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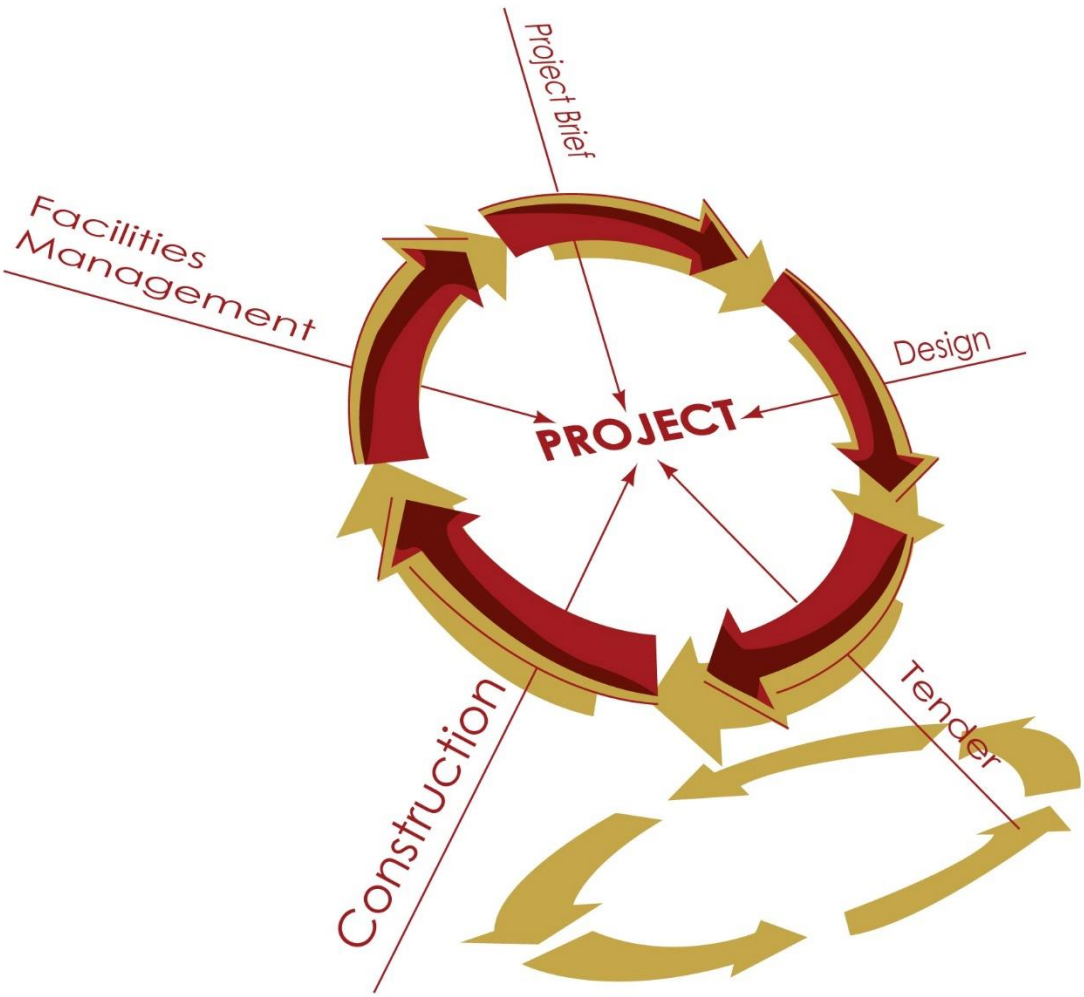

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Contents

INTRODUCTION

Welcome to the Special Issue of the Malaysian Construction Research Journal (MCRJ) in conjunction with the International Conference on Applied Science and Technology (ICAST) 2017. This conference was organised by Universiti Utara Malaysia (UUM) and was held on 2-5th April 2017 in Langkawi Island, Kedah. This annual event aims to create synergies among the researchers, academicians and industrialists worldwide to share, exhange and discuss their ideas and technologies in their fields.

This Special Issue of Malaysian Construction Research Journal (MCRJ) for International Conference on Applied Science and Technology consists of 20 selected papers by the conference committees and expert reviewers submitted in the ICAST 2017.

The volume showcases selected papers from the conference tracks on material and building technology, construction project management, supply chain management, built environment, and green technology. These papers discuss the various issues and challenges in the construction industry, and provide suggestions for alleviating these issues. All the papers had undergone a rigorious review process by independent expert reviewers who are knowledgeable in the pertinent subject area.

The global construction industry is a significant indicator of the economic growth of a nation, simply due to the fact that the government is the biggest client of the construction industry. With the turn of the century, and the move towards the digital era enabling the key players of the construction industry to work together in spite of distance and geographical borders, new trends has emerged and novel methods of addressing the issues have been formulated. Apart from coping with emergent technologies in the construction industry, various aspects of the soft technologies must not be ignored as the human capital relies greatly in their ability and knowledge in manning the hard technology to develop cutting edge projects within the construction industry.

This special issue volume also includes the many soft sciences aspect of the construction industry, which cross-linked the construction technology with many areas in business and management particularly in Supply Chain Management, Occupational Safety and Health, Quality Management, Building Information Management, Public Private Partnership, Knowledge Management, Decision Support Systems, Construction Material, Industrialised Building System (IBS), Project Scope Management and Sustainable Housing.

The volume offers a fresh perspective from the business and management viewpoints towards the construction industry and highlights the potential multidisciplinary areas of research within the built environment, as well as adding value to the practitioners in identifying future issues and ways to resolve them. It shows the importance of the human capital as the implementors of policies, practices and technologies in which will drive the success of the global construction industry.

Editorial Advisory Board (review paper)

Editorial

Welcome from the Editors

Welcome to the Special issue of Malaysian Construction Research Journal (MCRJ). The editorial team would like to extend our gratitude to all authors and reviewer for their contributions and valuable comments. The paper selected for this issue are come from International Conference on Applied Scienceand Technology, (ICAST) that has been held in Universiti Utara Malaysia, Sintok, Kedah on 29-30th August 2017. The purpose of this special issue is to acknowledge the recent findings of construction industry and environmental issues. It is hope that the readers will find beneficial information from this special issue edition. A total of Twenty (20) papers are discussed in this issue.

Salman Riazi Mehdi Riazi et al., reviews the insufficient performance of traditional practices that have been dominating the local construction industry in Malaysia. It adopts a review of previous literature approach concerning the methodology used in ranking and establishing the main factors affecting low labour productivity and grouping the main factors into distinctive root causes. Lastly , it identifies beneficial SCM tools in order to consequently develop a validated SCM framework to improve labour productivity. The findings highlight the labour productivity issues by utilizing beneficial SCM tools to address distinctive root causes and factors affecting low labour productivity. Thus, this study aims to develop a validated framework that utilizes beneficial Supply Chain Management (SCM) tools to improve the low labour productivity issues public sector projects.

Syahrul Nazmi Jamalullah et al., investigate the factors that are leading to non-compliance with the legal provisions on occupational safety and health (OSH) from Malaysian contractors and identify the level of compliance. A focus group discussion was conducted in order to gather data from key officers of the Department Occupational Safety and Health (DOSH) Penang. The findings show that the main factors contributing to non-compliance to the OSH regulations are lack of management commitment, cost, time, training, knowledge and supervision. Contributions to the insights of this study are from the Department Occupational Safety and Health (DOSH), National Institute of Occupational Safety and Health (NIOSH), Construction Industry Development Board (CIDB) and Non-Government Organization (NGO) in identifying factors of non-compliance with the occupational safety and health (OSH) acts and regulations among contractors.

Sohimi, N E et al., review on the issues concerning the quality standard in a construction project based on the QLASSIC training barriers and the competency improvement among respondents after attending the QLASSIC training. A quantitative approach of survey questionnaire has been conducted to 143 construction practitioners in Malaysia: the data were analysed by descriptive statistics using SPSS software. The finding of this study shows that the main issues found in the quality assessment training were the nonfulfillment of participants' needs and the inconvenient training environment. Thus, the paper addresses the solution of identifying the training model in order to enhance the quality assessment and to remove the ambiguities in conceiving how QLASSIC should be implemented.

Nuzaihan Aras Agus Salim et al., review the issues in the operational maintenance where several factors are combined, such as technology, expertise, equipment and environment collision. A qualitative approach through survey interviews method is applied in this study among building maintenance management departments. The findings of this study show how maintenance operation can achieve a better practice. Thus, this study focuses on developing new approaches by reviewing the challenges in building envelope maintenance operation in technologies and innovations for high-rise building.

Tan Yan Ting et al., study on building awareness about the adoption of a new software in the Architecture, Engineering and Construction (AEC) industries, such as Building Information Modelling (BIM). The methodology used in this study is a questionnaire survey among 164 Penang Construction Company from the AEC industries. The findings from the survey reveal the benefits and the barriers of the implementation of BIM and the level of the awareness about BIM.

Farah Salwati Ibrahim et al., highlights the major risks that contractors face in developing the hillside project and their current practice on implementing the risk management plan for their hillside development project. The research technique used in this study is semi-structured interviews among "risky" area as classified by the Penang State Government. The findings of this study show that the slope stabilization was found to be the major risks in Penang hillside project followed by design and technical operations, construction, safety, security and time. Most of the contractors are using the simple practice of risk management plan because of the lack of exposure to the actual risk management plans practice and compatible with their old ways.

Suzana Abd Samad et al., show the potential of BIM implementation as a channel for the public sector to gather information within BIM environment, especially in regard to project development information from the design phase throughout the construction phase. This study applied qualitative approach by interviewing five professionals from the public-sector agencies. The result has shown that BIM has a huge opportunity to facilitate electronic submission concerning building approval. Therefore, this study also developed a conceptual design for BIM-based electronic submission for building plan applications to support the public sector.

Hasnan Hashim et al., shows the key factors of defect management procedures, their implementation in Public Private Partnership (PPP) university projects and the way they significantly lead to project performance in order to develop a conceptual framework. The data are gathered from a case study in the form of a workshop with 70 practitioners and academicians at a local university. The data were analysed using a software for thematic analysis, Atlas.ti: a tool to find several key variables of defect management procedures comprising coordination, compliance, resources and training, work process, benchmarking, commitment of management, skill and competency as well as monitoring. The findings are meant to build guidelines for policy makers, from public to private sectors, in order to improve the defect management for PPP university projects in Malaysia.

Mohamad Nizam Yusof et al., reviews the importance of managing knowledge to perform actively in construction business environment. Since construction companies are losing their knowledge due to as knowledge is remaining in the mind of the individual. This study attends to provide a comprehensive literature on the concept of knowledge retention, competitive advantage and develop research model. The findings of the research are valuable to key players, stakeholders and researchers in the built environment field.

Nor Azlinda Ramli et al., propose to develop a model for the Load-bearing Masonry (LBM) technology adoption by Malaysian housing developer firms. By adopting a quantitative research, the data are collected based on a survey approach through questionnaires and analysed though a Partial Least Squares Structural Equation Modelling (PLS-SEM). The findings show that factors as organizational readiness, external supports and facilitating conditions have a significant effect on the Perceived Ease of Use (PEU) and also relative advantages. Therefore, it confirms that the Technology Acceptance Model (TAM) and Innovation Diffusion Theory (IDT) theories are valid when explaining LBM technology adoption.

Naziah Muhamad Salleh et al., study on thermal surface performance and daylight penetration of the Double Panel Window (DPW) with different type of glasses. The experiment has been conducted by using a software program developed at Lawrence Berkeley National Laboratory (LBNL) and called WINDOW7.3. The findings regarding the U- Value, the thermal transmittance and the relative solar heat gain coefficient values are obtained from both experiments with computer simulations. The above findings can lead to a reduction of about 50-70% of direct solar heat and still maintain high visibility by using low emissivity glass.

Haryanti, M. A et al., investigate on the roles and the tasks performed among Malaysian construction management graduates during their employment by using a Rasch Measurement Model (RMM). The findings show that the items reliability index was .83 and the respondents' reliability index was .88. The result is remarkable and has a sufficient number of items to measure what it needs to measure in the underpinning theory.

Ahmad Taufik Nursal et al., investigate on how Fuzzy TOPSIS (FTOPSIS) can be applied to Industrialised Building System (IBS) for the vendor selection process. FTOPSIS were tested and validated on a real IBS project before the decision model was finalised. The result shows a decision model with current practice by improving decision making process in IBS vendor selection. The findings of the research aim to minimize time and risk and lead to effective supply chain management.

Hazamaah Nur Hamzah et al., hightlights on Geopolymerization technique was implemented in the stabilization of Kedah laterite soil with differences, such as liquid instead of solid ratios, sodium hydroxide instead of sodium silicate and various molarities in order to obtain the optimum result of compressive strength. Kedah soil, fly ash and alkaline activator were mixed together with the solid to liquid ratios in range of 1.5 – 3.0 which produce an aluminosilicate gel. (The preparation of alkaline activator has been done by mixing sodium silicate and sodium hydroxide in range of ratios 0.5 -3.0.) The results show that the compressive strength of stabilize soil by geopolymerization was affected by solid to liquid ratios, sodium silicate to sodium hydroxide ratios and molarity of sodium hydroxide. (The

optimum compressive strength of the stabilization of Kedah soil by geopolymerization technique was achieved at solid to liquid ratio of 3.0, sodium silicate to sodium hydroxide ratio of 2.5 and 12 M sodium hydroxide concentration which is 5.58 MPa in seven days curing at room temperature).

Abdollah Saeb et al., investigates the development of Alternative Dispute Resolution (ADR) methods in the Iranian construction industry. The research adopted a mixed methods approach through semi-structured interviews with 30 experts and distributed questionnaires to 112 experts in order to find the potential of binding methods of ADR. The findings show that ADR can be effective in resolving disputes in the construction industry and yield positive results with resolution around 2.25 times more than non-binding methods.

Othman Mohamed et al., study on the factors that promote knowledge sharing initiatives in Malaysian Quantity Surveying (QS) firms and determine the challenges faced by Malaysian QS firms when implementing knowledge sharing initiatives. The paper used a mix methods approach through a survey questionnaire to 282 quantity surveyors and an interview session was conducted by involving 20 quantity surveyors. The findings of the research suggest that the senior management support is the greatest influencing factor to promote knowledge sharing initiatives. Moreover, the size of QS firms impacts the factors that promote knowledge sharing initiatives and it influences the challenges associated with the above-mentioned initiatives.

Ng Chiew Teng et al., reviews the benefits and the barriers of Building Information Modelling (BIM) performance in the construction industry. The study adopted a qualitative approach through multiple case studies embedded on the current BIM practices from the developers' perspective. The data have been gathered through the interviews approach and analysed by using a content analysis. The results show that the respondents have agreed that although there are plenty of benefits and advantages concerning the BIM adoption, its use in the Malaysian construction industry is still in its infancy and developmental stage.

Qais Hashil Salim Al-Rubaiei et al., reviews on project scope management as a main function in project management process. It is a critical function because any changes or modifications in scope will cause extra cost on the total project development expenses. In addition, scope management function ensures the successful management of other key project management areas, including time, cost, and quality. This article highlighted the importance of the scope management, how it is viewed by project management different methods and what it is impact on the project outcomes. Moreover, it highlighted the issue of the variation orders in the Sultanate of Oman and suggested the concept study to examine this issue.

Wan Mohd Azmi et al., study on property developers involved in residential projects for more than 10 years, from the aspect of current social sustainability scenario in housing development. Results from a qualitative approach (interviews with three different developer companies, and site observation of a selected project) show that developers do incorporate social sustainability elements in their housing development, but their understanding and application differs for each project.

THE IMPLEMENTATION OF RISK MANAGEMENT PLAN: TOWARDS SAFER HILLSIDE DEVELOPMENT PROJECT

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Abstract
Nowadays, the demand for residential sector in Penang, Malaysia is higher but the availability of flat land is limited due to the Penang topography which is most of it is categorized as hilly area. Due to this phenomenon, the developer has taken this opportunity to develop the hillside area to cope with the increasing of that demand and also to gain high profitability. However, most people are unaware that the hilly area is a sensitive area which minor mistake in the development process will invite hazardous to the construction projects. Thus, this study is conducted to identify what are the major risks that contractors faces in developing the hillside project and their current practice on implementing the risk management plan for their hillside development project. In getting the right and in-depth data for this study, semi-structured interviews method was chosen as the research technique and this study just focused on the "risky" area as classified by the Penang State Government. Moreover, as the results, this study has indicated that the slope stabilization was found to be the major risks in Penang hillside project followed by design & technical, construction, safety & security and time. Currently, the contractors aware about the important of risk management plan for their project but unfortunately, they are still using the simple practice of risk management plan because lack of exposure to the actual risk management plans practice and compatible with their old ways. As conclusion, this study is significant for the project's stakeholders especially for the hillside development project as their surface guidelines to identify the risks and manage risk management plan for their projects.

Keywords: *Hilly Area; Hillside Development Project; Risk Management Plan*

INTRODUCTION

Malaysia is categorized as a developing country whose urban population is expected to arise 9.8 million or 30.9% by year of 2040 (Department of Statistics Malaysia, 2016). Due to this population increment, the construction industry also affected in fulfils the increasing of demand especially in housing sector which the increasing of population was dominated overall the world property market including Malaysia (PMR, 1H2015). Meanwhile, in coping with the increment of the population and the demand for housing needs, the flat land will be the main issues nowadays because most of the main locations were fully utilized and it became scarcer day by day especially in main cities like Penang. Thus, this urbanization pressure has given opportunity to the developers to develop hilly and highland area. However, the improper development with inadequate risk management planning during the project life cycle will invite various problems especially in term of resident's safety and environment destruction.

In project life cycle, the risk management is vital to apply in every stage of the project because lacking of dealing with the risk and uncertainty event from the initial to handover stage of the project life cycle may result in failure especially in time, cost and quality of the project also affecting the safety and environment of the project (Hamzah, 2015). In situation of hilly development, the risk management is really important because the hilly area is sensitive zone which minor changes on it will give bad impact to the development and it is surrounding. This paper conducts an extensive review on the major risks that facing by the

contractor in managing their hillside project and also the current practice of risk management plan that the contractors used in managing that risks. The hillside classification and the nature of the risk are also discussed to make in-depth understanding about the risk management for hillside development project.

HILLSIDE DEVELOPMENT PROJECT

Developing a hillside area is categories as risky activity which the minor mistakes in handling this project will cause of damages also lose of fatality. Therefore, the implementation of risk management plan is important to ensure the risks can be identify earlier and the mitigation plan for each of the risks can be developed as well as to control and monitor the risk. In Malaysia, the classification of hillside is based on Malaysia Guidelines named *"Malaysia Guidelines on Development Planning for Hilly and Highland Area"* by Ministry of Housing and Local Government (MHLG) which has been announced on 2010, hillside is defined into seven (7) categories based on their height from above sea level, such as low land (less than 150m), hilly land (150m-300m), highland (300m-1,000m), mountain (more than 1,000m), hill slope ($\geq 15^{o}$), adjacent area and environmental sensitive area. Then, in perspective of slope degrees, the classification of hillside is divided in four classes which are class I ($<15^{o}$), class II (15^{o}-25^{o}), class III (25^{o}-35^{o}) and class IV ($>35^{o}$) which each of them has different geotechnical limitation, type and criteria of development that suit with each of its land condition. Additionally, there also mix classes area which some part of the development area is touched the Class III and IV area. If the project is located in mix classes' area, the developers need to AVOID Class IV area however, if part of development touched Class III area, EIA report is compulsory for the whole project area.

Moreover, the hillside also can be defines into two areas according to the development risk which the developers and contractors must be concern that the area with natural slope before any development activity started (cut and fill activity) is less than 25 degrees for low and medium development area whilst the area with natural slope more than 25 degrees is noticed as high risk area and some of it is classify as a sensitive area for development because that area is susceptible to the risk like landslide and has physical constrain (Rasip, 2006). Furthermore, it is important to make sure that any hillside development project is fit with its location in term of its density and the types of development to ensure that the hillside planning control is parallel with the element of the environment sensitivity, class attitude and also the level of the disaster risk which the higher the altitude, the higher of environmental sensitivity and the level of disaster risk.

Generally, most of the hillside development regulation in Malaysia is referred to this Malaysia's guideline but for Penang, the local governments has make some adjustment into this guideline to suit with their topography, slope gradient and their development planning. The classification of hillside and the development approval also may slightly different with the federal guidelines. The Penang hillside guideline named "*Safety Guidelines for Hillsite Development*" has been commenced on 2012 for hillside development area under Penang local authorities (MBPP and MPSP). This guideline is highly apprehensive on lesson learn from the previous tragedy related to hilly area like landslide and this guideline was deeply touched on slope classification, design requirement, the qualification of the related engineers and independent checker, and the maintenance of the slopes. Penang hilly area distribution is quite high for Class III (19%) and Class IV (20%) despite the Class I is the biggest area (52%)

followed by Class II (9%) area. This make Penang hillside development is more challenging with the development criteria and condition also needs to be more specific and detailed. The differences between the Federal and Penang hillside guidelines are the classification of slope gradient and the type of slopes. For the slope gradient, normally the classes are divided into Class I, II, III and IV but in Penang, the classes is adjusted into six (6) classes which are Class 1, Class 2, Class 3A, Class 3B, Class 4A and Class 4B and in term of type of slope, Penang also has divided it into natural slopes and man-made slope. Others than that, it will refer to the Federal guidelines and expert judgment as it appropriate to the current situation.

FAILURES OF HILLSIDE DEVELOPMENT

According to Thanapackiam (2012), the future slope failure which the slope failure intensity projection is resulted that 106 slope failures will occur during period of year 2012 to year 2018 and it will goes up 130 slope failures in period of year 2019 to year 2025. Unfortunately, the frequency of the intensity will arise to 154 slope failures around year 2026 to year 2032. This situation has figure out that slope failures in hilly area will be an impending threat to that area and it surrounding. The main factors of this problem are related to the urbanization and population pressures which the urbanization of an area will increase in-line with the population of that area.

Mukhlisin (2010), believed that landslides have posed serious threats to settlement and structures that support transportation, natural resources management and tourism in Malaysia which is more than 100 of hillside area has been identified by Public Work Department (PWD) as risky possible landslides. Series of landslide tragedies happened because of mainly caused by the slope failure like weather triggered factor such as rainfall (Aminudin, 2009), failure of professional to adopt a good planning and manage their project (Rasip, 2006; Too, 2011) and untighten regulation according to slope and soil investigation (Gue & Tan, 2006). Hence, the landslide expert Gue and Tan from G&P Geotechnics Sdn Bhd has conducted an investigation on 2006 to find out the main factors that contributed to the landslide and slope failures. From the investigation, the experts have summaries that the hillside development failures in Malaysia is based on five main factors which are design errors (60%), construction errors (8%), design and construction errors (20%), geological features (6%) and maintenance (6%). Meanwhile, in Penang, See-sew and Gue (2014) indicate that there are four main causes of slope failures which are causes from the (i) improper design with an inadequate site (ii) failures in making a proper planning for the whole construction phases (iii) lack on doing maintenance for existing and completed project also (iv) lack in communication and selfishness among the construction parties. Then Qasim, (2016) has summarized the causes of failures in hillside development according to the latest landslide tragedy in Malaysia (as at 2012 to 2016) as human negligence which related to the improper planning and investigation for their project during the construction process.

