Therefore, it is crucial on delivering knowledge to future construction professionals regarding sustainable education to prevent contradiction towards the industry expectation (Xia et al., 2016). Without the enforcement of sustainability knowledge, green building constructability seems unable to be procured (Sim & Putuhena, 2015). This seems to prove that there is an urge in embedding sustainability literacy in the quantity surveying program, to ensure that QS graduates would be equipped with certain level of sustainability literacy and apply it in the industry. This research aims to investigate the level of sustainability incorporation in a Quantity Surveying program offered in University College of Technology Sarawak (UCTS), Malaysia, and investigate the level of sustainability knowledge of the Quantity Surveying students in UCTS.

LITERATURE REVIEW

Sustainability could be practiced in the construction industry to efficiently balance ecological resources not just for the environment itself, but also for the improvement of profit and rivalry in construction companies. Consequently, a framework recognized as 21 for Sustainable Construction in Developing Countries (A21 SCDC) was presented to ensure effective use of capital, hence encourage economic and social development activities in the built environment, this shall minimize the environment effects of the construction industry towards nature (Gama et al., 2010; Tan et al., 2017). Hence, it is vital to integrate interdisciplinary teachings to enhance the awareness of sustainability into the community of higher education (Ceulemans et al., 2015; Garcia et al., 2017). Farag and Doheim (2020) stressed that the embedment of sustainability components shall be included in both theory and practical (i.e. site visit) aspects, in order for students to have a full grasp on the sustainability design.

Caniglia et al. (2018) claimed that education for sustainability (EfS) shall not be overlooked, nonetheless making vital changes in the pedagogy, organizational structure, as well as curriculum to meet the objectives of sustainable development, at the same time avoiding the likelihood of unsustainability occurring. Ramísio et al. (2019) supported this by stating that EfS is essential in ensuring the leadership position of higher institution in the area of sustainable development despite their active involvement in research. However, the current curriculum for quantity surveying seems inadequate and thus failing to keep pace with the efficacy upon current requirement of the construction industry in achieving sustainability (Adekunle et al., 2019).

The most efficient and effective method in transferring the knowledge of sustainability, is to merge sustainable literacy to the curriculum of all relatable program (Balakrishnan et al., 2020). Different studies had been conducted in developed countries, to investigate the incorporation of sustainability features into the construction related programme (Doamekpor & Duah, 2019; Kemmis & Mutton, 2012; Lim et al., 2015; Tan et al., 2017; Xia et al., 2016). For example, Ekundayo et al. (2011) stated that professionals in construction requires to master six types of sustainable knowledge, which are policies and regulations, environmental issue, background knowledge, economic issue, technology and innovation, and social issue, in order to deliver sustainability practices. Lim et al. (2015) reported that the embedment of sustainability into the syllabus could increase students' knowledge and helpful in their career. Xia et al. (2016) identified the factors on enhancing sustainable knowledge for future QS, by looking into aims, course learning outcomes (CLO), course structure and other learning materials, of quantity surveying program in a university in Australia. Tan et al. (2017) conducted a study in a university in the United Kingdom (UK), and found that 87 QS students assessed themselves as having relatively low level of sustainability knowledge but placed high importance on pursuing education that incorporating sustainability knowledge. Doamekpor and Duah (2019) reported that the Master of Construction Management students in one of the public university in Ghana, had narrow knowledge on sustainability concepts and sustainable construction.

In Malaysia, studies had been conducted in the area of environmental engineering, social science and architectural programs (Balakrishnan et al., 2020; Reza, 2016). Reza (2016) reviewed the environmental related program and disaster management program in 12 public and private universities and reported that the sustainability components incorporated into the program are mainly focusing on environmental aspects. Balakrishnan et al. (2020) supported this notion by stating that sustainability incorporation in higher education institutions had limited coverage in the social and economic aspects. In the built environment studies, research had been conducted in the architectural and interior design programs (Awang et al., 2020; Keumala et al., 2016). Keumala et al. (2016) reported on limited integration of sustainability in the assessment components. Awang et al. (2020) conducted a thorough literature review on the incorporation of sustainbility in interior design programs, and reported that 85% of the research in interior design was conducted internationally, which leaves a research gap of EfS of interior design programs in Malaysia. With regards to quantity surveying program, little-to-none research in Malaysia are focusing on quantity surveying program solely.

RESEARCH METHODOLOGY

EfS is considered as new in Malaysia. This research adopted exploratory case study to gain insights into sustainability embodiment in the quantity surveying program in UCTS. The quantity surveying program was introduced in UCTS since September 2013, as one of the first three programs since the establishment of UCTS (Moh, 2013). The 3.5 years quantity surveying program in UCTS is considered as one of the core program, and achieved the full accreditation by Board of Quantity Surveyors Malaysia (BQSM) in 2015 and Pacific Association of Quantity Surveyors (PAQS) in 2016 (University College of Technology Sarawak, 2020). With regards to sustainability measures, one of the quantity surveying program learning outcome is to produce graduates acquainted with the social and professional responsibilities towards sustainable development.