From these studies it can be seen that a proper planning, monitoring and controlling the project from the initial stages is important which each of the project parties needs to be co-operate and sharing their knowledge, problems of the projects and solving the problems together according to the previous experience, lesson learns or other current method that fit for the problem that has been befallen. One of the most important methods that have been negligence by many of the developers, contractors and consultants in managing their project is a risk management plan. This risk management plan is important to identify the risks that

will occur in the proposed project and the project parties/team will analyse the risks and come out with the solution to face the risk properly either to accept, reduce, avoid, transfer or share the risk. Then, all the planning that the project team has been identified will be used in monitoring the project successfully.

RISK MANAGEMENT PLAN

In construction project, there are lots of risks that we need to confront and manage to ensure that the project deliver in a good quality with affordable cost and in a right time as per agreed by the developers/contractors with their client. In managing the risk, the first step that the contractors/developers must do is to comprehend the nature of the risk and the uncertainty because when they understand, it will facilitate for them to identify and discriminate the risks occurs in their construction project (Hamzah, 2015). The risk is not only referred to the negative event but sometime, it can be a positive event or usually called as opportunities which both of these are associated with one another and it can affect the project objectives (Jaafari, 2001; Bunni, 2003; Loosemore, 2007; PMI, 2013). In other view, the risk may have one or more causes of it occurrence and impacts which a cause can be a given or potential requirement, assumption, constraint, or condition that creates the possibility of negative or positive outcomes (PMI, 2013). According to these definitions, the simple keyword to summarize the risk which the risk is an event either positive or negative that must be handle and manage properly as they will affect the project progress and performance, the smarter way you manage the risk, the lower of risk that you will face and the higher opportunities you will get it.

Classification of Risks

In classified the risks, there are two main categories that has been proposed by the Merna and Smith in 1996 which are (a) *global risk*, most of the global risk is associated with the government provision and regulation changes which the project team cannot argue and the project needs to follow the requirement and the situation that has been stated and happen such as legal risk, political risk, commercial risk and environmental risk (b) *elemental risk*, the risks can be control and manage by the project team or organization itself although the global risks are happen but the way they handle the risks is something that can affect the project progress and the implementation like financial risks, operational risks, implementation risks and revenue risks. Additionally, according to the previous studies about risks in the general construction industry, the researchers have categories the risks into several main group such as physical risks, design and technical risks, construction risks, financial & market risks, political and regulation risks, legal-contractual risks, safety and security risks, environmental risks, personnel risks and time risks (Cheng & Hamzah, 2013; Xianbo, 2013; Ilke Kardes, 2013; Chen Wang, 2015). Due to the common risks that has been listed above, this study has recorded an additional risk group that related to the hillside development project according to the literature review that has been done which are integrated under category of slope stabilization group. These risks groups are dealing with designing the slope stabilization and it depends on the experience and knowledge from the specialist including contractors such as relate to the geological condition of the slope and area, natural slope stabilization, improper slope design, improper in cut and fill the slope, lack of experience in handling the slope stabilization, design not compatible with the slope, inadequate geotechnical investigation and inadequate site investigation. For this study purpose, this risk group is important to be add on

into the establish risk groups as discussed when developing hillside development because once the slope stabilization risks occur, it may give huge impact to the development project, not only for the project but also to its surrounding area. Figure 1 has shown the theoretical framework of risk management plan and risk groups in construction industry.

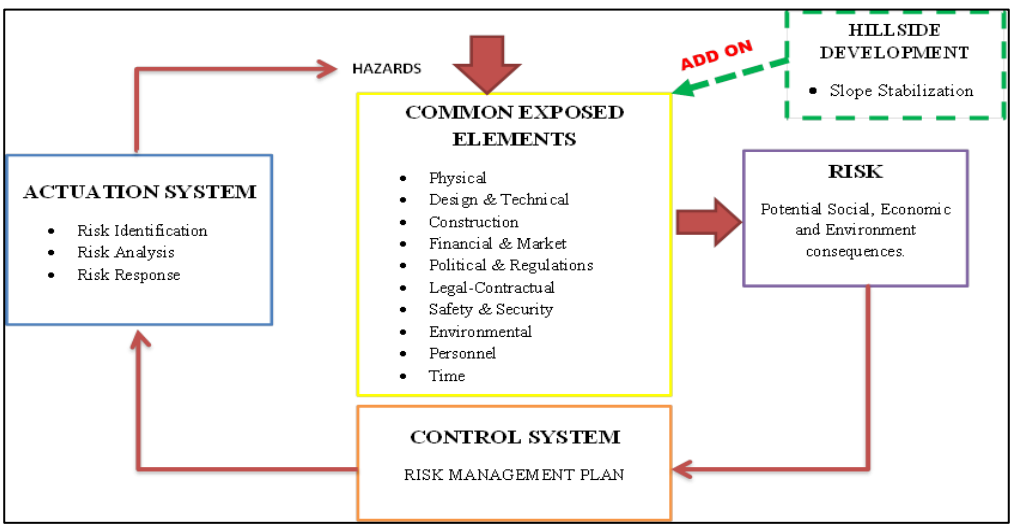

Figure 1. Theoretical Framework of Risk Management Plan and Risk Groups in Construction Industry.

Risk Management Process

Risk Management can be defined as a systematic process of identifying, analysing, responding, controlling and monitoring the project risk. The aims of the risk management plan is not to remove all the risks that occurred during the project progress but to properly manage the risks in a good way either to avoid, accept, reduce, transfer or share the risks so it does not impact negatively on the project by using an appropriate tools and technique which can support the decision maker in handling the risk in a brilliant and smoother way (Byoung, 2015; Hamzah, 2015). In carrying a risk management plan, all project teams including the client, contractor, design team, quantity surveyor, engineer and so on are responsible in managing the construction risk and aware of the effect of those risks. All the project team must collaborate to create a risk framework which this framework is important to help the teams in making a good decision on how to handle or treat the risk and fine the best treatment strategies for each of the risk to ensure the project could be delivered on time and within budget also with high performance (Chen Wang, 2015). The main process of risk management are risk identification, risk analysis (quantitative and qualitative methods), risk response (avoid, accept, reduce, transfer or share) and risk controlling & monitoring (Figure 2). These processes have the sequences between the input, tools & technique and outputs of each action that they are taken.

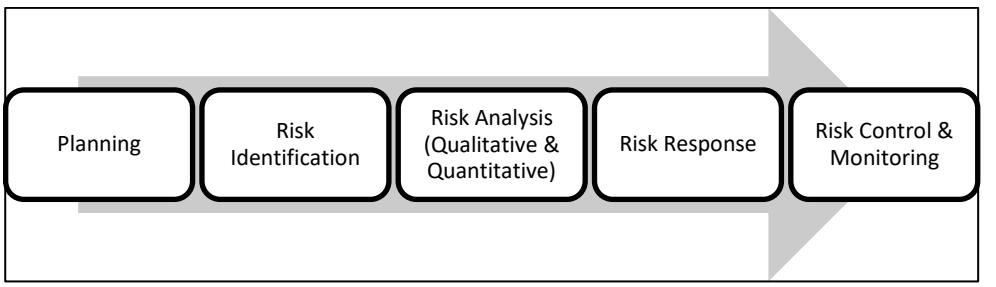

Figure 2. Risk Management Process

RESEARCH DESIGN AND METHODOLOGY

In producing an accurate data for this study, it was design as a qualitative research by using the case study as a strategy of the research and semi-structured interview as a research technique. For this study, five contractors are selected based on their on-going project on the "risky area" as categorized by the Ministry of Housing and Local Government (MHLG) in 2010 for Penang Island which are Batu Feringgi, Balik Pulau, Bukit Gambier, Paya Terubong and Persiaran Bukit Jambul. An interview schedule was constructed to make sure the data can be collected more structured and meet the objective. The interview schedule has divided into four sections which are respondent's profile (important to figure out the respondent's experience and projects on hillside development project), risk awareness and understanding (to investigate the level of contractor knowledge and awareness in term of nature of risk and risk management plan in construction industry), major risks in hillside project (to identify the most influence risk groups in their hillside project) and risk management plan (to find out their risk management practice that they used in manage their risks). Then all the data has been analyse using content analysis by assigning codes which may be in numbers and words to specify the same words or characteristics within the texts.

RESULTS AND ANALYSIS OF FINDINGS

After all the data collection and data analysis has been done, results have been shows that all five respondents are categories in G7 and class "A" contractors according to the CIDB and PKK registration which means the contractor is allow undertaking contracts with no limit to the contract sum and categorized as established and have strong capabilities in term of financial, specialization and experiences. Adding to that, 60% of the respondents have more than 21 years experiences in construction industry with more than 10 years experiences in handling hillside development projects. Then, to strengthen the capabilities of the contractor's as respondents, their experience in handling construction project within the last five (5) year also discovered which the results shows that 80% of the respondents are managing more than 3 construction projects with 40% of it are managed more than 10 projects successfully within this period. In term of their knowledge and awareness on risk management, all of them aware the existence of risk and risk management plan in construction project. The data obtained from the interview can be considered as accurate because the selected contractors were accustomed in managing huge and complex construction projects, at the same time they have experiences in dealing with variety of construction risks from the minor into the greater risk.

In identifying the major risks that associated with hillside development project, the respondents are requested to indicate the five major risks that can give them huge impact to their hillside development. There are eleven (11) risk groups have been presented to them with the list of the risks that associated with each of the risk groups including the physical, design & technical, construction, financial & market, political & regulations, legal-contractual, safety & security, environmental, personnel, time and slope stabilization. From this eleven (11) risk groups, five (5) of the major risks are chosen by the contractors are risks that associated with the design & technical, construction, safety and security, time and slope stabilization. However, in ranking the most risky to the less risky according to that risk groups, the contractors have indicates that slope stabilization is the major risk to them with 33% followed by design & technical (27%), construction (20%), safety and security (13%) and time (7%).

In term of current risk management practice that has been implement by these respondents, the result shows that in risk identification, majority of the respondents compatibly used learn from the previous experience, brainstorming and existing checklist method to identify the risks in their project. Moreover, in term of risk analysis, the expert judgment is the main method that they like to use in analysing the risks that occur in their project because in their perspective, the hillside development is very fragile, if they do wrong in predict the solution for the risk, it might get them in a problem. Due to that, the expert judgment is the safe way for them to get an accurate and faster solution. In other way the decision tree also are used to support the expert judgment analysis. Then, in response to the risks, all the contractors have thought that they will look the types and the complexity of the risks. If the risks are in small and light categories and they never go through it, they will refer to their past experience the way they manage the risk either they accept or reduce the risks but if the risks in categories in complicated and big, they encourage transferring the risks to the expert. By gather all the risks and the mitigation plan that they have planned all five (5) contractors control and monitor all the risks progress on-site and also in their planning as often as possible to ensure the mitigation plan are suit with the risks.

CONCLUSION

As conclusion, the hillside development's contractors have practice the risk management plan in their project but the way they do are still unofficial as it should be. It can be said that the current practice for official risk management plan is in moderate level because the contractors used the common methods in identifying, analysing the risks and not document it into proper risk management plan documentation or report. To encourage the contractors in implement a proper risk management for their project, more training programme should be offer to expose these important persons into an official risk management plan either for small development nor mega development. The high co-operation and good relationship between all the parties involved in the development also should be nurtured and encourage to build up the compatibility and good communication in managing the risk management plan into their project especially hillside development project. This study is important for those related to hillside development to extra aware in managing their development project that highly exposed to the risks.

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KNOWLEDGE RETENTION FOR SUSTAINING COMPETITIVE ADVANTAGE IN CONSTRUCTION INDUSTRY: A CONCEPTUAL

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Abstract
Knowledge is an important resource for the companies to remain active and perform in business environment. It is also a valuable resource for the improvement of the company's competitive advantage. Similar to other companies, construction companies also depend on ideas, knowledge and experience from various sources to meet the stakeholder expectations and requirements. However, and most unfortunately, construction companies are losing their knowledge due to as knowledge is remaining in the mind of the individual. There are several strategies in managing knowledge effectively including knowledge transfer, knowledge retention, knowledge acquisition, knowledge conversion, knowledge application and etc. Among others strategies, knowledge retention is the most significant strategy to retain knowledge in the organization, as this strategy is the first effort to ensure organization knowledge is retain in the organization before effectively managing its. The objective of this paper is to provide a comprehensive literature on the concept of knowledge retention, competitive advantage and develop a research model that can be a direction to undertaking further study that will benefit key players, other stake holders and researchers in built environment discipline.

Keywords: *Competitive Advantage; Construction Industry; Knowledge Management; Knowledge Retention; Performance*

INTRODUCTION

The construction industry is one of an important sector for the development of the nation. As one of an important sector, construction industry plays a vital role in the development of other sectors as an enabler to the growth of other industries (Ibrahim et al., 2010). Nowadays construction industry is facing many challenges due to the phenomena of globalisation, market penetration, the liberation of trade, knowledge economy and the rapid changing in technology. To stand in the challenges, construction companies must search a right strategy to sustain and compete and achieve competitive advantage in today's turbulent business environment.

One of the factor that can influence the competitive advantage is the organization knowledge (Hitt et al., 2001). In today's challenging environment, knowledge has become a powerful resource for the company to success. The traditional resources such as land, labour and financial capital have become secondary (Chen et al., 2006). Thus, companies that proper reuse of existing knowledge gained via experience can greatly shorten the time spent on problem solving, increase the quality of work (Othman et al.,2016; Dave & Koskela, 2009) and can derive organisations to become more adaptive, innovative, intelligent and sustainable (Wong & Aspinwall, 2004). Knowledge becomes valuable resource to organisations due to its characteristics that cannot be duplicated or imitated (Abu Bakar et al., 2016) These advantages help the organisations that effectively utilized knowledge in their operations, productions and services to keep their competitive edge. Based on resource-based view (RBV), knowledge has been considered as an important strategic plan and resource, which is called "intellectual capital" (Stewart, 1997). Intellectual capital is determined as a knowledge

that can be converted into profit and achieve competitive advantage (Harrison & Sullivan, 2000). While, knowledge-based view (KBV) considered knowledge as the most important strategic resource and consider the organisation is heterogeneous entities load of knowledge (Hoskisson et al., 1999).

Construction industry can be considered as knowledge based industry (Esmi & Ennals, 2009). Most of the construction projects as well as small projects need ideas, knowledge and experience from various sources to meet the stakeholder expectations and requirements. However, and most unfortunately, construction companies are losing their knowledge. This is because knowledge is remained in the mind of the individual. As a project based industry, construction companies always losing their valuable intellectual assets when many employees leave the organisations as employees are projected loyal rather than company loyalty (Esmi & Ennals, 2009). The loss of knowledge also because of the practices of employee downsizing. The employee downsizing is important strategy to improve the performance of organization, however it's often results in loss of critical knowledge, skills and experience, leading to deteriorating quality, productivity and effectiveness (Schmitt et al., 2011).

The importance of knowledge retention therefore need not be laboured, because as Price (2000) asserts, ''most successful organisations are those which make best use of their employees''. Knowledge and expertise of construction workers, is considered a valuable asset towards competitive advantage due to intrinsic characteristics of the industry. Thus, through effective practices of knowledge retention strategies, the competitive advantage of construction companies might be enhanced.

REVIEW OF RELATED LITERATURES

Knowledge

Previously a knowledge has been linked with terms such as data, information, intelligence, skill, experience, expertise, ideas, insight, which entirely depends on the context in which the words are applied. The definition of knowledge is believed firstly to appear in Plato's work which views knowledge as ''justified true belief'' (Gulley, 2013), and then was subsequently modified by Nonaka and Takeuchi (1995) to: ''a dynamic human process of justifying personal belief toward the truth'' at the organisational level. It also can be defined as information that is relevant, actionable and based at least partially on experience (Leonard and Sensiper, 1998). Knowledge has also been defined as 'know-why, know-how, and know-who', or an intangible economic resource from which future revenues will be derived (Rennie, 1999).

Knowledge can be divided into two main categories namely tacit knowledge and explicit knowledge. Tacit knowledge is accumulated through learning and experience; often, it is referred to as 'learning by doing' (Reed & DeFillippi, 1990). In other word, tacit knowledge is acquired by individual from non-formal and informal learning mostly at work station. In contrast to tacit knowledge, explicit knowledge can be formalized, codified and communicated. In fact, explicit knowledge is revealed by its communication while tacit knowledge is revealed through its application (Spender, 1996). Within the construction industry, knowledge is mainly in the form of tacit knowledge (Esmi and Ennals, 2009). The examples of tacit knowledge in the construction sector including an understanding the

construction process, the skills in handling the process of estimating and tendering, the experience of preparing bids, the communication skill in liaison with clients and project team members and also understanding the tender markets (Anumba et al., 2005). The examples of explicit knowledge include design codes of practice, performance specifications, drawings on paper-based or electronic format and construction techniques (Anumba et al., 2005).

Knowledge Retention

Knowledge retention is an important part of knowledge management processes. Knowledge retention might be referred to an individual's direct experience, observations and knowledge, routines, organizational processes and practices and culture (Schmitt et al., 2012). The following are three specific questions that must be asked when considering knowledge retention and any potential risk of loss of knowledge (Kirsch, 2008):

- What knowledge may be lost?
- What are the organizational consequences of losing that knowledge?
- What actions can be taken to retain that knowledge?

One of the most significant challenges for any organization is to get on the "front edge" of any potential knowledge retention challenge rather than waiting until organizational knowledge "walks out the door" (or is walking toward the door, such as in typical "exit interview" efforts to retain knowledge). The organization should focus knowledge harvesting efforts on obtaining as much information about its projects and processes, including the implicit knowledge that is often not directly documented. A key reason for performing knowledge retention is to grow the institutional memory of the organization. In this manner, employees can learn from past successes and failures to ensure positive results. Learning from others could help avoid going down the wrong paths or reinventing the wheel (Liebowitz, 2009).

Competitive Advantage

Competitive advantage can be define as "the prolonged benefit of implementing some unique value-creating strategy not simultaneously being implemented by any current or potential competitors along with the inability to duplicate the benefits of this strategy" (Hoffman, 2000). Competitive advantage can result either from implementing a value-creating strategy not being employed by current or prospective competitors or through the superior execution of a strategy which is also being employed by competitors (Bharadwaj et al., 1993), it is sustained when other firms are unable to duplicate the benefits of this strategy (Barney, 1991). Competitive advantage is recognised as the objective of organisational strategies (Porter, 2011), which can be measured in many dimensions such as innovativeness, market position, mass customisation, and difficulty in duplication.

Innovativeness applies to a culture where the generation, acceptance, and implementation of new ideas, processes, products, and service are the norm (Hurley & Hult, 1998). Innovativeness is almost seen as identical with competitive advantage. In most of the literature, it is accepted generally that innovativeness leads to competitive advantage (Byrd & Turner, 2001). A firm can raise strong barriers to entry for other firms with the relative market position since it is an important component for competitive advantage (Porter, 2011). Mass

customisation allows businesses to offer products and services to a wide range of customers and meet changing product demands through service of product variety and innovation together without increasing the cost (Boynton et al., 1993). Companies from various industries have been using mass customisation to achieve competitive advantage. Lado and Wilson, (1994) contend that the stream of strategy research in general postulate that organisational resources and capabilities which are rare, valuable, non-substitutable and imperfectly imitable establish the foundation for a firm's sustained competitive advantage, as asserted by Barney (1991). If a valuable resource is difficult to duplicate, it is a source of competitive advantage.

One key requirement for corporate success in this competitive environment is recognizing how to sustain competitive advantage. According to Porter (2011), we can create competitive advantage as we make tough choices about what we will do and not do. Competitive advantage is normally defined as the ability to earn returns on investment consistently above the average for the industry (Porter, 1985).

Porter (1980), specifically identifies five competitive forces that determine industry profitability, including rivalry among competitors, threat of new entrants, bargaining power of suppliers, bargaining power of customers, and the threat of substitute products. All of these competitive forces are affected by industry structure or the fundamental economic and technical characteristics of a particular industry (Davidson, 2001). The model allowed managers to examine the attractiveness of the market/industry and set up the most competitive position within that market/industry (Robbins & Wiersema, 2000). Porter (1980) affirmed that the centre of strategy development is coping with competition, and that firms should evaluate their competitive environment, choose their strategies, and then obtain the resources needed to implement their strategies (Porter, 1980). He further proposed that firms have a choice between three generic strategies for achieving above-average performance in a selected industry: cost leadership, differentiation, and focus (or niche orientation).

Knowledge Retention and Competitive Advantage

Knowledge is being recognised as a vital resource and source of competitive advantage in today's dynamic and changing business environment and knowledge economy (Burton-Jones, 2001). There is a general agreement that knowledge retention will represent the most important competitive advantage factor for organisations. Drucker, (1999) proposed that knowledge is not only the advantage resource of business, but also the one and only resource of advantage. Abu Bakar et al. (2016) supported that knowledge will become the ultimate substitute for any other resource. The capability to make good use of knowledge and appropriately manage and apply this of knowledge internally within a firm has become the major criteria for business competition (Prahalad & Hamel, 2006). Abu Bakar et al. (2016) pinned a universal agreement that concerning knowledge has important role as a basis for competitive advantage and superior operational effectiveness. Grant (1996), underlined that one thing that has to be noted is that the advantages of continual competition depend on the efficiency of knowledge integration.

Empirical studies have been proven that organizational knowledge as the source of competitive advantage. There was a common agreement that managing organizational knowledge will symbolise the largest competitive advantage for organisations in the new millennium (Abu Bakar et al., 2016). The development and practice of knowledge

management is continuously and dramatically increasing in organisations. And due to improvements in knowledge management, the race for seeking a competitive edge through knowledge increases at an even faster rate.

The ability to develop and leverage the value of these intangible assets comprises a core competency for organisations, particularly those providing financial and professional services. In these knowledge-intensive organisations, processing knowledge is central to business success (Prahalad & Hamel, 2006). Success in today's global, interconnected economy springs from the fast and efficient exchange of information. Sustainable competitive advantage is no longer rooted in physical assets and financial capital, but in effective channelling of intellectual capital (Seubert et al., 2001).

The long term success of the business is ensured by the retention of the human capital or otherwise employer has to bear the cost when an employee leaves the organisation in the form of loss of human capital and hiring of new employee (Lockwood & Ansari, 1999). The term human capital refers to the knowledge, skills, and abilities (KSAs) embodied in people (Coff, 2002). In this case, human capital determines the success of the organisation. Acton & Golden, (2003) further stressed by realizing the fact that it not only the loss of money and resources but also the loss of knowledge and experience for an organisation which hampers the performance of the organisation. It means that if organisations can create work environment that can attract, motivate and retain hardworking individuals, then organisations will succeed in a better position in the competitive environment with quality and cost-efficiency.

Research Model

This section provides the research model of knowledge retention and competitive advantage. Suggested research model includes two variables namely independent and dependent variable. The dependent variable is presented by competitive advantages of construction companies. Independent variable includes two variables namely knowledge retention processes and knowledge retention strategies. These two independent variables might have a significant impact on the company's competitive advantage.

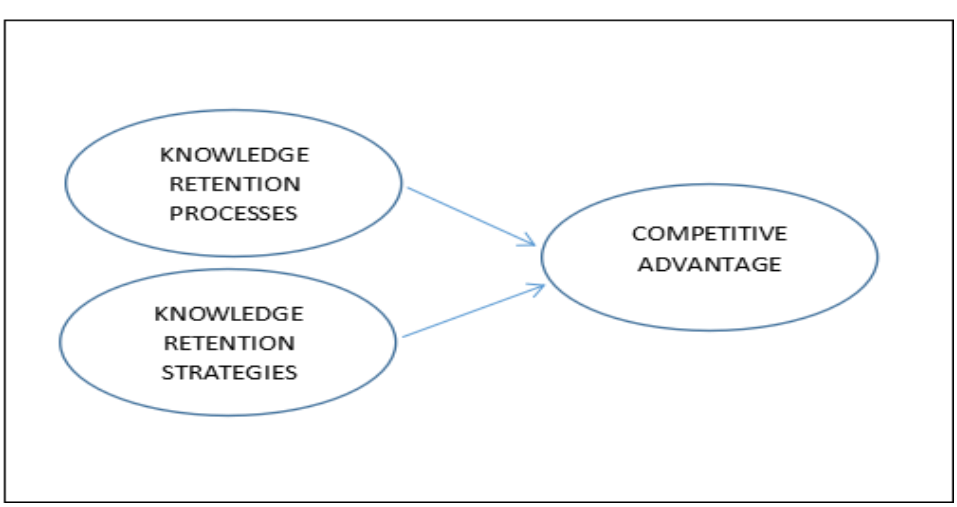

Figure 1. Research Model

CONCLUSION

Knowledge has become one of the key resource for organization's performance and it is critical in today's global economy. With effective of utilization of organizational knowledge, its might has a great impact on the organization's success, and can differentiate them from the competitors. Knowledge retention is the important process of knowledge management that need to be considered in strategic planning. In this paper, knowledge retention is considered as a process of retaining tacit and implicit knowledge within construction companies to enhance company's competitive advantage. As a project based organization, the operation of construction companies mainly depend on experiences, skills, knowledge to ensure the project can be implemented efficiently. Similar to other sectors, construction industry also face with the problem of loss of organization knowledge. Thus this paper try to fill the gap. This effort might beneficial key players, other stake holders and researchers in built environment discipline.

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CONSTRUCTION MANAGEMENT GRADUATES ROLES AND TASKS PORTFOLIO: ANALYSING USING RASCH MEASUREMENT MODEL

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Abstract
This study adopted Rasch Measurement Model in identifying the roles and tasks performed by the Malaysian construction management graduate during their employment. This research involved 156 construction practitioners located in Klang Valley area. The Rasch measurement model was used to analyze the items and respondents' reliability, the items' fit, and the item hierarchy. The findings revealed that the items' reliability index was .83, and the respondents' reliability index was .88. Which the result is considerably good and has a sufficient number of items to measure what it needs to measure in the underpinning theory. The results also found four items were misfits with the Rasch measurement model based on the values of outfit/Infit MNSQ and the z-standardized index. Furthermore, after the Rasch analysis, a roles and tasks portfolio with 10- item measure was identified. It is suggested, the academia and industry can refer to this portfolio in developing the performance assessment and future improvement to the training curricula.

Keywords: *Roles and Tasks; Construction Management Graduates; Malaysian Construction Industry; Industry Requirement; Rasch Measurement Model*

INTRODUCTION

Key to a successful construction project is significantly contributed in-part by highly competence construction managers. The work environment and culture of a construction project is unique compared to the most working condition. Contractors must deal with the nature of constructions which are unpredictable nature, nonlinear relationship, short-term task, working environment, volume, size, multiple feedback possess and physical boundaries (Gould & Joyce, 2009, Mat Isa, 2007; Hassan, 2005). Therefore, construction managers are expected to possess the ability to recognize the degree of uncertainty at any point in the execution of the project and to manage the efforts of others to achieve defined objectives that result in successful completion of the final product (Oberlender, 2000). To achieve the project as set out in the construction contract, construction project manager needs the ability to manage the project well and have the right competency to control, support, motivate and lead the team.

BACKGROUND

Construction management was recognized as a professional discipline, undergraduate and postgraduate degree courses have proliferated into many universities curricular in countries such as Australia, Hong Kong, China, UK, USA and Singapore (Love and Haynes, 2001). In addition, the discipline has steadily gained status and recognition in the eyes of industry clients and other built environment professionals (Fryer, 1997; Love and Haynes, 2001). Furthermore, construction graduates are currently in high demand by contractors in all types

of construction including residential, commercial, industrial, highway and heavy construction (Abudayyah et al., 2000). The diversity of employment opportunities among construction management graduates increasing a need to have a portfolio of skills to work efficiently and effectively with other professions in the industry (Love and Haynes, 2001).

Construction managers' roles and tasks are centered on managing construction resources, the achievement of project objectives, administrative as well as sundry duties; and their responsibilities to the third parties (Mat Isa, 2007). Workers with strong technical, managerial and organizational skills are necessary for the future, and this industry must compete against other industries for such people (Gould and Joyce, 2009). Mat Isa (2007), stressed that construction manager required the ability to interact effectively with people, to manage information to work efficiently, to be able to communicate, motivate and lead individuals and groups. This research aims to identify the roles and tasks performed by the construction management graduates during their employment in the project.

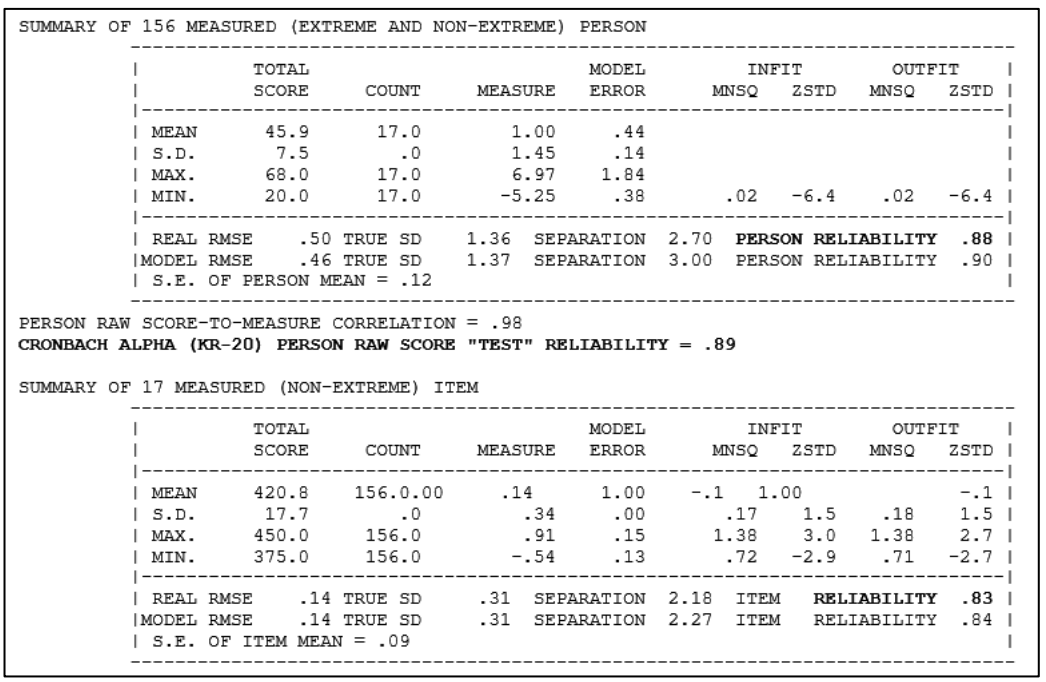
METHODOLOGY

The survey was administered randomly from 2,679 contractors Grade 5 -7 that registered under the Construction Industry Development Board (CIDB). Klang Valley is chosen as a location for this study because of an easily accessible respondent, and majority contractor is located at Klang Valley. The main objective of this study is to identify the roles and tasks performed by the construction management graduates during their first employment. Therefore, Rasch Measurement Model is adopted to analyze the data. Various facets of construct validity can be addressed by Rasch methods, such as fit statistics and item hierarchy (Smith, 2001). This study included investigation of reliability, Item fit, and item hierarchy. Data were analyzed using the Winsteps Version 3.70 software program (Linacre, 2011).

RESULT AND DISCUSSION

Reliability

The summary statistics revealed that the Cronbach- α value was .89 which contribute high reliability of raw score for the instrument in measuring the roles and tasks performed by the Malaysian Construction Management graduates during their first employment. The optimal categorization in which provides the best construct definition, best separates respondents along the variable and produces the best fit of data to model (Lopez, 1996). Table 2 showed “Good” reliability (Fisher, 2007) for both item and person reliability. According to Azrilah Aziz (2010), this is a high value of reliability which means there is a great consistency of a set of questions asked in this particular category, behavior. The instruments can reliably separate the person perception apart.



SUMMARY OF 156 MEASURED (EXTREME AND NON-EXTREME) PERSON

	TOTAL SCORE	COUNT	MEASURE	MODEL ERROR	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD
MEAN	45.9	17.0	1.00	.44				
S.D.	7.5	.0	1.45	.14				
MAX.	68.0	17.0	6.97	1.84				
MIN.	20.0	17.0	-5.25	.38	.02	-6.4	.02	-6.4

REAL RMSE	.50	TRUE SD	1.36	SEPARATION	2.70	**PERSON RELIABILITY** **.88**
MODEL RMSE	.46	TRUE SD	1.37	SEPARATION	3.00	PERSON RELIABILITY .90
S.E. OF PERSON MEAN = .12						

PERSON RAW SCORE-TO-MEASURE CORRELATION = .98

CRONBACH ALPHA (KR-20) PERSON RAW SCORE "TEST" RELIABILITY = .89

SUMMARY OF 17 MEASURED (NON-EXTREME) ITEM

	TOTAL SCORE	COUNT	MEASURE	MODEL ERROR	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD
MEAN	420.8	156.0.00	.14	1.00	-.1	1.00		-.1
S.D.	17.7	.0	.34	.00	.17	1.5	.18	1.5
MAX.	450.0	156.0	.91	.15	1.38	3.0	1.38	2.7
MIN.	375.0	156.0	-.54	.13	.72	-2.9	.71	-2.7

REAL RMSE	.14	TRUE SD	.31	SEPARATION	2.18	ITEM **RELIABILITY** **.83**
MODEL RMSE	.14	TRUE SD	.31	SEPARATION	2.27	ITEM RELIABILITY .84
S.E. OF ITEM MEAN = .09						

Figure 1. Item and Person Reliability

The item reliability in figure 1 is considerably good at .83 which means that there were, sufficient number of items to measure what it needs to measure in the underpinning theory. Meanwhile, the person reliability was .88 indicates high reliability. This indicates that the instrument can differentiate the person ability with the roles and tasks performed by the construction management graduates.

The separation in an instrument should exceed 2.0, with higher values of separation representing the greater spread of items and persons along a continuum. If the statistically distinct levels of item difficulty are defined as difficulty strata with centers three calibration errors apart, then this separation index G can be translated into the number of item strata defined by the test H and similarly for persons (Wright & Master, 1982). The H test formula: $H = (4G + 1)/3$. Where G, is a separation index.

Based on the H test calculation, the number of person strata is 3.93 which indicates that the contractor and construction practitioner can be separated into four group. Meanwhile, the number of item strata is 3.24 which indicates that the roles and tasks can be separated into three important level.

Item Fit on Roles and Tasks

The quality of the item is determined by the attributes point measure correlation. Point Measure Correlation is adopted in identifying either the item is able to differentiate the respondent's ability. Therefore, the PMC value must be within the acceptable parameter which is = x, $0.4 < x < 0.8$ (Bond & Fox, 2007). The further verification is done by looking at the outfit column for Mean Square value. Rasch item fit monitors the compatibility of the raw

item data with the Rasch model expectations and includes two types of fit statistics: (1) the outfit statistics and (2) the infit statistics (Bond & Fox, 2007).

INFIT statistics are sensitive to unexpected behavior that affects response to items. On the other hand, OUTFIT statistics are sensitive to unexpected behavior on items. Curtis and Boman (2007) consider that OUTFIT statistics scores are more sensitive to outliers. A close investigation of case outliers should occur if an item shows an acceptable fit on one index but marginal or poor fit on the other. The OUTFIT Mean Square value, MNSQ must be in the range of $0.5 < y < 1.5$ and ZSTD ±2 logit. Fit statistics higher than 1.5 and below 0.5 with zstd higher and lower than ±2, respectively indicated that these items did not discriminate well or provided redundant information. Items with poor fit statistics should be considered for removal from the roles and tasks portfolio (Wright & Stone1979).

ITEM STATISTICS: MISFIT ORDER

ENTRY NUMBER	TOTAL SCORE	TOTAL COUNT	MEASURE	MODEL S.E.	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD	PT-MEASURE CORR.	PT-MEASURE EXP.	EXACT MATCH OBS%	EXACT MATCH EXP%	ITEM
6	375	156	.91	.15	1.38	3.0	1.38	**2.7**	A .45	.59	61.3	64.7	**SECBTP1**
14	402	156	.35	.14	1.20	1.7	1.27	**2.2**	B .46	.59	62.6	60.6	**SECBS1**
13	421	156	-.01	.14	1.17	1.6	1.22	1.8	C .54	.59	47.7	59.3	SECBPO5
5	429	156	-.16	.14	1.20	1.9	1.17	1.5	D .58	.59	53.5	58.3	SECBCS5
4	415	156	.10	.14	1.09	.9	.99	.0	E .62	.59	61.3	59.9	SECBCS4
12	438	156	-.33	.14	1.05	.5	1.08	.7	F .54	.59	56.8	57.9	SECBPO4
7	414	156	.12	.14	1.03	.3	1.05	.5	G .58	.59	67.1	59.9	SECBTP2
8	425	156	-.09	.14	1.02	.3	1.05	.4	H .60	.59	62.6	59.2	SECBTP3
3	424	156	-.07	.14	.99	.0	.93	-.5	I .67	.59	58.7	59.2	SECBCS3
2	432	156	-.22	.14	.91	-.9	.99	-.1	h .67	.59	61.3	58.4	SECBCS2
9	450	156	-.54	.13	.98	-.2	.96	-.3	g .61	.59	64.5	58.1	SECBPO1
11	440	156	-.36	.13	.88	-1.2	.91	-.7	f .62	.59	63.2	57.9	SECBPO3
1	431	156	-.20	.14	.90	-.9	.87	-1.2	e .58	.59	64.5	58.4	SECBCS1
10	438	156	-.33	.14	.88	-1.2	.88	-1.1	d .63	.59	63.2	57.9	SECBPO2
16	411	156	.18	.14	.81	-1.8	.79	-1.9	c .62	.59	67.7	59.9	SECBS3
17	401	156	.37	.14	.78	-2.2	.75	**-2.3**	b .67	.59	71.0	60.6	**SECBS4**
15	407	156	.26	.14	.72	-2.9	.71	**-2.7**	a .68	.59	69.0	60.5	**SECBS2**
MEAN	420.8	156.0	.00	.14	1.00	-.1	1.00	-.1			62.1	59.4	
S.D.	17.7	.0	.34	.00	.17	1.5	.18	1.5			5.5	1.6	

Figure 2. Item Fit Order

Result from figure 2, show all items are in the acceptable parameter of point measure correlation. This result proved that the items have the capability to differentiate the respondent ability. However, the result identify, items SECBS2, SECBS4, SECBS1 and SECBTP1 are misfit with z-std > ±2 logit. This result indicates that the items are noticeably unpredictable which these items did not discriminate well or provided redundant information.

The items are:

a) SECBS2: Administrative (Site dairies, check drawings, maintain all site records, filing & correspondences)
b) SECBS4: Post-Construction (Handling over, perform contract close-out, performance report, and evaluation)
c) SECBS1: Survey Work (Site setting out, lines & levels, datum's, benchmarks, signage)
d) SECBTP1: Third Parties (Public, Local Authorities, Police, etc.)

Item Hierarchy on Roles and Tasks

Item hierarchy is the ability to identify items on an interval scale, enhance one's capability to understand a construct and recognize potential inadequacies in a given scale (Green, 1996). The most difficult items for the principal to agree with are above the item mean (.00), and the least difficult item for principals to agree with, were items with negative logit.

ITEM STATISTICS: MEASURE ORDER

ENTRY NUMBER	TOTAL SCORE	TOTAL COUNT	MEASURE	MODEL S.E.	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD	PT-MEASURE CORR.	PT-MEASURE EXP.	EXACT MATCH OBS%	EXACT MATCH EXP%	ITEM
6	375	156	.91	.15	1.38	3.0	1.38	2.7	.45	.59	61.3	64.7	SECBTP1
17	401	156	.37	.14	.78	-2.2	.75	-2.3	.67	.59	71.0	60.6	SECBS4
14	402	156	.35	.14	1.20	1.7	1.27	2.2	.46	.59	62.6	60.6	SECBS1
15	407	156	.26	.14	.72	-2.9	.71	-2.7	.68	.59	69.0	60.5	SECBS2
16	411	156	.18	.14	.81	-1.8	.79	-1.9	.62	.59	67.7	59.9	SECBS3
7	414	156	.12	.14	1.03	.3	1.05	.5	.58	.59	67.1	59.9	SECBTP2
4	415	156	.10	.14	1.09	.9	.99	.0	.62	.59	61.3	59.9	SECBCS4
13	**421**	**156**	**-.01**	**.14**	**1.17**	**1.6**	**1.22**	**1.8**	**.54**	**.59**	**47.7**	**59.3**	**SECBPO5**
3	**424**	**156**	**-.07**	**.14**	**.99**	**.0**	**.93**	**-.5**	**.67**	**.59**	**58.7**	**59.2**	**SECBCS3**
8	**425**	**156**	**-.09**	**.14**	**1.02**	**.3**	**1.05**	**.4**	**.60**	**.59**	**62.6**	**59.2**	**SECBTP3**
5	**429**	**156**	**-.16**	**.14**	**1.20**	**1.9**	**1.17**	**1.5**	**.58**	**.59**	**53.5**	**58.3**	**SECBCS5**
1	**431**	**156**	**-.20**	**.14**	**.90**	**-.9**	**.87**	**-1.2**	**.58**	**.59**	**64.5**	**58.4**	**SECBCS1**
2	**432**	**156**	**-.22**	**.14**	**.91**	**-.9**	**.99**	**-.1**	**.67**	**.59**	**61.3**	**58.4**	**SECBCS2**
10	**438**	**156**	**-.33**	**.14**	**.88**	**-1.2**	**.88**	**-1.1**	**.63**	**.59**	**63.2**	**57.9**	**SECBPO2**
12	**438**	**156**	**-.33**	**.14**	**1.05**	**.5**	**1.08**	**.7**	**.54**	**.59**	**56.8**	**57.9**	**SECBPO4**
11	**440**	**156**	**-.36**	**.13**	**.88**	**-1.2**	**.91**	**-.7**	**.62**	**.59**	**63.2**	**57.9**	**SECBPO3**
9	**450**	**156**	**-.54**	**.13**	**.98**	**-.2**	**.96**	**-.3**	**.61**	**.59**	**64.5**	**58.1**	**SECBPO1**
MEAN	420.8	156.0	.00	.14	1.00	-.1	1.00	-.1			62.1	59.4	
S.D.	17.7	.0	.34	.00	.17	1.5	.18	1.5			5.5	1.6	

Figure 3. Item Hierarchy

Result from figure 3 shows every item has a small measurement error mean of SE +0.14 logit. The spread of logit scale shows the maximum item measure value is +0.91 logit, and the minimum values are at -0.54 logit. This is giving a total ruler length of 1.45 logit. The difference between logit max where "Third Parties (Public, Local Authorities, Police, etc.) (SECBTP1) and the min logit min where "Time (Long/medium/short-term programs, monitoring & recording progress, schedules for information requirements, planning & progress meetings) (SECBPO1)" located $\delta = 1.45$. This indicates that the item difficulty of the item spread over 1.45 logit unit. Moreover, item SECBTP1 are observed as the most difficult items to be agreed to be important, while item SECBPO1 the easiest item to agree to be important. Seven items above the item mean which can be considered as not important items in the roles and tasks.

Table 4. Construction Management Graduates Roles and Tasks Portfolio

Num.	Roles and Tasks	Item Measure
1	SECBPO1: Time (Long/medium/short term programmes, monitoring & recording progress, schedules for information requirements, planning & progress meetings)	-.54
2	SECBPO3: Cost / Money (Appraisals, weekly & monthly cost control, assist valuation, claims & payments)	-.36
3	SECBPO4: Health & Safety (Risk assessment, site safety audits, health & safety equipment's, health & safety records/audits, health & safety administration)	-.33
4	SECBPO2: Quality (Prepare & check snag list, supervision, recording of tests, record performance, and quality administration)	-.33

Num.	Roles and Tasks	Item Measure
5	SECBCS2: Material (Take-off, schedule & requisition, Supplier liaison, weekly records, site use, stock checks, storage of materials)	-.22
6	SECBCS1: Staff (Visiting consultants, site/trade foreman, trainees, site supervisors)	-.20
7	SECBCS5: Sub-Contractor (Assist tendering and selection process, issue information/variations, coordination, liaison or works, meeting, initiate general correspondence, progress monitoring, administer quotations, claims, and payments, site measurements, etc.)	-.16
8	SECBTP3: Client, Clerk of Work & Design Team (Query list, variations, day worksheets, confirm verbal instructions, coordination, liaison of works, meetings, initiate general correspondence, reports)	-.09
9	SECBCS3: Labour (Recruitment, dismissal, inter-site liaison/transfer, supervision, direction & motivation, weekly and monthly records, approve wages, prepare working sketches)	-.07
10	SECBPO5: Risk (Risk assessment, risk management plan, project change methodology, compile project change, recommended preventive and correct action)	-.01

Result from table 4 shows the list of important roles and tasks portfolio that need to be performed by the construction management graduates. All industry personnel agreed, to easily endorse ten items that below Item Mean (negative logit). Based on the result, 50% of the items are the roles and tasks in achieving project objectives (SECBPO1, SECBPO2, SECBPO3, SECBPO4, and SECBPO5). Furthermore, 40% of the items are the roles and tasks in managing the construction resources (SECBCS3, SECBCS5, SECBCS1, and SECBCS2) and only 10% of the item is the roles and takes in communicating and responsibilities towards third parties (SECBTP3). Meanwhile, there are no role and tasks items in undertaking the sundries activities, and administrative duties is agreed to be important

CONCLUSION

As a conclusion, Rasch help to measure construction management graduates roles and tasks. The item fit is managed with careful manner and fits with the roles and tasks portfolio. The main research objective is to identify the roles and task portfolio for construction management graduates is achieved and successfully discussed using Rasch Measurement Model. This research identified that industries required construction management graduates to perform the roles and tasks in achieving project objectives, managing the construction resources and communicating and responsibilities towards third parties. This portfolio can be a platform for academia and industry in developing the performance assessment and future improvement to the training curricula.

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DEVELOPMENT OF ALTERNATIVE DISPUTE RESOLUTION IN THE IRANIAN CONSTRUCTION INDUSTRY

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Abstract
The purpose of this paper is to investigate and development of Alternative Dispute Resolution (ADR) methods in the Iranian construction industry. ADR methods were developed to acquire suitable solutions. From the research findings, despite the existence of laws for ADR methods, ADR has not been developed in Iran, and the infrastructures are not available for its development. Therefore, the Litigation process remains the main method of resolving disputes. If ADR is developed, it can be effective in resolving disputes in the construction industry and yield positive results. The potential of binding methods of ADR for dispute resolution in the construction industry is about 2.25 times that of non-binding methods. Mixed Method and Concurrent Triangulation Strategy have been used to carry out the investigations. The qualitative data collected for this research was through semi-structured interviews with 30 experts, and the quantitative data was collected through questionnaires with 112 experts.