This research is a mixed method research, by adopting both qualitative and quantitative method. Content analysis and questionnaire survey were used to provide an overview on the level of sustainability incorporation into a quantity surveying program. Content analysis could be defined as analyzing the content with priority given to the context in which it was developed in obtaining themes as well as extracting vital interpretations of data (Roller & Lavrakas, 2015). This method focuses on looking into further detail regarding to the course structure of quantity surveying program and allows researchers to identify the sustainability components from the Course Learning Outcome (CLO), synopsis, and topics covered in each course syllabus.

A questionnaire survey with different aspects of sustainability components were distributed to 195 quantity surveying students from September to November 2020, to gain their insight on their knowledge level on sustainability. As UCTS has a relatively small population of 195 quantity surveying students as of September 2020, this research reached out to all 195 students to grasp a better picture of the sustainability literacy for all year students. Questionnaire survey were distributed online to 195 students, with 85 valid responses returned (i.e. 43.59% response rate). Descriptive statistics were used to analyze the questionnaire to provide illustrations of variations in percentage, mean, and standard deviation (SD), to provide meaningful comparison between the results.

RESULTS AND DISCUSSION

Content Analysis

The UCTS quantity surveying program consists of 22 core courses, seven non-core courses, ten compulsory courses and two elective courses. The quantity surveying students are required to undertake one elective course to complete this program. This program is designed to provide a comprehensive coverage on the areas covered by the QS, inclusive of the professional skills and hand-on skills required in QS profession.

The analysis of the quantity surveying course structure identified that five courses have sustainability embedment. UCTS adopted both vertical and horizontal integration of sustainability features into the course syllabus. Vertical integrations refers to the integration process of newly added sustainability courses as an isolation option and hence allow those who desire in the field to have an in-depth exploration (Watson et al., 2013). Horizontal integration refers to integrating certain aspect of sustainability into the existing courses' syllabus. The results showed that one course (i.e Green Technology) was a compulsory course that had sustainability components vertically integrated into its syllabus. The remaining four courses (i.e. two core courses and two elective courses) were horizontally integrated. Table 1 showed the sustainability-related synopsis and learning outcomes in those five courses, after analysing the course outlines.

Table 1. Sustainability Related Synopsis and Learning Outcomes

Course Name	Year	Synopsis Relevant to Sustainability	Learning Outcomes Relevant to Sustainability
Construction III (core)	Year 2	Equip the students with the knowledge related to equipment employed in the construction, defects and remedies works in building, **site safety and management**.	NIL
Urban Land Development (elective)	Year 3	Considered the background of property market and development process, property development considerations, site layout and design, development control, development appraisal, funding for the development, development risk and **sustainable development**.	NIL
Project Management (core)	Year 3	An overview of project management structure, prime objective of project management, roles of a project manager from inception till project close-up and feedback, common techniques used to facilitate the project management tasks and aspect of **occupational health and safety** are considered in principles.	NIL
Site Planning and Management (elective)	Year 3	Encompasses site personnel and responsibility, site planning, supply chain management, **safety and health management**, project supervision and building inspection, risk and hazard management, and also, environmental and waste management.	Propose measures for **environmental safety** and management, which consists of planning, assessing and managing **construction waste**
Green Technology (compulsory)	Year 3	NIL	- Describe the fundamentals of **green technology terminology** and principles in general - Demonstrate the **green value** and role as a member of an established profession - Develop awareness in **energy saving, environmental conservation, health and safety** life without damaging or depleting natural resources in future

As shown in Table 1, 80% of the sustainability related courses are delivered to students in their Year 3. Two out of the five courses had covered sustainability components in the course learning outcome, and four out of the five courses had sustainability components in the synopsis. There is only one elective course that consisted of sustainability components in both synopsis and learning outcome. This may imply that UCTS quantity surveying program did not make the sustainability components explicit at the earlier stage of the course delivery.

The weekly topics covered in those five courses were further evaluated to identify the sustainability components. Table 2 showed the breakdown of sustainability aspects covered in the five courses. The topics covered was cross-checked with the categories that had been identified in the categories as identified in Ekundayo et al. (2011), for instance environmental, economic, policies and regulations and lastly technology and innovation.

Table 2 shown that UCTS QS courses had adopted more sustainability components that classified under the environmental category. About 71% of sustainable topics were found under the compulsory course (i.e. Green Technology). The Year 2 core course (i.e. Construction III) covered construction/demolition waste management, site safety and management, and green building systems. These three topics that fall under the category of environmental, social and technology respectively may signify that the students are exposed to the general level of sustainability knowledge in the early days of their undergraduate studies.

Table 2. Sustainability related Topics Covered in UCTS QS Courses

Category	Topics	Course Name
Environmental	Environmental assessment Noise & vibration hazard Concrete waste management Solid waste management Hazardous waste management	Site Planning and Management
	Environmental management	Urban Land Development
	Construction and demolition waste management	Construction III
	Sustainable living in harmony Global warming 3R – Reduce, Reuse, Recycle Green building rating tools Green building strategies	Green Technology
Policies and Regulations	Concepts of sustainable development	Urban Land Development
Social	Occupational safety and health	Project Management
	Site safety & management	Construction III
Technology and Innovation	Green building systems	Construction III

The UCTS quantity surveying program only managed to cover four out of the five categories that has been identified in the literature review, which made the categories of economy not available in the content analysis. Under the environmental category, the program had covered a wide range of environmental related topic, this includes green building rating tools, green building strategies and other related components (see Table 2). Kemmis and Mutton (2012) supported this by uttering that environmental issues had raise concerns regarding global warming and other issues which stimulates remedies to reduce this issue.