Keywords: *Alternative Dispute Resolution; Construction Claims; Iran*

INTRODUCTION

If disputes are not resolved promptly, they tend to be prolonged and escalate creating a more complicated and less manageable scenario. They evolve into severe cases between parties involved, damaging the work environment and significantly increasing the cost and duration of projects (Nawi et al., 2014; Marzouk et al., 2011; Cheung et al., 2002; Hartman & Jergeas, 1995; Fisher, 1991).

The traditional dispute resolution technique is litigation. They were put in place for dispute resolution but litigations tend to be lengthy and costly processes in resolving construction dispute. The perceived shortcomings of litigation with its associated escalations in costs, delays, and adversarial relationships (LTSF, 2013; Brown & Marriott, 1999; Fenn & Gameson, 2003) have led to the emergence of other dispute resolution techniques (Glasner, 2000; Treacy, 1995) with benefits including faster resolution, lower costs, preservation of relationships and flexibility which have been emphasised by researchers. These methods are known as Alternative Dispute Resolution or by the acronym ADR (Chaphalkar & Patil, 2012; Chong & Rosli, 2009; Harmon, 2003; Cheung, 1999).

Despite that there are some codified laws on arbitration and compromise within the Iranian legal framework, the methods have not been developed but rather virtually abandoned and have not been in use practically (Darvishi, 2005; Yusifzade, 2004; Katvzyan, 2003) leaving the litigation process as the preferred method for dispute resolution. However, such an approach is associated with disadvantages such as the disruption of previously valuable relationships between parties, high cost and time consumption of such processes (Dorri, 2014; Harrisi, 2011; Darvishi, 2005).

Furthermore, the litigation proceedings are famous for being prolonged in Iran as compared to other countries (Dorri, 2014). Therefore, this study examines the existing status of ADR methods and assesses the potential for their development.

RESEARCH METHODOLOGY

Mixed method and Concurrent Triangulation strategy have been used to carry out the investigations. The qualitative data source collected for this research was through semi-structured interviews with 30 experts from five construction disputes involved groups in Iran including; contractors, owners, consultants, official experts and lawyers. Table 1 shows the experts' attributes. Qualitative content analysis and inductive approach were used to analysis the data. Furthermore, Maxqda software was used to manage and organize complete interview transcripts and facilitate the qualitative data analysis process. Figure 1 shows steps of the qualitative data analysis.

Table1. Attributes of Interviewees

Interviewee codes	Document group	Experience	Degree	Field of degree
E1	Lawyer	8	PhD	Private & commercial law
E2	Lawyer	7	master	Private law
E3	Lawyer	7	PhD	Private law
E4	Lawyer	8	PhD	Private law
E5	Lawyer	10	master	Penal Law
E6	Lawyer	10	master	Private law
E7	Legal expert	30	graduate	civil-water
E8	Legal expert	40	master	construction
E9	Legal expert	20	master	architecture
E10	Legal expert	30	graduate	civil engineering
E11	Legal expert	40	master	construction
E12	Legal expert	20	graduate	civil engineering
E13	Contractor	30	master	construction
E14	Contractor	15	graduate	civil engineering
E15	Contractor	34	master	construction
E16	Contractor	25	master	Foundation
E17	Contractor	10	master	architecture
E18	Contractor	20	graduate	civil engineering
E19	Consultant	12	master	structures
E20	Consultant	25	master	civil engineering
E21	Consultant	8	PhD	Construction management
E22	Consultant	14	master	architecture
E23	Consultant	15	master	earthquake
E24	Consultant	15	graduate	civil engineering
E25	Owner	17	master	structures
E26	Owner	22	graduate	civil engineering
E27	Owner	15	master	structures
E28	Owner	15	graduate	civil engineering
E29	Owner	32	graduate	law
E30	Owner	20	master	Project management

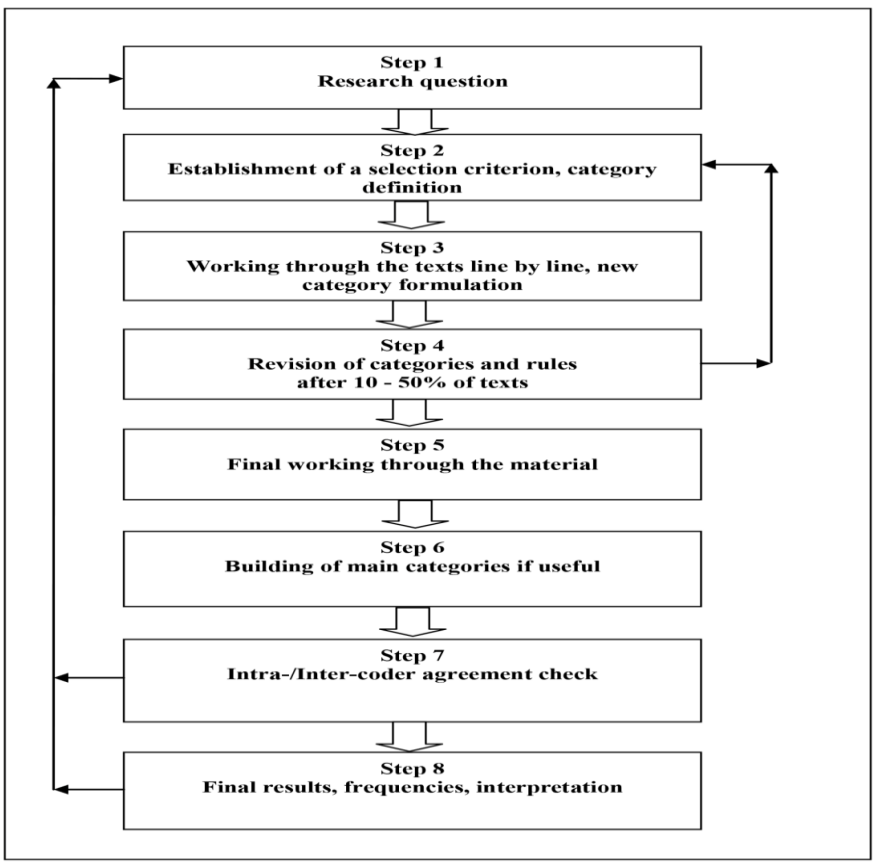

Figure 1. Steps of data analysis (Mayring, 2014)

Random sampling approach was followed in the quantitative data collection phase. Official experts of grade E1 were defined as the group of the most specialised experts which included owners, contractors and consultants and they were selected as the population to fill the questionnaire. The population of construction official experts of grade E1 hosted 307 experts among whom 200 experts were randomly sampled for the sake of the questionnaire. Ultimately, of the 200 experts invited to fill the questionnaire, 112 experts admitted to participate. Figure 2 shows their work background. 59.82% have more than 15 years, and 91.96% have more than 10- years work background.

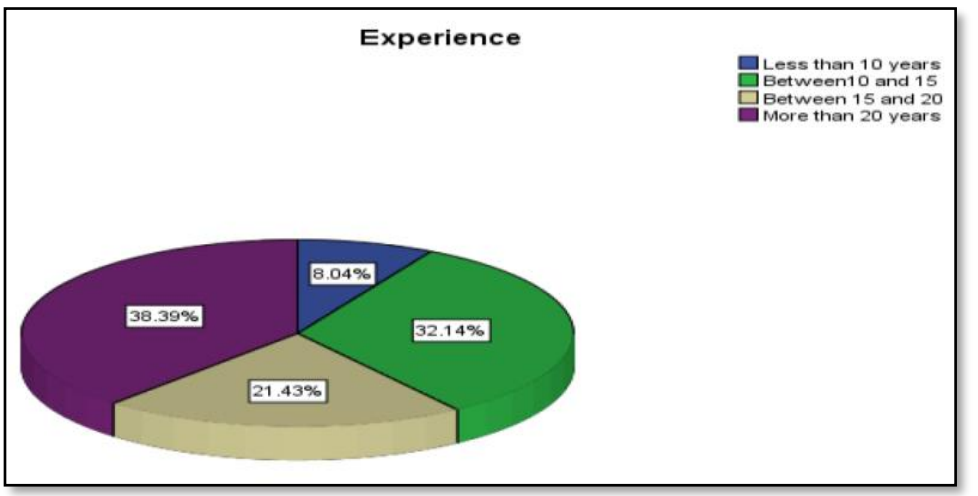

Figure 2. Experience of respondents

Table 2 shows that 42% of the respondents had backgrounds as contractors, 33% as consultants and 25% as owners. In this study to analyse quantitative data, descriptive and inferential statistical techniques were used by applying SPSS software version 20.

Table 2. Background of respondents

Background	Frequency	Percent	Valid percent	Cumulative percent
Contractor	47	42.0	42.0	42.0
Consultant	37	33.0	33.0	33.0
Owner	28	25.0	25.0	100.0
Total	**112**	**100.0**	**100.0**	

Necessity of the Development of ADR Methods in Iran

Raising the numbers of cases in courts and the length of court's processes has revealed the need to develop out-of-court methods for dispute resolution. Thus, to reduce the reference of people to courts, Dispute Resolution Councils were established. These councils only settle affairs with no great legal importance or with lowers complicated nature (Centre for Dispute Settlement of Whole Country Council, 2009). According to the current statistics, it became apparent over time that these councils are not considerably helpful (Centre for Dispute Settlement of Whole Country Council, 2013). Therefore, the underdevelopment of ADR methods gets worse every day.

The Research Centre of the Islamic Consultative Assembly claims that development of ADR methods not only has a direct impact on the improvement of legal cases and settlement situation, but it also has an impact on greater goals, such as economic restructuring or stress management in society. According to the Research Centre of the Islamic Consultative Assembly, development of ADR methods is crucial for the following reason (Ranjbar, 2003).

a. Contributing to reform the courts;
b. Avoid inefficient or corrupt judiciary;
c. Increase public satisfaction and contentment;

d. Provide access to dispute resolution and justice for the deprived groups of society;
e. Reduce costs and time of settlement of disputes;
f. Increase civic participation and facilitate economic recovery and;
g. Affect managing the crisis of development programs.

There is an urgent need to develop ADR methods in the construction industry due to the complexity of disputes, importance of time and maintaining of relationships. Many studies have identified that inadequate dispute resolution would jeopardise the project success (Werderitsch and Krebs, 2000; Cheung, 1999; Pinnel, 1999; Merna and Bower 1997). General Condition of Contracts' disputes resolution mechanisms are impractical and ineffective (Saeb, 2012 & Harrisi, 2011). In this regard, like the other countries in the world, litigation in Iran has some disadvantages including damages to relationships, cost and time-consumption and shortcomings of the general conditions of the contract dispute resolution contractors which all lead to litigation (Harrisi, 2011). Furthermore, prolongation of the proceedings in Iran as compared to that in other countries is tiresome (Dorri, 2014). Furthermore, external risks like political, social, and economic issues are high (Hasheminasab et al., 2014).

As a result, dispute management in the construction industry has become a big problem in Iran, and it has irreversible effects on public projects. One of the reasons for delays in projects is the inability to manage disputes properly (Javadian & Husseini, 2014; Hussein pour and Dodpour, 2012; Parchami and Adlparvar, 2006). Only 9.55% of public projects could be achieved in 2012 (MPO, 2014). Due to the problems caused by inappropriate disputes resolution systems (Harrisi, 2011; Safavi et al., 2010; Atai, 2003), the average forecasted time for completion of the projects is 2.6 years, but they are finished in 10 years (MPO, 2012). A comprehensive research is necessary to identify the barriers to the development of ADR methods, recognise the existing capacity to its development and finally provide a good model of ADR for the construction industry.

Development of ADR methods in Iran

Since the beginning, the legislative Alternative Dispute Resolution mechanisms in Iranian law have been followed in almost the same pattern. These mechanisms that are limited to compromise and arbitration can be predicted in the legal codes. These ADR methods are not shaped as independent organisations or non-governmental organisations (NGOs) and the existing mechanisms are required by the government system. The lack of development of these mechanisms can be due to the following.

a. Lack of a popular tradition such as that in Bangladesh and India.
b. Lack of development of economic and commercial relations in developed countries (Ranjbar, 2003).

Legally, there are few limitations, and the development of ADR methods is possible According to Article 10 of the civil code, the private contracts shall be binding on those who have signed them, providing they are not contrary to the explicit provisions of law. Thus, the parties can make any agreement in their settlement. Civil Procedure Code has set the following limits for arbitration. The following cases may not be referred to for arbitration (ICPL§496).

a. Claims for bankruptcy;
b. Claims for marriage, marriage termination and
c. Divorce. Article 139 of the Iranian Constitution

The convey of claims about public properties to be referred to for arbitration must be approved by the Board of Ministers and the Islamic Consultative Assembly must be notified. If the claimant is a foreigner, the important interior affairs must be approved by the Islamic Consultative Assembly. The important affairs may be defined by the law (IC§139).

Thus, for the development of ADR in the construction industry, there isn't any legal problem but the arbitration on public projects must be approved by the government cabinet. However, the economic state in Iran is a mostly governmentally run while the private sector is undeveloped and unorganised. If the development of ADR methods starts from public projects, the conclusions will be reached sooner and the methods will expand to the private sector quickly. According to the Research Centre of the Islamic Consultative Assembly, if the ADR systems are supported by the public sector and have sufficient funding, they can survive without the government institutions support. However, the political support will have considerable impact on the success, development, sustainability, and pervasiveness of the ADR methods.

The Research Centre of the Islamic Consultative Assembly suggests the following factors as important in the development of ADR methods (Ranjbar, 2003).

a. Suggesting an appropriate ADR mechanism with regard to legal, social, and cultural issues.
b. Considering the needs of the country in dispute resolution issues.
c. Applying an appropriate manner in selection, training, and supervision of mediators or arbitrators (ADR staffs).
d. Finding or creating sufficient financial resources.
e. Establishing a convenient location
f. Using appropriate dispute procedures.
g. Using proper evaluation techniques to select neutrals.
h. Being trusted by people.

DISCUSSION AND RESULTS

Iran's civil law has defined Litigation, Arbitration, Compromise, and the Dispute Resolution Council. But in the meantime, Arbitration and Compromise have been abandoned and the Dispute Resolution Council, in addition to its limitations, is ineffective. In this research, the following four issues are highlighted.

a. The current situation of ADR methods in Iran.
b. Predict the success of ADR methods in construction industry of Iran.
c. Appropriate methods of ADR for dispute resolution in Iranian construction industry.

The current situation of ADR methods in Iran

ADR is not progressing in Iran (C17, f= 30) and the infrastructures are not available for its development. Independent and expert organisations are not available in this field to develop ADR methods (C18, f= 15). While dispute resolution out of the court occurring in a friendly manner is a part of the Iranian tradition, it has gradually lost its previous status. The old methods are no longer responsive to today's needs. The old traditions shall be organised and with a potential of being responsive to issues today (C19, f= 13). Among different ADR methods, Arbitration and Mediation are recognised in Iran (C20, f= 29).

The codes and categories were explained and displayed with some text passages of the expert participants below. The results were displayed in Table 3. This table shows the order of the categories following the frequency of the experts' opinions by which the category was coded.

Table 3. Codes of the current situation of ADR methods in Iran

Codes ordered by their frequencies	Number of experts
C1: ADR methods have not been developed in Iran.	30
C20: Arbitration and mediation are known in Iran.	29
C3: There is no infrastructure for the development of ADR	15
C 4: Although ADR is Iranian long-standing tradition, its use has been declining.	13

C1: ADR methods have not been developed in Iran.

"Unfortunately, modern ADR techniques are underdeveloped in Iran and the traditional methods of out-of-court dispute resolution have also declined." (E1)
"They have not been developed. There must be an independent and specialised institution for dispute resolution that the public has access to." (E3)
"*They are not developed enough and the required foundation is not yet ready." (E7)*

C2: There is infrastructure for the development of ADR

"The main reason for this is limited infrastructure and independent institutions in this field." (E13)
"*They are underdeveloped. If professional organisations are available to settle disputes out-of-court, people will prefer to go for it." (E20)*
"*In general, out-of-court dispute resolution procedures are underdeveloped in Iran mainly because of the limited infrastructure and independent organisations available to handle issues in the field." (E21)*

C3: Although ADR is Iran's long-standing tradition, its use has declined.

"We have not worked on this issue yet. We have to organise and exploit our good traditions in this area so that we can use them to resolve today's disputes." (E7)
"*Although resolving disputes out-of-court is our long-standing tradition, its use has declined gradually. I think we should be equipped with these good traditions to be able to solve today's complex disputes." (E8)*
"*Traditionally, these methods are a part of our culture and are of great values in our society;*

however, they are used less as they may fail to solve today's problems as they are currently that is, the methods have not been updated regularly*." (E17)*

C4: Arbitration and Mediation are known in Iran.

"I am familiar with Arbitration and Mediation. Mediation is not advisable in public construction industries because it requires the engaging parties to ignore some of their rights, which is inadmissible in public projects as executive agents should follow government-set regulations and circulars. If you change the problem description, it will become Arbitration instead of Mediation." (E1)

"*I am familiar with Arbitration. Arbitration is the process where parties choose an arbitrator to settle a dispute that arises between them. The arbitrator's decision is binding." (E4)*

"*… conceptually, in Arbitration, parties choose an individual or organisation to end their dispute(s). The arbitrator decision is then binding. But the aim in Mediation is to reconcile and mediate between the parties, trying to reach an agreement with the mediator having no power to make binding decisions." (E10)*

Predict the success of ADR methods in construction industry of Iran. If ADR develops in the country, it can be effective in resolving disputes corresponding to the construction industry and will yield positive results (C4, f= 23). Some text passages related to this question were displayed in the following sections.

"*Yes, generally speaking, all ADR methods are recommended because both sides will end up being satisfied, with their working relationship still in place." (E2)*
"Yes, all out-of-court methods are recommended." (E8)
"Surly, once further developed and well introduced, it will be successful." (E10)

Quantitative results also confirm the qualitative findings. As Figure 3 shows, 80.36% believed that ADR methods could succeed in resolving disputes associated with the construction industry.

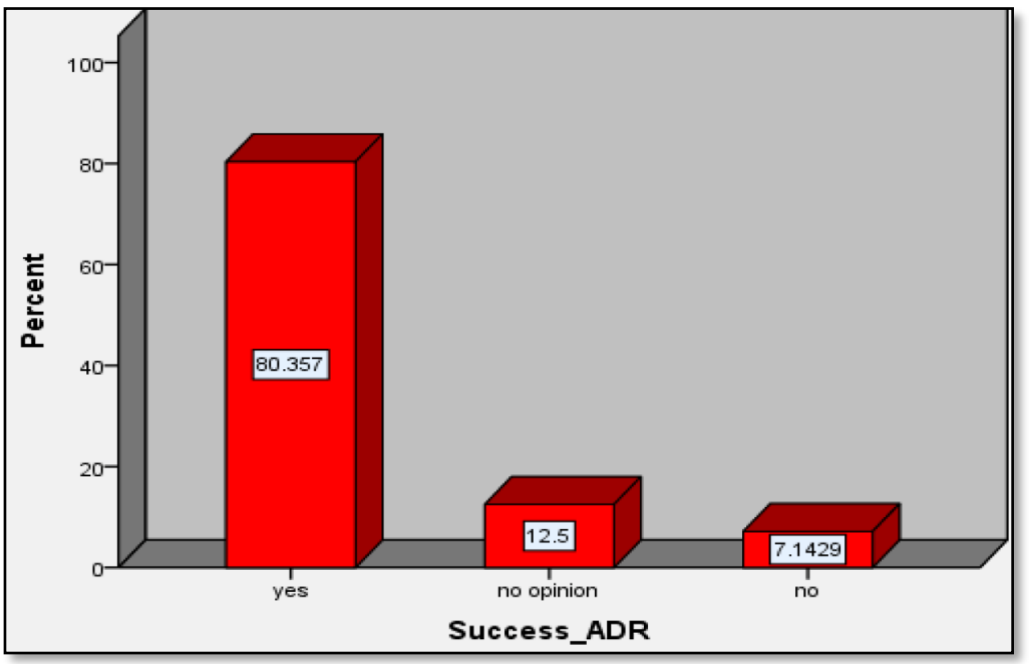

Figure 3. Predict the success of ADR methods in construction industry of Iran

Appropriate methods of ADR for dispute resolution in the Iranian construction industry

Authors classified ADR techniques under two classes, namely Binding (formal) and Non-Binding (informal) procedures (Honeyman et al., 2004; Cheung et al., 2002; Kellogg, 1992). From Non-Binding Methods to Binding Methods, there is a reduced level of control of the outcome and increased level of costs and hostilities (Richter, 2000). According to this research finding the majority of the respondents agreed with the use of Binding methods and believed that Non-Binding methods just make the dispute resolution process lengthy and are not suited for the construction industry (C22, f= 23). Some text passages related to this question are displayed in the following sections.

C5: Binding methods are preferred to Non-Binding Methods.

"*I think the Non-Binding methods are not effective. I prefer Binding specific methods*." (E1)
"*… Binding methods*." (E4)
"*I prefer Binding methods. Non-Binding alternatives tend not to achieve definite outcomes and waste time*." (E11)

The results of quantitative research also confirm that of the qualitative findings. According to the assessment of the quantitative research average of the potential of Binding Methods for dispute resolution in the construction industry, it is about 2.25 times greater than that of the Non-Binding Methods. In quantitative part participants were asked about the potential of two types of ADR namely Binding and Non-Binding for dispute resolution in the construction industry using interval measurement from 1 to 5. For comparison, the Mann-Whitney U test was used.

The Asymp.Sig. = 0.000 value in Table 4 is less than 0.05 which indicates the difference between the Binding and Non-Binding Dispute Resolutions. The interval measurement was converted to ordinal measurement with five levels Very high, High, Average, Low, Very low as seen in Table 5 (the cross-tabulation table). It is observed that the maximum frequency of the potential of Binding Arbitration is at the very high and high (f=101) and the highest frequency of the potential of Non-Binding Arbitration is at an average and low levels (f=79).

Table 4. Mann- Whitney U Test for binding and non-binding methods

Ranks					Test Statistics[a]	
	g1	**N**	**Mean Rank**	**Sum of Ranks**		**m1**
m1	Binding methods	112	**69.20**	7750.00	Mann-Whitney U	1422.000
	Non-binding methods	112	**155.80**	17450.00	Wilcoxon W	7750.000
					Z	-10.384
	Total	**224**			**Asymp. Sig. (2-tailed)**	**.000**
					a. Grouping Variable: g1	

Table 5. Cross tabulation for binding and non-binding methods

	Binding methods	**Non-Binding methods**	**Total**
Very high	57	2	59
high	44	29	73
average	10	47	57
low	1	32	33
very low	0	2	2
Total	**112**	**112**	**224**

If we divide the means of Table 4 (155.8/69.20=2.25), we would see that on average the potential of Binding Arbitration for dispute resolution in the construction industry is about 2.25 times greater than of Non-Binding Arbitration.

CONCLUSION

Despite the existence of laws for ADR methods including Arbitration and Compromise, they are not used to their fullest. ADR has not been developed in Iran, and the infrastructures are not available for further development. Therefore, the Litigation process remains the main method for resolving disputes, although it has disadvantages including damaging relationships, high cost, and time-consumption.

Independent and expert organisations are not available in this field to develop ADR methods. While dispute resolution out of the court in a friendly manner is a part of the Iranian tradition and regarded as a value, it is gradually losing its previous status. Now old methods are not responsive to today's needs. However, the old traditions can be organised and developed to have the potential to respond to current issues. Among different ADR methods, Arbitration and Mediation are recognized in Iran.

If the use of ADR is developed in the country, it can be effective in resolving disputes in the construction industry and yield positive results. The potential of binding methods of ADR for dispute resolution in the construction industry is about 2.25 times that of non-binding methods. Therefore, binding methods such as Arbitration and Adjudication can be more effective in resolving the construction industry disputes.

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KNOWLEDGE SHARING INITIATIVES IN MALAYSIAN QUANTITY SURVEYING FIRMS: WHAT ARE THE PROMOTING FACTORS AND CHALLENGES?

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Abstract
Knowledge Management (KM) has attracted much attention in the construction industry especially with the emergence of the knowledge economy and is also one of the most significant current issues in the construction industry. Thus, the primary aims of this study are to: i) investigate the factors that promote knowledge sharing initiatives in Malaysian quantity surveying (QS) firms and ii) determine the challenges faced by Malaysian QS firms when implementing knowledge sharing initiatives. This study also investigated whether the size of the QS firm affected the factors that promote knowledge sharing initiatives and influenced the challenges faced by these firms. Responses from two hundred and eighty-two (282) quantity surveyors from three hundred and six (306) QS firms were analysed in this quantitative survey. The QS firms were classified into two (2) groups, i.e. small (less than 50 employees) and medium (50 to 250 employees) sized QS firms. The survey (postal, email and web) was derived and developed from semi-structured interviews involving twenty quantity surveyors. The Cronbach alpha (α) values of the 20 items in the questionnaire ranged from 0.813 to 0.872, indicating that the data were reliable. Findings from this study suggest that i) senior management support is the greatest influencing factor to promote knowledge sharing initiatives, ii) the size of QS firms impacted the factors that promote knowledge sharing initiatives, and iii) the size of the QS firm influenced the challenging factors associated with knowledge sharing initiatives. It is recommended that future studies explore the inhibiting factors and organisational readiness when implementing knowledge sharing initiatives.

Keywords: *Challenge factors; Knowledge management; Knowledge sharing initiatives; Promoting factors*

INTRODUCTION

An organisation's ability to acquire, synthesize, manipulate and exploit knowledge has been considered paramount to efficient working in projects and for improving organisational performance (Nawi et al., 2014; Anumba et al., 2005; Bresnen et al., 2003; Egbu, 1999; Scarbrough et al., 1999). According to Wilson (2002), the management of this process is known as Knowledge Management (KM) has attracted much attention in recent years in the construction industry especially with the emergence of the knowledge economy. KM is also one of the most significant current issues in the construction industry because knowledge sharing (one of the stages in KM) is regarded to be the most important process in KM (Issa & Haddad, 2008). The construction industry is a strong, knowledge-based industry that relies greatly on the knowledge contribution of diverse participants in a project team and has become more competitive than ever before. In this competitive environment, knowledge is thought to be the primary resource.

In order to maintain and develop employees' innovative skills further, the construction industry needs to develop their understanding of KM as a key business driver rather than as a resource-intensive additional initiative (Zanjani et al., 2008). To enhance competitiveness and meet their goals, organisations need to ensure that their employees share their knowledge.

Increased sharing of knowledge raises the likelihood of new knowledge being created and supporting valuable innovation (Nonaka & Takeuchi, 1995). According to Egbu and Botterill (2001), Gan (2000) and Egbu (1999a), innovation is viewed as a major source of competitive advantage and is perceived to be a prerequisite for organisational success and survival. Hislop, (2003) recommends that there is a need to explore and improve our understanding of what shapes the willingness (or reluctance) of employees to share their knowledge. According to Davenport and Prusak (1998) little is known about the favourable circumstances that stimulate people in organisations to share knowledge. Giant corporations such as British Petroleum (BP), Chevron, Shell, Hewlett Packard, Buckman Labs and Xerox are examples of success stories of companies that have implemented KM in their business strategies management (Anumba et al., 2005).

Referring to these success stories, Malaysia, in setting its goal as a developed nation by 2020 is attempting to apply KM in their organisations (Mohamed, 2006). Such commitment requires a high level of capability at the economic and social levels, and knowledge management, amongst other business practices, has been adopted in a number of Malaysian organisations to help achieve this major goal. The Construction Industry Development Board Malaysia (CIDB), has collaborated with various organisations representing the construction industry to develop the Construction Industry Master Plan (CIMP) which identifies and recommends measures to address these challenges. CIMP is a comprehensive plan charting the strategic position and future direction of the Malaysian construction industry over the next 10 years. Knowledge sharing initiatives is one of the themes under strategic thrust number 6 in CIMP, which is in line with the government's vision to create a knowledge-based economy. According to the Institute of Strategic and International Studies (ISIS) Malaysia (2002), a knowledge-based economy is defined as an economy where knowledge, creativity and innovation play an ever-increasing and important role in generating and sustaining growth of construction industry.

Thus this preliminary study contributes to the body of knowledge by investigating the factors that promote knowledge sharing initiatives in Malaysian QS firms. This study also attempts to determine challenges faced by Malaysian QS firms when implementing knowledge sharing initiatives (KSI).

The following research objective, research questions and hypotheses guided this study:

RESEARCH OBJECTIVES

1. To determine the important factors that promote knowledge sharing initiatives of small and medium-sized QS firms.
2. To determine the main challenge factors of small and medium-sized QS firms when implementing KS initiatives.

RESEARCH QUESTIONS

1. Do the important factors that promote KSI differ between small and medium-sized QS firms?
2. Do the challenge factors that are associated with KSI differ between small and medium-sized QS firms?

Hypotheses

1. The factors that promote KSI do not differ between small and medium-sized QS firms
2. The challenge factors that are associated with KSI do not differ between small and medium-sized QS firms

Literature Review

Knowledge Management (KM)

The term 'knowledge management' (KM) was first coined by Wiig (1986), cited in Fong and Cao (2004) and since has become the subject of much debate amongst philosophers and members of diverse fields (Nonaka & Takeuchi, 1995). The concept of KM is one that has many different views and interpretations. To some, it is the next stage in information and communication technology (ICT) development; designing software solutions to manage knowledge and this has been classified as the 'codification' approach (Hansen et al., 1999). According to Mason and Pauleen (2003), KM is considered as more than this because it is a social process with a need to take account of social and human factors. The 'personalisation' approach to KM requires an understanding of the social processes and communication patterns that underpin successful knowledge creation and sharing. The success of personalisation strategies is dependent on nurturing an appropriate organisational climate and culture (Hansen et al., 1999).

Bhatt (2001), stated that KM is a process that enables organisations to learn, create, develop and apply necessary knowledge. KM primarily aims to tap and manage knowledge from all members of the organisation to enable sharing and access of information easily. Lee (2002), cited in Fong and Cao (2004), also believed that KM has already been practised in the past, in one form or another. It is an amalgamation of concepts borrowed from the fields of artificial intelligence, knowledge-based systems, software engineering, business process reengineering, human resource management and organisational behaviour.

Knowledge Sharing (KS)

According to Alvi and Leidner (2001) and Earl (2001), knowledge sharing is a key component of knowledge management systems. Based on the taxonomy of knowledge management systems proposed by Earl (2001), Bartol and Srivastava (2002), identified four major mechanisms for individuals to share their knowledge in an organisation, i.e. (i) contribution of knowledge to organisational databases; (ii) sharing knowledge in formal interactions within or across teams or work units; (iii) sharing knowledge in informal interactions within individuals; and (iv) sharing knowledge within communities of practice, which are voluntary forums of employees based around a topic of interest.

Promoting Factors in Knowledge Management

The Nature of Knowledge

The nature of knowledge means the most fundamental and common classification of organisational knowledge is along the explicit-tacit dimension. In this classification, explicit knowledge is considered to be formal and objective, and can be expressed unambiguously in words, numbers and specifications. Hence, it can be transferred via formal and systematic methods in the form of official statements, rules and procedures and so is easy to codify. Tacit knowledge, by contrast is subjective, situational and intimately tied to the knower's experience. Thus, it is difficult to formalise, document and communicate to others. Insights, intuition, beliefs, personal skills and craft and using rule-of-thumb to solve a complex problem are examples of tacit knowledge (Daft, 2001). These two categories are closely interlinked so a bipolar map is difficult to draw in practice.

Motivation to Share

Motivational factors that influence knowledge sharing between individuals can be divided into internal and external factors. Internal factors include perceived power attached to the knowledge and the reciprocity that results from sharing. According to Ipe (2003), external factors include relationship with the recipient and rewards for sharing. Two important elements involved in this relationship are trust, and the power and status of the recipient. However according to Davenport (1997), if individuals perceive that power comes from the knowledge they possess, it is likely to lead to knowledge hoarding instead of knowledge sharing whilst Brown and Woodland (1999), pointed out that individuals use knowledge for both control and defence.

Opportunities to Share

Opportunities to share knowledge in organisations can be both formal and informal. Bartol and Srivastava (2002), referred to these as "formal interactions". Formal opportunities include training programmes, structured work teams, and technology-based systems that facilitate the sharing of knowledge. Whereas the informal opportunities include personal relationships and social networks that facilitate learning and the sharing of knowledge (Brown & Duguid, 1991).

The Culture of Work Environment

Cook and Yanow (1993), mentioned that organisations are essentially cultural entities. Organisational culture is increasingly being recognised as a major barrier to effective knowledge creation, sharing, and uses (De Long & Fahey, 2000). According to McDermott and O'Dell (2001), companies that successfully implement knowledge management do not try to change their culture to fit their knowledge management approach but they build their knowledge management approach to fit their culture. As a result, there is no one right way to get people to share but many different ways depending on the values and style of the organisation. Furthermore De Long and Fahey (2000), mentioned that organisation's culture also shapes the perceptions and behaviours of its employees.

Knowledge Sharing Initiatives (KSI) and Organizational Size

There are many definitions about KSI. According to Karl-Erik Sveiby (2001), KSI are an organisational approach on how companies create value from their intangible assets while Bhirud, Rodrigues and Desai (2005) defined KSI as the events or mechanisms for the purpose of formalisation and sharing best practices and experiences within the organisation. According to Bishop et al. (2008), sharing initiatives are an organisational approach to managing its knowledge which includes human (soft) and components (hard).

Some studies mentioned that the size of organisations and functional areas influence the effectiveness of knowledge sharing activities in and between business functions. Thong (1999), revealed that organisational size is positively related to the organisation's adoption decision of information systems because Dasgupta et al. (1999) highlighted that larger organisations are more likely to adopt information technology. This is supported by Sarvary (1999), who mentioned that large firms with a large customer base tend to perceive a KM system as more useful and have a better chance to apply a KM system to build sustained competitive advantage. However according to Xu et al. (2005) basically there is no major difference in the significant factors of KM between large and small and medium (S&M) businesses across different industry. According to them in today's highly competitive market environment, all the companies have to practice KM and it is quite impossible to survive the severe competition without managing knowledge in the knowledge economy. Connelly and Kelloway (2003), reported that the negative relationship between organisational size and knowledge sharing results from the changes in social interactions.

Statement of the Problem

An organisation's ability to acquire, synthesize, manipulate and exploit knowledge has been considered paramount to efficient working in projects and for improving organisational performance (Anumba et al., 2005; Bresnen et al., 2003; Egbu, 1999; Scarbrough et al., 1999). Most research done on KM had been carried out in large and multinational organizations but little attention was given to small and medium size organizations. According to Ribeiro, (2000) studies on KM has been undertaken in the manufacturing, pharmaceuticals, chemical, financial and information technology sectors while relatively very little has been carried out in construction industries. Kazi (2005), argued that the construction industry has generally been reluctant to pick up new management paradigms but has been willing to see what can be achieved with KM when presented in a form that is understandable to the industry. Grant (1996), stated that the knowledge and expertise created and accumulated by a construction firm represents a strategic asset that can boost competitive advantage. According to Kogut and Zander (1992), a construction firm's knowledge is gained from years of business in which the knowledge created by individuals and teams is combined into a collective knowledge.

Construction firms that are willing to improve their business performance and achieve sustainable competitive advantage in global markets need to implement KM tools that lead to real improvement in their "learning capability". However, few construction firms have implemented KM systems to collect, organise, convert and connect their knowledge systematically (Love et al., 2005). The construction industry is a strong, knowledge-based industry that relies greatly on the knowledge contribution of diverse participants in a project team and has become more competitive than ever before. According to Chen et al. (2006)

employees must be provided with knowledge. In order to maintain and develop their innovative skills further, the construction industry needs to develop their understanding of KM as a key business driver rather than as a resource-intensive additional initiative (Zanjani et al., 2008). However, there is a paucity of research that has investigated the nature of the different approaches to improve the effectiveness of knowledge sharing, the appropriate organisational factors at play for knowledge sharing to be fully exploited, and the knowledge sharing benefits derived by QS firms in Malaysia. Thus this study was carried out to determine factors that promote knowledge sharing initiatives in Malaysian QS firms and the challenges these organisations face with regard to KS.

Methodology

Sample and Data Collection

Nine hundred and eighteen respondents (918) from three hundred and six (306) QS firms were identified to take part in this quantitative survey. The respondents (i.e. quantity surveyors) were categorized into three (3) groups: senior QS, middle-ranked QS and junior QS. The firms were classified into two (2) groups: small (less than 50 employees) and medium (50 to 250 employees). Surveys (postal, email and web questionnaires) were sent/made available to 918 quantity surveyors in QS firms in Malaysia. Two hundred and eighty-two (282) usable questionnaires were received, giving a response rate of 30.7%.

Instrument

The survey instrument in this descriptive study consisted of three (3) parts:

Part 1: Demographics of the respondents (e.g. length of service, current position in organization)

Part 2: Factors that promote KSI and challenges (10 items)

The following Likert-scale was used.

Extent of promotion of KS	1 (Promote to a very high extent	2 (Promote to a high extent),	3(Promote to a low extent)	4 (Does not promote)
Level of challenges of KS	1 (Very challenging	2 (Challenging)	3 (Fairly challenging)	4 (Not challenging)

Part 3: Impact of organisational size on KSI in QS services (10 items)
The following Likert-scale was used.

Impact of organisational size on KS initiatives	1 – Very high level of impact	2 – High level of impact	3– Low level of impact	4 – No impact at all

Data Analysis

Descriptive analysis and Mann-Whitney U Test were employed to analyse the data using the Statistical Package for Social Sciences program (SPSS version 19.0). The Cronbach alpha

(α) values of the 20 items in the questionnaire ranged from 0.813 to 0.872 and were deemed acceptable for a measurement scale.

RESULTS AND DISCUSSION

Promoting Factors Associated with KSI and the Size of Organisation

Table 1. Factors That Promote KSI – Mean Value Comparison According to Firm's Size

Promoting factors	Small	Rank	Medium	Rank	Overall Mean value
Effective senior management support	1.25	1	1.50	6	1.26
Effective and appropriate business strategy	1.29	2	1.36	4	1.30
Adequate resources (including budget and management support)	1.32	3	1.50	7	1.33
Effective and appropriate reward plan and incentives	1.34	4	1.36	5	1.34
Establish an effective organisational culture	1.39	5	1.29	1	1.39
Effective and appropriate organisational infrastructure	1.44	6	1.29	1	1.44
Effective and appropriate KM strategy supported by both IT and non-IT	1.57	7	1.57	8	1.57
Appropriate training and education	1.67	9	1.29	1	1.65
Appropriate organisational structure	1.65	8	1.79	10	1.66
Effective and appropriate knowledge mapping	1.72	10	1.71	9	1.72

The scale: 1 (Promote to a very high extent), 2 (Promote to a high extent), 3 (Promote to a low extent), 4 (Does not promote)

From Table 1, 'effective senior management support', 'an effective and appropriate business strategy', 'adequate resources', 'an effective and appropriate reward plan and incentives', and 'establish an effective organisational culture' are ranked the top five (5) for small QS firms. In contrast, for medium-sized QS firms, the top five (5) are 'establish an effective organisational culture', 'effective and appropriate organisational infrastructure', 'appropriate training and education', 'an effective and appropriate business strategy', and 'effective and appropriate reward plan and incentives'. The inference that can be drawn from this result (Table 1) is that promoting factors are dependent on the size of organisation. This can be implied that when the organisation is getting bigger, the promoting factors will also be different according to the size of the organisation.

For the small QS firms, possible reasons why senior management support is ranked the highest is that senior management support is important for the latter. This is parallel with Liebowitz, (2000) who mentioned that effective senior management support is essential for the prosperity of KM. According to him, without senior management commitment and involvement, KM cannot be carried out successfully. In addition, according to Keramati and Azadeh (2007), top management commitment includes activities such as: active support for KM, setting a personal example, communicating the company's KM value, reinforcing knowledge message, meeting with the workforce and the customers, giving formal and informal recognition of KM, personal training, and training others. In contrast, in medium-sized QS firms, 'establish an effective organisational culture' is ranked the highest promoting factor for KSI. A possible reason why positive culture is the most promoting factor for medium size QS firms rather than senior management support could be drawn from McDermott and O'Dell, (2001) who stated that organisational culture strongly influences knowledge sharing. According to Delong and Fahey, (2000) the impact of organisational culture on the context for social interaction can be assessed by vertical interaction (interaction

with senior management), horizontal interaction (interaction with colleagues on the same level) and special behaviour that promotes knowledge sharing. Furthermore, according to Forbes, (1997) the biggest challenge in knowledge management is not the technical but the cultural. This is confirmed by Smith and McKeen, (2003) who found that organisational culture is the main constraint in KM and also KS. From Table 1, another top ranked in medium-sized QS firms is 'effective and appropriate organisational infrastructure'. This agrees with Egbu and Botterill, (2002) who said that face-to-face meetings, storytelling, quality circles, mentoring and coaching, brainstorming, reports, project summaries and job rotation are considered to be effective in sharing tacit knowledge. The other top promoting factor for medium-sized QS firms is appropriate training and education. This is because medium-sized QS firms consider that training and education are important for their organisation.

The middle ranked for small and medium-sized QS firms comprise of 'establish an effective organisational culture' and 'effective and appropriate reward plan and incentives'. This indicates small QS firms have a flatter structure that promotes a positive culture whilst the medium QS firms confirmed that an 'effective and appropriate reward plan and incentives' could be instituted to encourage knowledge sharing.

'Effective and appropriate knowledge mapping' and 'appropriate organisational structure' are the lowest ranked for small and medium QS firms respectively. The inference that can be drawn from this result (Table 1) is that small- sized QS firms possibly lack the awareness of the importance of knowledge mapping within an organisation. For organisational structure, medium-sized QS firms are possibly more centralised in terms of organisational structure, resulting in less attention to the promotion of KSI (Chong, Chong & Yeow, 2006).

Challenge Factors Associated with KSI

Table 2. The Main Challenges That Organisations Face In Respect Of KS

Descriptive Statistics	N	Overall Mean Score	Rank
Challenge involved in implementing an effective and appropriate KM strategy supported by both IT and non-IT tools	282	1.30	1
Challenge involved in implementing an appropriate training and education for knowledge sharing	282	1.37	2
Challenge involved in implementing an effective and appropriate business strategy	282	1.39	3
Challenge involved in making available and implementing adequate resources	282	1.46	4
Challenge involved in implementing and establishing an effective organisational culture	282	1.48	5
Challenge involved in implementing effective senior management support	282	1.55	6
Challenge involved in implementing an effective and appropriate reward plan and incentives	282	1.65	7
Challenge involved in implementing an appropriate organisational structure	282	1.73	8
Challenge involved in implementing an effective and appropriate organisational infrastructure	282	1.83	9
Challenge associated with K-mapping (how to find, what to find and where to find appropriate knowledge)	282	1.94	10

The scale: 1 (Very challenging), 2 (Challenging), 3 (Fairly challenging), 4 (Not challenging)

From Table 2, it is evident that the most challenging factors that are associated with KS in QS firms in Malaysia are: an effective and appropriate KM strategy, appropriate training and education, an effective and appropriate business strategy, adequate resources and establishing an effective organisational culture. These are closely followed by effective senior management support, effective and appropriate reward plan and incentives, appropriate organisational structure, effective and appropriate organisational infrastructure and knowledge mapping.

The inference that can be drawn from Table 2 is that the upmost challenge that QS firms face with regard to knowledge sharing is to implement codification and personalisation strategies for KSI. This inference is similar to Egbu et al. (2005) who stated that identification, capture, storage, mapping, dissemination and creation of knowledge are important challenges for small and medium-sized organisations. Furthermore, converting tacit knowledge into explicit knowledge and sharing such knowledge is crucial in an organisation with scarce resources such as the QS firms in Malaysia. The implication of this result is that QS firms will be at a losing end when a staff member leaves an organisation due to the investments made for that person's professional development and competence (Barchan, 1999). This is in line with Kazi, (2005) where he proposed firms to develop a system that encourages people to record and submit information to the electronic repository and reward people for sharing knowledge directly with others.

In referring to Table 2, knowledge mapping is ranked the lowest in terms of mean value. What is surprising is that knowledge mapping is the lowest in the challenges that organisations face in respect of KS and also the lowest in promoting factors for KSI (Table 1). The inference that can be obtained from the findings (Table 2) is the existence of a lack of awareness about the importance of knowledge mapping implementation within these firms (Hamzah & Woods, 2003). As mentioned before, most of the QS firms in Malaysia are small and medium-sized organisations. However according to Axland (1992), this indeed gives small and medium-sized organisations an advantage since it is easier to get all the employees together to initiate and implement a change. As argued by Chong et al. (2006), K-mapping is critical to KM implementation as it helps to identify the position of an organisation relative to its competitors.

Challenge Factors Associated with KSI and the Size of Organisation

A thorough observation of Table 3 reveals that effective and appropriate KM strategy was ranked the top challenge factor associated with KSI for small-sized QS firms, and the sixth by medium-sized QS firms.

In this study, KM strategies are supported by both IT (i.e., Internet and intranet) and non IT (i.e., face-to-face meeting and brainstorming). It seems possible that these results are due to small QS firms having a shortage of knowledge workers compared to medium QS firms. As stated by Reige (2005), deficiency of company resources would provide inadequate sharing opportunities.

Table 3. Challenge Factors that are associated with KSI - Mean Value Comparison According to Size of Firm

Challenging factors	Small	Rank	Medium	Rank	Overall mean value
challenge involved in implementing an effective and appropriate KM strategy supported by both IT and non-IT tools	1.27	1	1.93	6	1.30
challenge involved in implementing an appropriate training and education for knowledge sharing	1.36	3	1.43	2	1.37
challenge involved in implementing an effective and appropriate business strategy	1.33	2	2.43	10	1.39
challenge involved in making available and implementing adequate resources	1.46	4	1.64	4	1.46
challenge involved in implementing and establishing an effective organisational culture	1.49	5	1.43	3	1.48
challenge involved in implementing effective senior management support	1.53	6	2.00	8	1.55
challenge involved in implementing an effective and appropriate reward plan and incentives	1.64	7	1.93	7	1.65
challenge involved in implementing an appropriate organisational structure	1.72	8	2.00	9	1.73
challenge involved in implementing an effective and appropriate organisational infrastructure	1.85	9	1.36	1	1.83
challenge associated with K-mapping (how to find, what to find and where to find appropriate knowledge)	1.94	10	1.86	5	1.94

The scale: 1 (Very challenging), 2 (Challenging), 3 (Fairly challenging), 4 (Not challenging)

Conversely, in medium-sized QS firms, organisational infrastructure (teams, relationship and network) is ranked the top challenge factor that their organisations face with regard to KS. A possible reason is that medium-sized QS firms (number of employees are between 50 and 250) do not find it easy to have face-to-face meetings with their staff compared to small QS firms.