As for the social category, two courses (Construction III & Project Management) consisted the element of safety and health in the synopsis. Previous research by Shen et al. (2007) and Zuo et al. (2012) criticized this by stating that safety and health is a general issue in social sustainability that poses a threat to both workers and site as well as its surrounding communities.

For the category of technology and innovation, Green Technology course covered the element of green building systems as one of the topics. This is an important topic as energy consumption could be reduced if the practices of sustainability in a building is apprehended

(Robichaud & Anantatmula, 2011). Chwieduk (2013) suggested that the implementation of renewable technologies could assist in curbing the current pollution matters in the environment.

In the aspect of the delivering of sustainability knowledge, the program had adopted the traditional way of lecturing. In this way of teaching, this makes future graduates to be able to meet the needs of the society in being capable of having critical-thinking skills in solving issues. However, more hands-on approach, for instance, site visits to the construction project and/or building that adopts sustainable construction methods would greatly beneficial towards students in understanding multiple aspects of sustainability as well as implementing the knowledge in their workplace.

Questionnaire Survey

Table 3 showed the respondents' profile. Majority of the students (58%) are male full time. This is quite a good representative for the whole quantity surveying program in UCTS. There are 42% of the students are in Year 3 and Year 4, which could serve as a representative on the impact of sustainability embedment in quantity surveying program on their sustainability literacy level. Fifty-three percent (53%) of the students have working experience, this is not a surprise finding as some students may complete their diploma program and have certain level of working experience before pursuing their bachelor degree in UCTS.

Table 3. Respondents' Profile

Profile	Categories	Percentage
Gender	Male	58%
	Female	42%
Year of study	Year 1	33%
	Year 2	21%
	Year 3	21%
	Year 4	25%
Working experience	Yes	53%
	No	47%

The students were asked to rank the effectiveness of the embedment of sustainability elements in the quantity surveying program. The mean and Standard deviation (SD) were calculated to show the representative of the students. The students were classified into Year 1 and Year 2, Year 3 and Year 4, and Year 1 to Year 4, to provide a detailed analysis on whether the mature year students have more sustainability knowledge compared to lower year students.

Table 4 shows that all years students are considering themselves having quite good knowledge in relation to sustainability (mean 3.43/5). This may indicate that the students are sensible towards current sustainability knowledge.

Table 4. Perceptions of Students Towards Sustainability Embedment

Perceptions of Sustainability Embedment	Year 1 - 2		Year 3 - 4		Year 1 – 4	
	Mean	SD	Mean	SD	Mean	SD
Knowledge of sustainability	3.43	0.57	3.38	0.57	3.43	0.58
Comprehensiveness of sustainability incorporation into the QS program	3.59	0.58	3.41	0.83	3.53	0.72
Effectiveness of sustainability content in QS program that helps to improve general sustainability knowledge	3.63	0.64	3.49	0.93	3.59	0.79
Importance of sustainability knowledge in future profession	3.87	0.69	3.86	0.82	3.86	0.77
Confidence in promoting sustainable construction after completing QS program	3.57	0.83	3.30	1.00	3.45	0.93

With regards to the comprehensiveness of sustainability incorporation into the QS program, it is interesting to note that the mean value of Year 1 – 2 students are slightly higher compared to Year 3 – 4 students. Overall, the students perceived that the sustainability knowledge had been well embedded (mean 3.53/5). The students also perceived that the embedment of sustainability knowledge into the existing program could help to improve their sustainability knowledge.

In terms of the impact of sustainability knowledge in their future career, the students ranked that it is very important to have the sustainability knowledge in the future profession, and they are quite confidence in promoting sustainable construction after their completion of QS program. This seems to indicate that the students are aware of the importance of sustainable construction and have certain level of confidence in implying such knowledge in the future workplace. This result is tally with a study conducted by Lim et al. (2015), that the students regarding sustainability knowledge is useful in their future career.

CONCLUSION

This research had investigated on the level of sustainability incorporation in the quantity surveying program in UCTS. It seems to indicate that this program had somehow achieved the minimal integration of sustainability into the syllabus. However, with more uptake of sustainability in the construction industry, there might be a need to revise the existing syllabus to incorporate more aspects of sustainability, to ensure that the quantity surveying students could expose to sustainable construction knowledge at the early stage of their education. From the results of questionnaire survey, the students seems quite confidence in respect of their level of sustainability knowledge. This research could add to existing literature hence furnish the knowledge gap in this area. By analyzing the components of sustainability in quantity surveying program, this study could serve as an advising document to the UCTS management to incorporate more sustainability elements into the future quantity surveying syllabus.

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