The challenges in organisational culture and knowledge mapping were both ranked fifth by the small and medium QS firms, respectively. For organisational culture, it seems possible that this result is due to small QS firms being faced with the challenge of having a supportive organisational culture for KS. In knowledge mapping, it seems possible that these results are due to medium QS firms finding that the process takes too much time to collect the data, which might prove costly, especially during the start-up phase (Soliman & Spooner, 2000) when the QS firms attempt to identify knowledge gaps.

From Table 3, the challenges involved in implementing an effective and appropriate organisational infrastructure and knowledge mapping were ranked lowest in terms of mean value in small QS firms. A possible explanation for this result is that in small QS firms, the organisational structure is more flat and the employees know each other, hence, implementing an effective and appropriate organisational infrastructure and implementing knowledge mapping are less of a challenge for them. Conversely, the challenges involved in implementing an appropriate organisational structure and effective and appropriate business strategy were ranked lowest in terms of mean value in medium QS firms. A possible reason is that the medium-sized QS firms have a flatter organisational structure and have fewer constraints in terms of resources for KSI compared with small QS firms.

Null hypothesis Ho - The factors that promote KSI do not differ according to the size of QS firms.

The test of null hypothesis was used to investigate whether the size of QS firms has an impact on the results discussed in section 6.1. The Mann-Whitney U Test of two independent samples was used to test whether most of the responses are the same regardless of the size of the firms.

Table 4. Mann-Whitney U Test Statistics for Factors that Promote KSI according to the Size of QS firms

	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
Asymp.Sig	.459	.038*	.787	.959	.587	.136	.503	.013*	.440	.925

* Result is statistically significant at ρ < o.o5

Key:

P1: Promote Business strategy, P2: Promote Adequate resources, P3: Promote Reward plan and incentives, P4: Promote Organisational culture, P5: Promote Organisational infrastructure, P6: Promote Senior management support, P7: Promote Km strategy, P8: Promote Training and education, P9: Promote Organisational structure, P10: Promote Knowledge mapping.

As shown in Table 4, at the 5% level of significance, the ρ value is statistically insignificant in most instances. Thus, the results suggest that the factors that promote KSI do not differ according to the size of the QS firm. Therefore the null hypothesis is accepted. This finding contradicts that of the results in Table 1 where it was found that promoting factors are dependent on the size of the organisation. As argued by Serenko, Bontis and Hardie (2007), when the organisational size increases, the degree of intra-organisational knowledge sharing will decrease. The implication is that when the organisation is getting bigger, the effectiveness of knowledge sharing will also decrease according to the size of the organisation. The promoting factors will also be different according to the size of the organisation. According to Table 4, the significant promoting factors that are dependent on the size of the organisation are adequate resources and training and education. It is recommended that QS firms focus on these promoting factors because the latters will have greater influence on the KSI within their organisation.

Null hypothesis Ho - The challenge factors that are associated with KSI do not differ according to the size of QS firms

The above was examined using a mean value comparison (Table 2). The mean values given in Table 3 are arranged according to the ranking order obtained from Table 2. As per Table 3, the results do not show any significant variations to the findings presented in Table 2. This was further examined using a Mann-Whitney U Test of two independent samples.

Table 5. Mann-Whitney U Test Statistics for Challenge Factors that are Associated with KSI According to the Size of QS firms

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
Asymp.Sig	.000*	.531	.000*	.220	.994	.003*	.247	.019*	.000*	..612

* Result is statistically significant at ρ < 0.05

Key:

C1: Challenge in KM strategy, C2: Challenge in Training, C3: Challenge in Business Strategy, C4: Challenge in Adequate Resources, C5: Challenge in Culture, C6: Challenge in Senior Management Support, C7: Challenge in Reward, C8: Challenge in Organisational Structure, C9: Challenge in Organisational Infrastructure, C10: Challenge in Knowledge Mapping.

As shown in Table 5, at the 5% level of significance, the ρ value is statistically significant in most instances. Thus, the results suggest that the challenge factors associated with KSI differ according to the size of QS firm. Therefore the null hypothesis is rejected. The inference that can be drawn from this result (Table 5) is that small and medium QS firms have a different impact on the challenge factors that organisations face with regard to knowledge sharing. The implication of this result is that bigger organisations face different challenges with regard to KS. It is therefore recommended that QS firms focus on the significant challenge factors (i.e. KM strategy, business strategy, senior management support, organisational structure and organisational infrastructure) that are associated with KSI in QS firms. QS firms have to be ready with knowledge to face the challenge within their organisation and employees be given appropriate training to exploit the benefit.

CONCLUSIONS AND RECOMMENDATIONS

In sum, the findings from this study indicated that i) senior management support is the greatest influencing factor to promote KSI, ii) the size of QS firms impacted the factors that promote KSI, and iii) the size of the QS firm influenced the challenging factors associated with KSI. When categorising the QS firms into small and medium-sized organizations, it was observed that for small QS firms, the top promoting factor for KSI is getting support from effective senior management whilst the least promoting factor is the importance of an effective and appropriate knowledge mapping. For medium-sized QS firms, the top promoting factor is establishing an effective organisational culture, whilst the least promoting factor is having an appropriate organisational structure. The results of this study also revealed that the top challenging factor for small QS firms is the challenge in implementing an effective and appropriate KM strategy whilst the least challenging factor is the challenge associated with knowledge mapping. For medium QS firms, the top challenging factor is in the implementation of an effective and appropriate organisational infrastructure and the least challenging factor is in the implementation of an effective and appropriate business strategy. It is therefore recommended that future studies explore the attributes of top management for the successful deployment of KSI in small and medium-sized QS firms.

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PROJECT SCOPE MANAGEMENT EFFECT ON VARIATION ORDERS IN GOVERNMENT FUNDED PROJECTS: A PROPOSED STUDY ON THE SULTANATE OF OMAN

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Abstract
Project scope management is a main function in project management process. Moreover, it is a critical function because any changes or modifications in scope will cause extra cost on the total project development expenses. In addition, scope management function ensures the successful management of other key project management areas, including time, cost, and quality. There are six main steps in scope management process namely; plan the scope, collect the requirements, define the scope, create work breakdown structure (WBS), validate scope and control the scope. These processes have been highlighted in different scale in project methods and standards. This article highlighted the importance of the scope management, how it is viewed by project management different methods and what it is impact on the project outcomes. Moreover, it highlighted the issue of the variation orders in the Sultanate of Oman and suggested the concept study to examine this issue.

Keywords: *Project management; Scope management; Oman; Variation orders*

INTRODUCTION

Managing the scope of the project is very important function which can impact the level of the project management success and it is considered one of the most important function that is need to be accomplished by project manager (Khan, 2010). Furthermore, a failure or uncertainty in project scope management process is directly reflects in the cost, time and quality of the project outcomes (Dumont et al., 1997). The size of the impact can vary form one project to another, however, it's could be a huge in mega project. Many scholars in project management field for many years have focused in studying project success factors such as project manager skill, stakeholders involvements, communications and top management supports (Williams, 2015). However, the area of scope management itself still needs more digging and investigations. Therefore, almost all project methodologies consider the scope management a fundamental element or tool (Helgason, 2010).

Project scope management process covers the procedures which confirm that project will be completed as planed and intended and it is defining and controlling the maim components of project scope by illustrating what is in and what is not going to be part of scope is a major sector of scope management process (PMI, 2013). Scope management process can be seen as one package used to fulfill the main purpose of the project. Therefore, it is a comprehensive formulation of a continuous and systematic approach to be used during the execution phase of a project to complete the project objectives and accomplish the driving business need (Dumont et al., 1997). These process are divided to six main steps which are; conceptual development, the scope statement, work authorization, scope reporting, control system Process and project closeout (Bredillet, 2007).

On the other hand, Project Management Institute (PMI) process highlighted scope management as six main steps which is indicted in Figure 1 namely; plan scope, create work break down structure, collect requirement, validate scope, define scope and control scope (PMI, 2013). This article will use this definition of scope management as main process because PMI carries the label "Global Standard" on its cover, as well as it labels itself among other organizations as a "standard and guideline" (Rankins, 2013). In general, there is no methodologies better than the other, but the degree and level of project analysis acceptance could lead to select best tool to achieve all targeted goals successfully (Obrutsky, 2016).

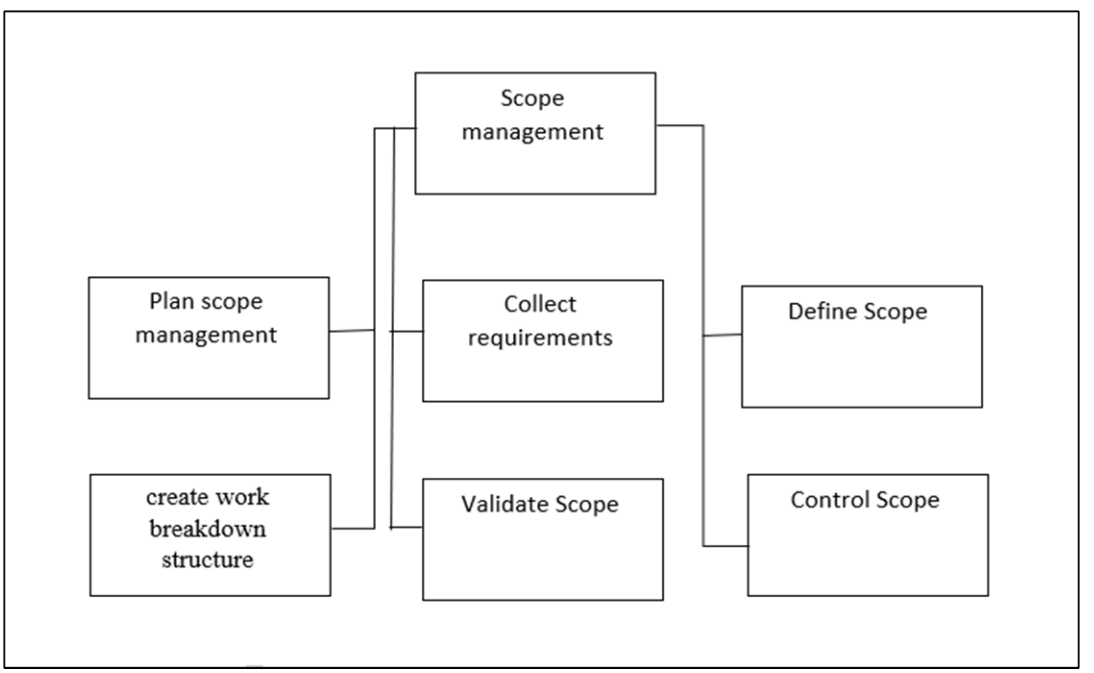

Figure 1. Scope management process (PMBOK)

SCOPE MANAGEMENT PROCESS

Scope management process are key step in project management method. These processes are divided in to six main steps as showed in Figure 1. However, defining the scope considered as the main step in these processes because the scope of the project generally defines the limitations of a given project, chooses what deliverables are in and what are out of scope of the project and it defines how work will be plan (Shrivastava, 2015; Kenneth, 2014).

There will be an expected level of difficulty in project development process, should there be any shortfall in shaping and determining the scope of the project in first stages of a project's life cycle (Fageha & Aibinu, 2013). Therefore, if there is failure in managing the scope it will result as scope creep. The scope creep is the uncontrolled and unexpected changes in a project which will cause time and cost overrun in the projects and perhaps the projects are terminated for these overruns (Shirazi et al., 2017). To manage the project scope the following steps, need to be effectively obtained.

A. Plan Scope

The scope management plan is generated in this phase, it documents, defines and describes the intended project scope as well as specifying how the scope will be validate and control (Monnapa, 2017). This step will deliver how the project scope will be managed throughout the project which will be a guide an direction for the entire project plan (PMI, 2013).

B. Collect Requirement

The project stakeholder's requirements and specifications are collected, documented and managed in this phase with one major goal which is achieving project objectives (PMI, 2013). The list of project requirements is generated through an in-depth investigation process with clear target of including and not leaving hidden items (Monnapa, 2017). Moreover, it works to minimize unexpected changes – scope modification / scope creep - in the project life cycle (Loh, 2009). Generally this step will provide the foundation for defining and managing the project scope (PMI, 2013).

C. Define the Scope

A comprehensive full description of the project and its key required deliverables are the main purpose of this phase with indicating what can and cannot be achieve and accomplish in the project (Monnapa, 2017). The key value of this step is it describes the project boundaries by defining the requirements of the project scope (PMI, 2013).

D. Create Work Breakdown Structure

The project components are separated into essential elements aiming to ensure that all required deliverables are involved and these elements will represent the scope of work in a hierarchical breakdown structure (Khan, 2010; Kenneth, 2014). Moreover, this step minimized scope creep at low level through liking cost, time, and resources requirements with each deliverables with clear framework and charts (Kenneth, 2010; Loh, 2009). Commonly this step, provides a "structured vision" of what has to be delivered in the project (PMI, 2013).

E. Validate scope

The project quantified deliverables are checked and tested based on the project defined and planed requirements (Khan, 2010). Also, it focuses primarily on project owner acceptance and it is confirmed only when the project owner formally accepts authoritatively all the project deliverables (Monnapa, 2017). This step conveys objectivity to the "acceptance process" by validating each deliverable (PMI, 2013).

F. Control scope

The changes and modifications in the project scope is evaluated and monitor based on the scope baseline in this phase (PMI, 2013). Moreover, any new or additional requirements

inquired by the project owner is evaluated based the project scope (Monnapa, 2017). The scope baseline is maintained throughout the project in this step (PMI, 2013).

WHY SCOPE MANAGEMENT?

Scope management process involves clear communication tools to ensure that stakeholders and project team members have similar understand of the scope of the project while approving on how the project goals and objectives will be obtained. There are many reasons of having scope management process which all mainly focusing on managing and controlling the project scope (Monnapa, 2017). The following Table 1 summarized some of these reasons.

Table 1. Reasons of having scope management process

No	Reasons
1	Avoid challenges during the project execution phase especially when there is a new or amendment on the scope.
2	Clearly in determining "what is" or "is not" included in the project.
3	In the execution phase it controls and monitor what gets added or removed
4	Establishes control instruments to address factors that may result in changes during the project lifecycle.

Source: Monnapa, 2017

Without having the project scope management process, the cost or/and time will be difficult to be control, and scope creep will exist which will introduce the variation orders. Moreover, the project may lose its credibility if it is unable to control the planed budget or timescale and when it has lost credibility, the stakeholders are more likely to cancel the project (Nath & Momin, 2014).

SCOPE CREEP

Scope creep is what happens when a project receives many number of changes or variations orders on the original agreed scope that creates an extra work with extra financial obligations (Nath & Momin, 2014). Also, it can be defined as adding new features and functionality to the project scope without stating the effects of it on the approved project management plan. There are many causes of having variation orders most these occurs when defining the scope by inexperienced parties, misconstruction of the business needs, bad realization of client's need in defining the scope and unrealistic project goals (Shirazi et al., 2017).

Many research have been conducted in scope change field and the main reasons of scope change can be categories to the following reasons (Poddar et al., 2002):

- Client changes
- Owner / customer changes
- Contactor
- Mixed reasons

The following Table 2 summarized some of these reasons.

Table 2. Causes of Scope Creep

Scope creep causes
Defining the scope by inexperienced experts.
Misconstruction of the business needs.
Bad realization of the client's needs on defining the scope.
Unrealistic project goals.
Variety in the size and the detail of scope statement and not checking it by third party
Lack of clarity about system boundaries
Define the procedures by inexperienced experts
Not involving the project team for defining the procedures
Not checking the procedures by third party
Lack of configuration management plan
Lack of communication
Not having risk management

Source: Shirazi, Kazemipoor & Tavakkoli-Moghaddam, 2017

SCOPE MANAGEMENT AND VARIATION ORDERS

Scope creep occurs when a project receives some changes on the original agreed scope which is the source of the variation orders (Nath & Momin, 2014). Variation orders defined as an amendment or changes of the original scope of work as in the contract (Memon et al., 2014). There are many negative effects of variations orders, some of these are an increase in project cost, delay in the completion project schedule or time and in some cases rework and destruction (Oyewobi et al., 2015; Nawi el al., 2014a; Neff, 2014). The variation orders causes have been investigated by different scholars and it is founded that one the main reason of the variation orders is the change in the project scope which indicts the importance of scope management (Yadeta et al., 2016; Ayham et al., 2016; Muhammada et al, 2015). Based on that results, different studies in different countries have been recommended to conclusion of design or scope of the work before starting the project (Oloo, 2015; Msallam et al., 2015; Nawi et al., 2014b; Nawi et al., 2014c; Bichoy Samir Tamer Aziz & Khalil, 2014).

THE ISSUE OF THE SCOPE MODIFICATION IN THE SULTANATE OF OMAN

The Sultanate of Oman is a developing country which mainly depends on oil exports as main product of country income production. The Sultanate as a developing country uses around 25 % or more (39,333 million US dollars) of the yearly total income in government projects mainly in infrastructure projects such as roads, hospitals, industrial zones. schools and airports (MOF, 2016). During the years from 2010 till 2015, the Sultanate of Oman has spent more than 6.5 billion US $ on the variation orders modification which indicates the big size of the scope modification in the government project. Next table highlighted the size of the scope modification in the government projects during the indicated years (Tender Board, 2016).

Table 3. Variation orders during the years 2010 – 2015

Year	Size of Variation orders (US Dollar)
2010	1,107,890,541
2011	1,730,401,135
2012	1,144,143,132
2013	945,124,614
2014	622,514,235
2015	1,008,839,443
Total	**6,558,913,101**

The size of scope modification has been discussed as importance issue in the A'Shura Council and it was heighted as a recurrent problem in many government projects and linked directly with the variation orders (A'Shura Council, 2015). Many studies around the worlds have founded that the main causes of the variation orders is the change of the scope which indicates its importance (Yadeta et al., 2016; Ayham et al., 2016; Muhammada et al., 2015). Unfortunate little attention has been given to study the cause of the variation orders in the government project of Sultanate of Oman.

The reason which indicates needs to study this area in the sultanate's projects is the big size of the project scope modification and the size of the current government projects plan for the ministries during the years 2016 till 2020. The following Table 4 shows the size of investment in government projects from the year 2016 to 2020.

Table 4. The 9th Plan for the ministries government projects (in millions USD)

Year	2016	2017	2018	2019	2020	Total
Amount	3109	3627	3886	4275	4404	19301

Source: MOF, 2016

MAIN CONCEPTS FOCUSED IN THE STUDY

Since Scope management has been identified by many researchers such as (Tsiga et al., 2016; Fageha & Aibinu, 2013; Pinto, 2007; Watson, 2010) as main element in project management process but it is not yet investigated in depth as a variable in the relationship with variation order costs in the Sultanate of Oman government projects. It is critical to test, validate and examine the causes of the variation orders and its relationship with the scope management in government projects in order or minimize the size of the scope modifications. The following Figure 2 indicts the concept under study.

Figure 2. Main concepts focused in this study

The sample size of the study will cover ministers in the Sultanate of Oman with high size of the variation orders during the same period of the scope modification reports from the year 2010 to 2015. The ministries are listed in Table 5 below.

Table 5. Ministries with high number of variation orders from 2010 – 2015

Ministry	Expected total population	Sample size
Ministry of Transport and Communication	20	6
Ministry of Regional *Municipalities and Water Resources*	20	6
Ministry of Manpower	20	6

Ministry	Expected total population	Sample size
Ministry of Housing	20	6
Ministry of Health	20	6
Ministry of Education	20	6
Ministry of National Economy	20	6
Ministry of Tourism	20	6
Ministry of Higher Education	20	6
Sultan Qaboos University	20	6
Supreme Council of Planning	20	6
Ministry of Sports Affairs	20	6
Ministry of Information	20	6
Ministry of *Interior*	20	6
Ministry of Agriculture and Fisheries	20	6
Ministry of Justice	20	6
Ministry of Heritage and Culture	20	6
Ministry of Social Development	20	6
Ministry of Finance	20	6
Ministry of Environment and Climate Affair	20	6
Public Prosecution	20	6
Total		126

Source: Tender Board, 2016

The expected outcomes of this study will contribute in solving scope issues in government projects in the Sultanate of Oman through identifying the causes of the variation orders and its relationship with scope management.

SCOPE MANAGEMENT IN DIFFERENT PROJECT MANAGEMENT METHODS AND STANDARD

Project Management Body of Knowledge (PMBOK) and Projects IN Controlled Environment (PRINCE2) are most widely used project management methodologies in the worl. Moreover, International Project Management Association (IPMA) considered one of the leading project management practices beside the PMBOK and PRINCE2 (Chin et al., 2016).

There are other international recognized standards such as International Project Management Association Competence Baseline (ICB), Project & Program Management (P2M) and SCRUM methodology. These methodologies and standards have cover the scope management area from different prospective in different way and weight. Starting by the Project Management Body of Knowledge (PMBoK) and PRINCE2 which have recognize scope management as the key project performance parameters (Memon et al,, 2014).

Based on project planning process group on the PMBoK to accomplish the project objectives; the scope of project needs to be established, project objectives need to be refined and action required needs to be defined (Memon et al., 2014). Moreover, PMBOK has given more attention to finish every planning process at the beginning of the project process including scope plan and it recommend to start work of project development only when planning is finished (Obrutsky, 2016).

In contrast, SCRUM generates usually scope creep and lives with it because there are a regular and repeated changes on the scope by the stakeholders through process called a sprint

which start by asking for changes or adding more requirements on the scope after the project start (Obrutsky, 2016). Simply, its main concern to start the development and it is a framework for developing and sustaining complex products (Schwaber & Sutherland, 2013).

On other hand, International Project Management Association Competence Baseline (ICB) sets a quality standards and requirements as baseline to achieve and fulfil the project deliverables (scope) within time frame and cost controlled operation (ICB, 2016). The scope in ICB indicated in execution phase with no specific procedures as scope management process. However, in Project & Program Management P2M the part which heighted the scope management is Project Objectives / Goal Management which concerns with meeting or exceed stakeholders satisfaction by attaining scope and quality within time and budget (Low, 2015), as shown in the following Table 6.

Table 6. Project & Program Management P2M

PM Entry		
Project Management Framework & Principles		
Program & Project Management Area		
Project Management Strategy Project Finance Management Project Management Approach Project Organization Management	Project Objectiveness Management Project Resources Management Project Risk Management Project IT Management	Project Relation Management Project Value Management Project Communication Management

Source: Low, 2015

It is worth to indicate that The Association for Project Management (APMBoK) have in Execution the Strategy the method contains scope management process as shown in Table 7 below. On the other side, PRINCE2 is similar to a construction management method not as is a complete project management methodology, so fairly it is an implementation methodology which not start with original need; therefor, the new requirements added to the project as solution generating or feasibility studies and it can be considered as separate projects in their own right (Poddar et al., 2002). For that reason PRINCE2 project managers founded in a study that they have not have any thoughtful worries about the scope of their projects management (Rankins, 2013).

Table 7. Execution of strategy PRINCE2 method APMBoK

Project management in context				
	Project management Portfolio Management		Project context Project Office	
Planning the strategy				
Project success criteria Stakeholders management	Value management Quality management	Project management plan	Risk management	Health, Safety and Environment
Execution the strategy	**Techniques**	**Business commercial**	**Organization and Governance**	**People and Profession**
Scope management Other elements/function Management	Requirements Development Estimating Testing	Business case Marketing Financial	PLC Concept definition Roles Methods	Communication Team work Behavior Negotiation

Source: Peng, Junwen & Huating, 2007

In summary, Comparing with PRINCE2, P2M does not specify its scope only on IT projects. Though PRINCE2 also covers non-IT projects, but it mainly emphasizes on projects related with IT. ICB is more on behavioral competencies of people, whereas P2M concentrates more on its philosophies of theories, ideology and mindset of the project managers (Low, 2015). Therefore, PMBOK considers to be more details in scope management process and linked with different types of project.

CONCLUSION

This paper has summarized project scope management process and how this task been viewed form difference methods prospective as well as its link with variation orders. Project management is a dynamic business method and standards, but the project scope part has to be freeze at the beginning of the project to accomplish the project goals and objectives effectively.

Scope of work is differently viewed by project management methods and standard; it is viewed by PMBoK as a full details list of works; so further change is difficult but in Scrum it is an approximate list of projects works. It normally to be discussed and debated many times by project owner and development team as project going on. On other hand, ICB indicated the scope only in execution phase with no specific procedures as scope management, as well as P2M does not specify its scope only on IT projects. Nonetheless, PRINCE2 have recognize scope management as the key project performance parameters. The strong link between the scope of work and variation orders and its impacts on total cost of project has driven scholars to look at this relation from different prospective. That's way, it is considered as critical function in project management.

In conclusion, it is suggested to make the most verified choice of methods or standards resulting from explanation of the task on optimizing the project's scope to the following measures: profit, time, cost and quality. Therefore, further studies are essential in scope project management filed and its impact on project success rate and variation orders.

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HOUSING DEVELOPER'S PERSPECTIVE ON SOCIAL SUSTAINABILITY

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Abstract
This study has aimed to identify the current scenario of social sustainability consideration in housing development from the developer's perspective. The study has mainly focused on the property developers, involved in residential project, to identify their understanding on social sustainability in housing development. Qualitative method in the form of interview has been conducted that aimed to get the understanding of the developer, and identify ways to improve social sustainability in housing development. An observational study has been carried out to validate the interview results, and get the actual insights from the site observation on the selected projects. For the interview session, developers from three different companies have been selected, who were involved in residential projects for more than 10 years. A project from one of the developer was selected, and an evaluation on several aspects of social sustainability was conducted during the site observation. The findings have shown that the developers practice social sustainability element in their housing development, but the understanding and application differs for each project.

Keywords: *Developer; Housing Development; Residential Project; Social Sustainability*

INTRODUCTION

Housing industry by nature is a multi-faceted domain that consumes natural resources and possesses significant impact on the natural environment (Said, 2017). The economic activities are formed in a way, so that they can easily contribute in the social development and quality of life. Therefore, the issues on sustainability are needed to be excluded from housing development as key features of progress and governance.

Sustainable Development in Housing

The concept of sustainable development revolves around three pillars globally, which are environment, economy, and social network. Consequently, sustainable development is defined as the process that meets the needs of individuals without compromising their future abilities (World Commission on Environment and Development, 1987). Environment Sustainability refers to the ability of ecosystem to maintain or improve its quality and reach a long-term stable situation, despite of short-term changes (Nijkamp & Soeteman, 1988). The sustainability of a development activity acknowledges biophysical limits, and the needs to maintain essential ecological processes and life-support systems (Zovanyi, 1998). It has been evaluated that environment sustainability comes in various angles that ensure the capability of projects to enable energy saving, minimum resource utilization, efficient waste management, use of environmentally-friendly building materials, and construction systems; and also encourages simple lifestyles.

Economic sustainability refers to a system of production that satisfies present consumption levels without compromising future needs within the given environmental

constraints and costs (Bamgbade el al., 2017; Abdul Nifa, et al., 2015; Basiago, 1998; Khan 1995). The modern concept underlying economic sustainability seeks to maximize the flow of income that could generate and maintain the stock of assets, which yield beneficial outputs. The development of technology, building materials, and housing designs to mitigate environmental impact of housing activities and their implication for financial viability are crucial (Said, 2017). Social sustainability has received various views on its definition. One of the most popular views is interpreted as people-oriented, which refers to maintain and improve well-being of people in future generations (Borrini-Feyerabend, 1997; Pugh, 2014; Chiu, 2003). However, much importance has been given to social cohesion and integrity, social stability, and improvement in the quality of life. Any development should be determined by social goals reflecting the present and future needs and aspirations of the involved communities (Kozlowski & Hill, 1993).

Social Sustainability in Housing

Housing plays an important role in social sector. Today, housing is not regarded as a shelter for the residents, but also act as a basic social need, which can provide a better quality of life, equity distribution, social empowerment, accessibility, cultural identity, and security. Housing development that caters the needs of the residents would give positive effect towards the residents; while, housing development with insufficient services and needs can develop negative impact towards the residents lives. Therefore, social sustainability in housing is an important factor that contributes to overall well-being of a community.

Social and physical environment housing is perilous to human life because it is a critical component contributing to the well-being (Sukimin, 2008). Sukimin (2008), further noted that housing perfectly meets the needs of residents, gives prosperity to households, and helps to lead a better quality of life. Housing developers should provide good environmental qualities within and around the neighbourhood; such as green space provision and proximity to parks, when constructing housing projects. Open spaces in the neighbourhood, particularly parks and gardens, play an important role in supporting social sustainability as their primary function is for informal activities, relaxation, and social and community purposes (Choguill, 2008).

Social links with neighbours and friends living nearby contribute towards higher housing satisfaction among the homeowners. The housing developers should pay attention to house designs that capture differences in life-cycle patterns of the homeowners (Tan, 2010). Community experts indicated that the social benefits maybe intangible to developers, but they are strongly depicted as financial and environmental ones.

Definition of Social Sustainability

Social sustainability is one of the pillars of sustainable development, which often receives less attention as compared to other two pillars that are related with economics. Social sustainability has gained recognition as a fundamental component of sustainable development. Social sustainability is mainly about the combination of physical environment with a focus on how people live and use a space to communicate with each other. It can be elevated by producing development, which serves the right infrastructure to support strong social and cultural life, opportunities for people to get involved, and scope for the community to evolve. Sustainability is achieved through community participation and the reconciliation

of short and long term economic, social, and ecological well-being. It combines design of the physical realm with design of the social world to support social and cultural life, social amenities, system for citizen engagement, and space for people and places to evolve.

Baines and Morgan (2004) and Sinner et al. (2004) perceived that the content of social sustainability needs to include;

- Acknowledging cultural and community diversity and fostering tolerance
- Attention to the equitable distribution of opportunities in development
- The people are empowered to participate on mutually agreeable terms that influence choices for development and in decision-making
- Personal responsibility is fostered, which is associated with social responsibility and regards for the needs of future generations
- The stock of social capital need to be maintained and developed to foster trusting and co-operative behavior is needed to underpin civil society;
- The basic necessities need to be mentioned and the disadvantage attributed to personal disability need to be overcome.

According Valdes-Vasquez (2011), there are various interpretations on social sustainability within the industry, and the industrial players have interpreted it according to their preferences and level of importance. Another scholar suggested that social sustainability should focus on the process, needed to achieve better living conditions (Mihelcic et al., 2003, Dillard et al., 2009).

The Principles of Social Sustainability

The common principles of social sustainability proposed by Barron and Gauntlett (2002) and Mckenzie (2004) include:

- Equity - The community provides equitable opportunities and outcomes for all its members, particularly the poorest and most vulnerable. Although equity has been listed as a separate principle, it is a fundamental component as it cannot be separated from the other principles. Equity is a filter through which all other principles are viewed.
- Diversity - The community promotes and encourages diversity.
- Interconnectedness - The community provides processes, systems, and structures that promote connectedness within and outside the community at the formal, informal, and institutional level.
- Quality of life - The community ensures that basic needs are met that fosters a good quality of life for all members at the individual, group, and community level.
- Democracy and governance - The community provides democratic processes and opens governance structures.

PROBLEM STATEMENT

Many problems are likely to arise, when developer neglects important sustainability issues. It may even lead to fighting among the residents in both areas that would bring distance in the relationships. There is a need to improve application of social sustainability among

Malaysian developers, despite of its importance in housing development. Therefore, the present study has identified current scenario of social sustainability, considering the housing development from perspective of a developer. The study has also found out ways to improve the application of social sustainability for in-housing development.

Study Objectives

The study has aimed to provide a comprehensive review of literatures and social sustainability development among the developers as a tool to achieve sustainable development goal. The main objectives of the study include:

- To identify the understanding of developer on social sustainability for in housing development
- To identify ways to improve the application of social sustainability for in housing development

LITERATURE REVIEW

The Importance of Considering Social Sustainability in Housing

Social sustainability is not considered as an acquitted concept Gray and Milne (2004), have discussed about the political minefield of social sustainability. Over a billion of people accommodate themselves on less than a dollar per day; more than 800 million are malnourished; and over 2.5 billion lack access to adequate sanitation (Parliament, 2005). Therefore, social sustainability is known as an uptight concept. If this concept is neglected, it can lead to various social problems within the communities as follows:

- Deprivation and poverty
- Crime and safety issues
- Inequality and segregation of communities
- Low quality of life
- Social exclusion

The Ministry of Local Government has expressed a view that social issues need to be taken care by the national government. If the problems are being longed for such a long period, then it would be more costly, rather than getting it right in the first place.

Risk management

The plan for mitigating potential negative outcomes is performed by looking at the potential social impacts of the actions, in terms of likelihood and consequence. It can help to avoid substantial delays in the process because of the problems that were not considered previously. Considering social issues at an early age help in improving the community outcomes, which are specifically tasked with improved wellbeing of an individual. Private sector organizations are capable of creating a better social environment, which people want to live in. It can increase the value of land and properties, which affect the bottom line.

Reputation

In recent times, consumers have become more demanding about the products and services that they purchase. The reputation of organization can be improved by improving the approach of social wellbeing, which is a significant factor for attracting customers.

Cutting through the red tape

The positive social contribution can be overshadowed by the negative outcomes. Understanding the social benefits can be a valuable tool that helps to mount a strong argument to secure planning funding for a project.

Related Studies

The housing industry is perceived as one of the important sectors that serves to fulfil every individual's basic need of life. It is one of the biggest investments made by an individual; therefore, special attention should be given to it. Housing industry is becoming more crucial and difficult within the threatening contemporary development patterns, resulting in various social problems. Abidin (2009), deduced that majority of the developers' perceived sustainability as a source of protection without social and economic consideration within the construction industry. The efforts continue to demonstrate the integration of industry players in providing housing that is socially sustainable.

Bramley et al. (2006) distinguished two comprehensive concepts at the core of the notion of social sustainability, which include social equity and sustainability of community. It has also been linked with the notion of social justice, which urges the fair distribution of resources in society to allow fair access to jobs, housing, and local services. However, issue has been raised due to lack of attention on social sustainability aspect to widen the social gap between the high income group and low income group. The prices of houses in Malaysia are too high; for instance the price of a median house is 4.4 times more than the annual household income of low income group. According to the Prime Minister, it would be impossible for low income group to own their own house. Therefore, it is believed that social sustainability promotes social equity and access to housing.

Alias (2016), stated that homeowners in Taman Perumahan Bandar Hillpark vent their resentment towards the developer who allegedly failed to keep his promise of providing security to the residents. The claim was presented by a homeowner, who urged the developer to be responsible in the case of burglary that involved a number of residents. The case would not have happened only, if the developer kept his promise in providing 24-hour security television (CCTV) as specified in the sales brochure. It is crucial to adopt social sustainability as a development because it promotes well-being of individuals including; health, education, and access to goods and services. These facilities are fundamental for a decent living and political achievements; such as a sense of security, dignity, and the ability to be part of a community through recognition and representation (Dugarova, 2015). Social sustainability also incorporates harmonious social relations that are commonly known as sustainable community.

METHODOLOGY

The study has employed qualitative approach and semi-structured interviews have been conducted to maintain the flexibility and consistency between the researcher and the respondents. A voice recorder has been used to record all the interviews session between the researcher and the respondents. Camera was also used to complete this research as the researcher needs to capture the elements in existing housing of their respective projects.

The interview was an alternative method of collecting data survey from experts during the early stages of the research project (Walliman, 2017). During the interviews, the developers were asked a series of questions related to the elements of social sustainability. Only three elements of social sustainability were inquired through these interviews. These elements include amenities and infrastructure, social and cultural life, and voice and influence. The developers were also asked if they were aware about the elements used for in-housing development projects. These elements were tested in 4 Berkeley development project in London.

Sampling

Out of 91 developers, interviews with 3 developers were conducted to investigate and identify the understanding of social sustainability in housing from their perspectives. The developers were selected using a criterion sampling approach. The developers with 10 years' experience in housing industry were contacted because they had encountered lots of development process throughout their career. Besides that, they have high possibility in developing more housing projects as compared to developers with less experience. The developers were identified from a list of developers at Real Estate and Housing Developers' Association (REHDA) Penang Branch. After filtering developers with experience of 10 years; only 3 developers responded positively and were ready to participate in the interview within the research timeframe.

Background of the Developers

The interviewees have been selected from managerial post as they are the one, who direct and supervise projects that relate to their company. All the interviewees were known as D1, D2 and D3 to maintain confidentially but general introduction of the developers has been described.

D1

Bertam Properties Sdn Bhd is strategically located in a vast area of 3,700 acres in Northern Hub. It has planned to develop Kepala Batas into an integrated township for residential, commercial, institutional, and recreational purposes. The completion of 6,800 residential and commercial units is proof of Bertam Properties Sdn Bhd's reliability and reputation. Bertam Perdana is expected to have a population density of 45,000 to 50,000 people, and the completion of this huge project is expected to be ready by the year 2025.

D2

Lone Pine Group of Companies was established in the year 1987 for the development of residential *and* commercial properties. Over the years, they have evolved into an integrated company with services of buildings construction. To date, Lone Pine Group of Companies has authorized and issued capital of RM4.5 million with the principal activities of property development and management. They have completed residential and commercial projects of over 2,300 units amounting to RM303 million. In 2003, they were awarded the "Best Managed Medium Cost Flat" in Malaysia for the landmark project, Taman Lone Pine. Lone Pine Group of Companies continues to embark on current and future projects with a GDV of more than RM860 million, aspiring to be ultimate developer in the property industry.

D3

Asas Dunia Berhad is a trusted property developer with a successful track record of offering affordable, modern lifestyle, and quality homes at prime locations. The company was incorporated in 1982, and was listed on the main board of Bursa Malaysia Securities Berhad from 1995 to 2013.

Observation

Observation is a type of qualitative research method, which not only includes participant's observation, but also covers ethnography and research work in the field. In the observational research design, multiple study sites are involved. Observational data can be integrated as auxiliary or confirmatory research. Participants' observation was meant to validate the information, obtained from the interview. The researcher choose one housing development project from one of the developers interviewed with different categories, which were low-cost housing, medium cost housing, and high end development. The data obtained from this observation was used for validating and strengthening the study findings.

Site Background for Observation Bertam Perdana 2 and Bertam Perdana 3

Bertam Perdana is the biggest township in Bertam. Bertam Perdana was developed by Bertam Properties Sdn Bhd in 2004. Upon its completion in 2017, there would be 45,000 residents, living within the 3,700 acre smart township hailed as the "Putrajaya" of the north. Bertam Perdana can easily be accessed as it is located near main highways, self-contained, and growing at amazing rate. Bertam Perdana is deemed to be the prime residential hub in the northern region as it is located within Bertam Township. It tends to offer conducive living with urban conveniences such as shopping, banking, healthcare facilities, educational institutions, colleges, and office lots. This site has been chosen for the observational purpose as it consists of high end development (Bertam Perdana 2), medium cost development, and low-cost development (Bertam Perdana 3).

RESULTS AND DISCUSSION

According to D1, social sustainability is created through community living, where spaces of interaction among residents are sufficiently provided. These considerations are taken during the planning and designing stage of a development. It is clearly reflected in the various

facilities and amenities that are provided in developments these days. As for D2, social sustainability is where the society is endowed with the basic amenities within the community; such as education, health, and residence. In housing development, social sustainability helps in planning for basic needs of the community within the area such as mosque, playground, and public hall. All these basic amenities are helpful for the community to strengthen their relationship and participation to achieve good quality of life. While for D3, social sustainability provides a balance quality of life in terms of safety, basic amenities, and infrastructure. In every phase of development the designation for amenities and infrastructure acts tools for the community to interact with each other.

Berkeley Group (2012), stated that there are four elements of social sustainability that have been implemented on tested housing development in London. However, the study has tested these elements to evaluate their understanding on social sustainability in housing development. According to the interviewees, D1, D2, and D3 the following elements of social sustainability have been perceived;

- Amenities and Infrastructure
- Social and Culture
- Voice and Influence
- Adaptability and Resilience

The residents have spaces to interact and have a balanced lifestyle by providing a multitude of facilities and amenities. For instance, multi-purpose halls are provided; so that the residents can hold events and have a healthy living by conducting exercises in those spaces. Playground and kindergarten are integrated into housing development to cater young children; while, rest areas and handrails are provided in consideration of the elderlies. Property management agents are appointed upon the completion of development. They address the concerns and issues faced by the residents. Joint Management Body (JMB) comprises of resident volunteers, who discuss and decide on matters related to the property. Residents can channel their concerns and raise issues through both of these means. The developer also suggested an additional dimension to be included in social sustainability, which provides accessibility to the community to reach the facilities provided within their area. They suggested that this concept can be applicable by implying the neighbourhood concept, where the main focus is on the safety of the residents ensuring comfort of the neighbourhood.

Barriers in Implementing Social Sustainability in Housing

D1 agreed that under development and lack of resources hinder the implementation of social sustainability. Eradicating poverty might be hard for them as that part is played by the government. Therefore, D1 suggested that this barrier can be overcome only, if the development can be upgraded or maintained with the aid of government programs; such as Housing Assistance Program of Penang. D2 and D3 also had same review as D1. However, they also believed that the developer can join together with the government to overcome this poverty and under-develop area issue as more ideas can produce good results and solutions. A provision of 10% for public open space is required for all developments as set by the planning department.

Based on the data obtained from the literature review, the reasons of the developer do not implement social sustainability because of lack of funds. Additional facilities and interactions are provided for the area that can be used as sellable area. Therefore, if the application of social sustainability is promoted by incentivize developers; it provides socially sustainable environment by reducing development charges. It is suggested to design and create spaces that are multi-functional so that lesser community spaces can be provided in the development and at the same time can save the cost.

D1 claimed that socially sustainable housing development is a place, where residents are happy to go home every day. Thus, housing developments are usually homogenous and have lesser social mix. Social sustainability can be improved if the space provided is sufficient for the number of residents that are expected to stay in that development. A guideline can be set up, so that developers have a better idea of what the sizes of facilities and amenities should be in relation to the number of residents expected in the development. D2 agreed on socially sustainable housing development as a place where an individual willingly stays for long period. Interviewee D3 also shared same views. A socially sustainable housing development is a place where an individual can access all the basic need and preferences. The residents prefer a comfort and calm environment where they do not have to worry about their safety. Standard guidelines should be provided and penalties should be imposed for the developer who do not comply with the standards to improve the application of social sustainability in housing development.

Observations were also conducted to validate the results obtained from the interview and also from the literature review. Services are provided within the housing development such as mosque and surau, pedestrian walkways, street landscape, recreational space, public hall, and security assistance at the entrance of the development area. Although majority of the list on amenities and infrastructure is well delivered but there are some aspects that have been neglected that provide access to the housing area using public transport. The accessibility of the residents to the provided services are questioned as most of them are not within their walkability area.

The results obtained from the study are appropriate to answer the objectives of the study that were set in the beginning of the paper. The understanding of social sustainability by the developer is not satisfying but most of the view from the developer are similar as they perceive social sustainability. Social sustainability is all about providing basic needs and promoting a good quality of life. For instance, among four elements of social sustainability, three of them are accounted by the developers. It gives a broad explanation on amenities and infrastructure. If the size of the development is big the application in social sustainability is delivered at a large scale. There are some developers who are willing to pay for the charges instead of providing the basic needs for the small scale development to make things worse. The sad truth is that they do provide services such as schools, shops, mosque, hall and open spaces but the ability to sustain it for a long term is still left undecided. Social sustainability has become a serious matter in future due to lack of understanding. However, the understanding in social sustainability can be improved if the developer has the will to cooperate and learn more about the real definition and concept of social sustainability.

The application of social sustainability in housing is still far from the target in achieving the sustainability goal due to the barriers that have been listed during the interview.

Surprisingly, the developers are all aware about the barriers and help in giving ideas to improve application of social sustainability. Since poverty and under develop area is becoming the issue the key players need to be proactive and cooperate with the developer to achieve social sustainability development. A wide coverage of information regarding the social sustainability in housing should be provided for the other barriers such as lack of exposure to the developer. The community observes the developer as the one who gains the most profit out of it but the truth is the bigger the scale of the development the bigger amount they have to pay. Therefore, it is best for the developer to maximize the use of space and minimize the design of the development.

CONCLUSION

The present study has highlighted the understanding of social sustainability for improving the application of in-housing development. In our life, practicing and providing social support is important as it is encountered every day and it related with the heart, body, and mind of the community. Developers play a significant role in achieving socially sustainable development. The understanding of the sustainable concept is still at the low level, and levels of implementation on sustainable issues are also not getting much attention. The knowledge about social sustainability should be learned. The developers need to study the elements and dimension of social sustainability before developing any housing project.

RECOMMENDATION

The study recommends that further research in social sustainability is needed in relation to low cost housing scheme. Most of the social problems and complains come from the low cost housing due to inadequate facilities and exposure to development related problem. At present, a number of social sustainability perspectives are neglected. Lack of resources as cited by the respondents in current research can relate to lack of social sustainability application in the development of low cost housing scheme.

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CONFLICT OF INTEREST

This research holds no conflict of interest and is not funded through any source.

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THE AWARENESS OF BUILDING INFORMATION MODELING IN MALAYSIA CONSTRUCTION INDUSTRY FROM CONTRACTOR PERSPECTIVE

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Abstract
Building Information Modeling (BIM) is one of the newly software in the Architecture, Engineering and Construction (AEC) industries that can solve the problem often occur in the construction process in Malaysia construction industry. The focus of this research is mainly to examine the awareness of Building Information Modeling in Malaysia construction industry through the questionnaire data from a survey of about 164 Penang Construction Company from the AEC industries. The questionnaire is intended to determine the general awareness of the characteristics of BIM and whether companies planning to adopt this technology in the future. It was found that BIM has the potential to improve the productivity and solve the problem facing the construction industry. Therefore, the research also carries out on the benefits of BIM and also the barriers to implementation BIM in Construction industry. At the end, the level of the awareness of BIM and the potential of implementation are discussed.

Keywords: *Architecture; Building Information Modeling; Contractor's Awareness; Engineering, Construction*

INTRODUCTION

The construction industry is one of the key drivers of the Malaysian economy, contributing to 0.5 trillion in terms of value generated between 2011-2014, which continually adapt to meet competitive challenges around the global market. Nevertheless, Alshawi and Ingirige (2003), mention that current trend involves building upwards and bigger, thus becoming more complex involving more specialist and large number of stakeholders. In line with the government's effort through the Construction Industry Transformation Programme (CITP) framework which highlighted productivity enhancement in the master plan, BIM has been identified as a key tool. An idealized framework of productive construction work process is to have more with less; more speed, more efficiency with less manpower, costs, and delays. This digital revolution in the construction technology allows replacements of the old-style two-dimensional blueprints and even three-dimensional AutoCAD with five-dimensional (length, width, depth, time and cost). Zahrizan et al. (2013) stated that information exchanged among them mostly involves a lot of documents and drawings. This practice creates errors as the paper-based format is not properly managed thus results in miscommunication among them. Having wrong information in the construction process could hinder the productivity of projects because, in a construction project, information is perhaps the most important construction material.

The utilization of Building Information Modeling (BIM) reduces at least 2% of construction costs and 30% of total maintenance cost throughout the building's life cycle (Heights). BIM allows greater visibility on the complexity of a project and predicted cost, thus it can also help with abandoned project particularly due to financial constraint. The computer will generate model contains the information needed to support the construction, fabrication, and procurement activities that is needed to realize the building. Undoubtedly, the adoption of BIM brings many advantages for the construction industry and their stakeholders;

nevertheless the current trend causes the cost to outweigh the benefits. This research addresses the issues of BIM adoption by the contractors in the northern region of Malaysia. The limitation and reasons of the contractors not utilising and adopting BIM are further investigated using statistics software MiniTab 16. At the end of the research, the analysis data is able to help the researcher to identify the awareness of Building Information Modelling in Malaysia Construction Industry.

LITERATURE REVIEW

The Current AEC Business Model

Currently, the facility and information depend on paper-based modes of communication. Therefore, errors and omissions in paper document always happen and it will cause unanticipated field costs, delays, and conflict between the various parties in a project team. Recent efforts to attend such problems have used is real-time technologies, such as project Web sites for sharing plans and documents and implementation of 3D CAD tools which always named as AutoCAD, which involves two common dominant contract methods which are Design-Bid-Build and Design-Build (Eastman et al., 2008).

Typical problem in Malaysia Construction Industry

Construction processes is no longer linear where different stages used to be defined, but now there are overlaps and parallel job scope during the construction phase. According to Sambasivan and Yau (2007), the delays are typically caused by contractor's improper planning, Contractor's poor site management, Inadequate contractor experience, Inadequate client's finance and payment for completed work, conflicts between contractor and sub-contractor, shortage in material, labour supply, equipment availability and failure, lack of communication between parties and mistakes during the construction stage (Sambasivan & Yau, 2007).

Cost overrun as mentioned by Memon et al. (2012) is identified as main critical issues. Main factor causing cost overrun can be related to frequent-design-changes with incomplete design at the time of tender, change in the scope of the project, mistakes and errors in design because of inadequate monitoring and control. This was supported by Cheung et al. (2006) who agreed that conflict always happened in construction caused by frequent change in construction plans and specifications on top of information errors due to massive documentations. Additionally, effective material management, efficient resource planning and management and standardized design method should also be created for cost control of the project (Cheung et al., 2006). According to Jaffar et al. (2011) the other factor that causes conflict is due to defective plans. The construction today has to work with incomplete plans that were submitted.

The drawing considers as defective plans when that is mistakes in the dimension, wrong scales, poor specification, the specification of the material detailed. The ineffective communication between the design team and construction team also identified as major issues. They may have a different expectation when just viewing a 2D CAD plan which caused conflict among them. Therefore, an intelligent 3D simulated model needs to communicate the design vision to the owner and construction team accurately to gain approvals.

BIM in construction industry

BIM is defined as 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. While some may simply take it as an intelligent simulation of architecture to enable us to achieve integrated delivery. The main different between Computer Aided Design (CAD) and Building Information Modeling (BIM) is older CAD system produce 2D drawing with plotted system is created separately for all type of plan. For example, the architecture plan, engineering plan, plumbing plan, door and window plan, etc.

Nevertheless, CAD system is improved to 3D modeling and complex surfacing tools were added but it only shows the geometrical modeling 3D with digital volumes and surfaces. In BIM, the intelligent model is created in the form of an interactive tool and support different views of data contained within the drawing set with 2D and 3D. The information that shows in BIM include the properties of the material like width, height, bearing or non-load bearing, cost, quantities, and even the suppliers. The BIM platform shows all the information into one system that all parties in the project team can review. In spite of that, there is no linkage between the data created by CAD.

Adoption of Building Information Modeling (BIM) in the Malaysian Construction Industry

The challenge in adopting BIM in the construction industry is classified into two categories which are non-technical and technical (Zahrizan et al., 2013). Non-technical challenges are related to human being and organizational culture and according to Arayici et al., such as unawareness of benefits BIM compared to 2D drawings, education, and training existing staff, new roles and responsibilities of different stakeholders in BIM. Technical issues are related to the current technologies in the construction industry such as upgrading the technologies so that it compatibility to BIM software. This is because not all organization can afford to invest or buy the new technology, especially for small-medium Company. According to the research of "Exploring the Adoption of BIM in the Malaysia Construction Industry" by Zahrizan et al. (2013) the adoption of BIM in Malaysia had divided into 4 categories which are organizational culture, people, Technology and Recognition from the government.

Table 1. Adoption of BIM in Malaysia

Categories	Detail in adoption of BIM in Malaysia Construction Industry
Organizational Culture	Low-level knowledge about BIM in majority construction players. This is because there is no standard for BIM implementation guideline at the national level The majority of the construction players are still doubting the effectiveness of BIM because of the limited data in the Malaysia context has proven the effectiveness of BIM.
People	A new post related to BIM system should be created and giving a clear job scope is one of the strategies to the implementation of BIM,
Technology	In order to implementation BIM successful in organizations the software, hardware and infrastructure of organizations need to be upgraded so that it can support the BIM system. Besides that, the complexity of BIM software is one of the barriers to BIM implementation.
Recognition from the government	The government has to establish BIM committee member to support the adoption of BIM in Malaysia. The National BIM standard and guideline should provide by the government to the players in the Malaysian construction industry.

METHODOLOGY

The study begins with an overview of current design software used in Malaysia Construction industry for both 2-Dimensional and 3-Dimenisonal CAD. Primary data will be collected by survey questionnaire and the secondary data will be from the related journal, article, conference report, reference book and etc. Then the collected data was analyzed using MiniTab Statically Software 16. In this study, the quantitative approach of survey questionnaire is implemented in this research to identify the level of awareness of Building Information Modeling in Malaysia Construction Industry.

Research Sampling

The research sample in this research concentrates on contractors in the northern region comprises only those from grade 5 to 7, which under the sub-categories of "Building General Work (B04). According to Scott M. S (2013) before calculating a sample size, a few things need to determine about the target population and the sample needed such as population size, the margin of error, confidence level and standard deviation (Arayici et al., 2011). Therefore, ideal respondent numbers identified are 164 respondents. The total numbers of contractor in Malaysia with different grade and the number of respondents expected are shown in the table below: A total sampling from contractor grade 5 to grade 7 are 227 and the expected respondent is 164 (Jaffar et al., 2011). A total of 220 survey questionnaire were distributed to Contractor Company with grade 5 to grade 7 and 93 respondent were received through e-questionnaire but 4 respondent contained invalid answers therefore only 89 valid respondents were gathered.

DATA COLLECTION AND ANALYSIS

General Awareness and Understanding

The results reflect the percentages of people general awareness and understanding toward BIM by choosing Yes, No and maybe for each of the survey questions. From the bar chart shown in Figure 1, most of the people choose does not have a good understanding of the impact of BIM toward the industry and organization which is 48.9% out of 100%. In addition, the highest percentage for YES is the Q5 47.8% this means that most of the people agree that the BIM is a key to sustainable construction and the second higher is the pie chart C this show that people understand the differences between the 3D modeling and BIM. The higher percentage for Maybe is 47.8% from Q7. Thus, people still doubt in BIM is the newest technologies to improve infrastructure asset management.

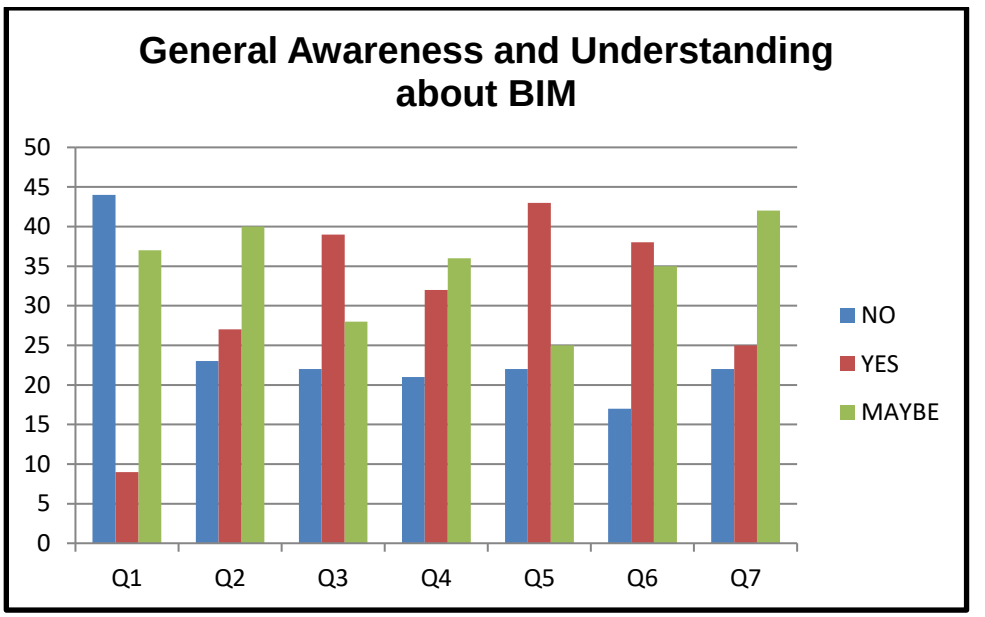

Figure 1. General awareness and understanding toward BIM

Benefits of BIM compared to 2D and 3D CAD system

This section is to compare the difference between CAD System and BIM system with the comparison factor of benefits that can be gain by BIM system shown in Figure 2. The result reflects that BIM is able to improve cost estimating at each project is the benefits factor that people agreed the most. Nevertheless, people still have doubt that BIM can reduce overall project cost better than CAD system as it is the lowest rate among the questions.

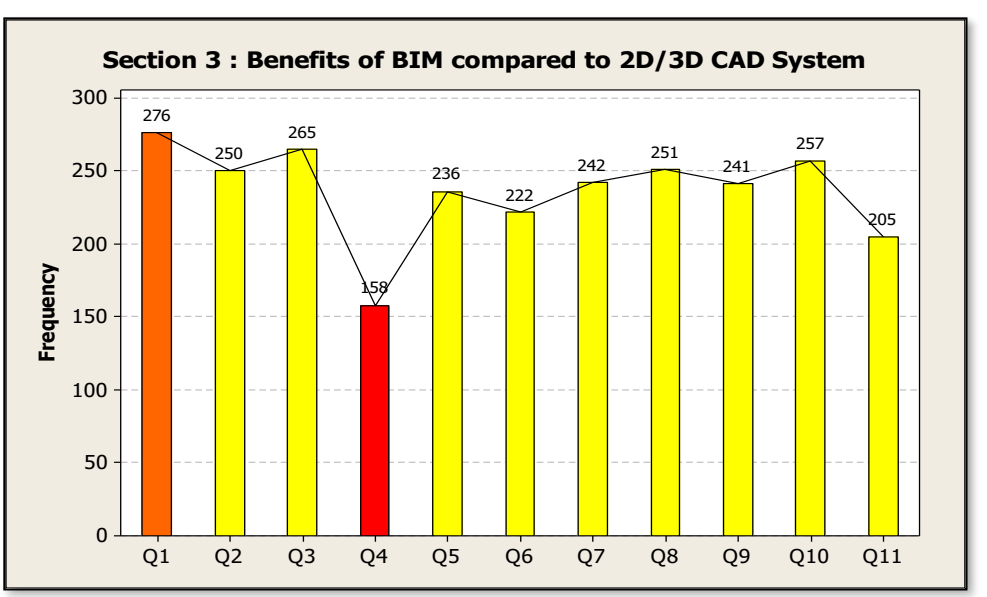

Figure 2. Frequency between CAD System and BIM system

The Barriers of BIM Implementation

The barriers will affect the speed of implementation BIM into Malaysia Construction Industry, therefore, it is important identify the barriers which limits the use of BIM among the construction industry. The bar chart shows below in Figure 3 are the barriers implementation BIM from the 89 respondents. The results reflects that Immaturity of software in term of data exchange and interoperability (Q3) is the factor of barriers to implementation to BIM which holds about 11.46% out of 100%. The higher point following by Q7, Q5 and Q6 and three of them are related to the cost of new software and updates, the cost of employing additional staff and cost of new software and updates. In spite of that, the graph shows that the time required training existing staff (Q8) is the lower rate of the 11 questions which is only 6.21% out of 100% and the second lower is Lack of skilled personnel which is 6.87%.

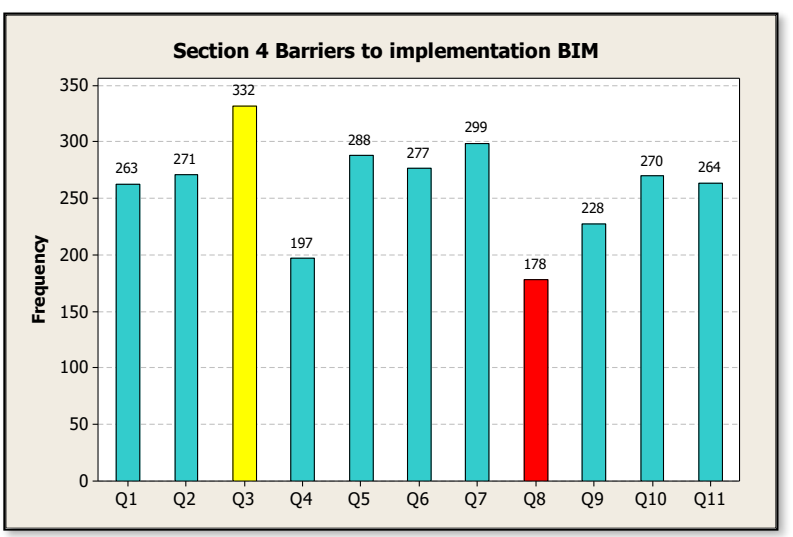

Figure 3. Barriers to implementation of BIM

DISCUSSIONS AND RECOMMENDATIONS

The awareness of BIM among the construction industry is still low because BIM as a new design software system has not been clearly defined by the construction player. The analysis shown most of the respondents agreed that low understanding of the impact of BIM contributed to the highest factor. This is because the practice of BIM in Malaysia is still low and also the low-level knowledge about BIM in Malaysia construction player (Scott, 2013). From the analysis related to the benefits of BIM shows that constructor under the categories of G5 had the lowest average point among the other 2 categories. This is because not all organization can afford to invest the new technologies, especially for small-medium Company. The highest barriers to BIM implementation into Construction Industry is identified as immaturity of software in term of data exchange and interoperability, which involve all parties to submit their model and plan in the specific format and stored in the common server. The complexity of the software of BIM becomes major barrier to BIM implementation which also caused the operational cost increases to upgrade the company server system. The government should play their role to adopt BIM technology in smaller scale public projects, thus this allow contractors to gain a lot of experience and also

information regarding BIM system. Standard and guidelines for BIM implementation should be designed as such that will allow standardization for BIM users and promote for stronger BIM industry.

CONCLUSION

The purposes of this study were to study the awareness of Building Information Modeling in Malaysia Construction Industry from the contractor's perspective. The conclusions drawn from this research are as follows:

BIM is an intelligent 5D modeling with time as 4D and cost as the 5D and the CAD system is only a simple 3D modeling.

The advantages of BIM that can bring to the construction industry are BIM can help to have better management and design in pre-construction phase until the post-construction phase. Besides that, BIM also can help to reduce the typical problem in the construction industry as stated.

The level of awareness of the contractor company is in low-level as most of the contractors still has doubt that BIM may bring change to their organization and also do not have enough experience in BIM projects.

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THE POTENTIAL USE OF BIM THROUGH AN ELECTRONIC SUBMISSION: A PRELIMINARY STUDY

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Abstract
Globally, the public sector plays an important role in leading the market towards BIM adoption as they can be a catalyst towards better utilisation of BIM in the industry. Implementation of electronic submission for instance, may become a channel for the public sector to gather information within BIM environment, especially project development information from the design stage throughout the construction phase. The aim of this paper is to investigate the potential of BIM implementation within the public sector, specifically how BIM could be utilised to facilitate electronic submission. The research method applied for this study includes a literature review, interviews and qualitative analysis of the data collected. The study is limited mainly to the current status in the public sector. Therefore, semi-structured interviews were conducted with five professionals from the public sector agencies and the data gathered has been analysed using a content analysis procedure. Finally, the results have been used to create a proposed conceptual system environment for a BIM-based electronic system. This study shows that BIM can be very useful to facilitate electronic submission concerning building approval. The outcome is also presented as a conceptual design for BIM-based electronic submission for building plan applications which could support the public sector to adopt BIM.

Keywords: *Building Information Modelling (BIM); Construction; Electronic Submission*

INTRODUCTION

Realising that there are many advantages that could be gained from the implementation of Building Information Modelling (BIM), many countries have been taking action to promote the utilisation of BIM and even some that have currently mandated the use of BIM. Based on the National Building Specification (NBS) International BIM report, many countries are rapidly adopting BIM and the public sector projects are required to use BIM (NFB, 2013). However, despite many countries around the world move towards the adoption of BIM technology, the level of BIM adoption by the Malaysian construction players is still low, especially in the public sector (Zahrizan et al., 2013).

In Asia, Singapore is the first country that has proved BIM to be successful when used in the public sector, through a BIM electronic submission for regulatory approval (Khemlani 2005; BCA, 2011). Electronic submission would not only prove beneficial to the public sector, but also to project stakeholders because the manual checking of building designs for compliance against national codes is complex and prone to human error with significant cost implications (Tan et al., 2010). Furthermore, this regulatory framework can provide a standard environment and be a catalyst for a wide acceptance in the industry and will create a basic foundation for construction players to stand on (Wong et al., 2009). Therefore, Zakaria et al.

(2012) believe Malaysia also requires the engagement from the government which will be the aspiration towards better utilisation of BIM in Malaysia.

BIM could be regarded as a technology comprising of a large amount of programs (Linderoth, 2010). Therefore the implementation process needs appropriate strategic planning and a thorough assessment of many elements. Therefore it is important to assess the potential of using BIM to assist electronic submissions for building plan approval within the public sector. This is because electronic submission may become a channel for the public sector to gather information within BIM environment, especially project development information from the design stage throughout the construction phase.

BIM

Currently, there are many different definitions of BIM. A couple of definition from the idea of Building Information Model focuses on the model as well as information attached to that model. However, for the purpose of this paper, the BIM definition refers a set of interacting policies, processes and technologies (as illustrated in Figure 1) that generate a methodology to manage the essential building design and project data in digital format throughout the building's life-cycle (Penttilä, 2006; Succar et al., 2012; Omar el al., 2014; Nawi et al.,2014).

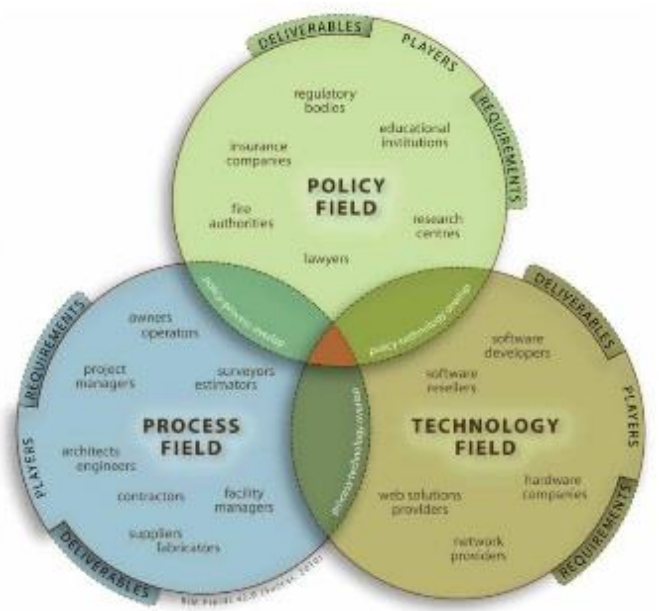

Figure 1. The interlocking fields of BIM implementation (Succar et al., 2012)

As stated by Succar (2009), the interlocking fields of BIM implementation determining domain players and their deliverables. Policy field players are those who focused on regulating the delivery of facilities, educating practitioners, conducting research and minimising conflicts. These include regulatory bodies, educational institutions, research centres and insurance companies. Meanwhile, process field players are those who involved in procuring, designing, constructing, manufacturing, using and maintaining facilities like architects, engineers and contractors. And finally, technology field players are those who

develop or deliver software, hardware, tools and equipment related to design, construct and maintain facilities. The model also representing the overlaps of BIM fields as they share players and deliverables (Succar, 2009).

This paper would emphasis more on the role of policy field players who involves in the electronic submission for building plan approval within the public sector. By given Singapore as an example of success story of BIM implementation within the public sector, it is important to engage with the policy field players in Malaysia in order to assess the potential of using BIM in the abovementioned process.

ELECTRONIC SUBMISSION

Electronic submission is specific submission data files uploaded in electronic form for approval or change or for a renewal procedure (EMA, 2013). Generally in the construction industry, electronic submission consists of submission of digital building or development plans by industry players to a regulatory body and automated compliance checks will be executed on the specific parameters of the proposed building against the building codes and regulations for approval (Rahim, 2004). These particular rule checks are required for all buildings constructed within a jurisdiction (Eastman et al., 2009). Electronic submission is essential due to the fact that the manual checking of building designs to meet the national code requirements is complicated and prone to human error (Tan et al., 2010).

As stated by Lee et al. (2009) automated rule checking is referred to software capabilities to assessing a design on the principle of the arrangement of objects, the connections and attributes without modifying a building design. Generally, automated code checking involves the computerisation process of code checking activities against building rules and regulation. Lee et al. (2009) also claim that automated code checking has the capabilities to reduce lot of time and save cost in the building delivery process.

CURRENT PRACTICE OF ELECTRONIC SUBMISSION IN MALAYSIA

A One Stop Centre (OSC) was announced by the Malaysian government in April 2007 as a way to realise the government's vision of achieving efficiency in the public delivery system, Following that, the OSC Online was developed in 2009 to facilitate even faster and more efficient processing of development application proposals (Phoon, 2009). OSC Online is an electronic system for submission and processing applications for development proposals which allows for separate or concurrent submission of land development, planning permissions, building plans and engineering plans in 2D drawing (MUWHLG, 2013). It was developed on a Java platform and is designed to facilitate communication among Users; the Submitting Person; OSC Secretariat; Internal Technical Department; External Technical Department; and OSC Committee Members (LGD, 2014d). In addition, the OSC Online consists of eight sub-modules; e-application, e-reference, e-enquiry, e-complaint, e-service request, e-guide, e-payment and e-report card (LGD, 2007).

One of the projects is E-plan and one of the application systems in it is Electronic Planning Submission and Approval Systems (Rahim, 2004). Subsequently, a number of non-BIM based electronic submissions have been developed, for instance the Selangor Electronic Planning Approval System (SEPAS) for the Selangor State Town and Country Planning Department

(Meng and Ahmad, 2000), the Intelligent CAD Checker System for building plan approval (Sulaiman et al., 2002) and the development of a computerised development control and approval system for the Planning and Development Control Department, City Hall of Kuala Lumpur (Yaakup, 2003).

Apart from that, Perbadanan Putrajaya (PPj) took the initiative to develop a planning submission system earlier in 1997 (PPj, 2014b). PPj was established to manage and administer the Federal Territory of Putrajaya, together with the functions of a local authority and local planning authority (PPj, 2014a). In order to support its function efficiently, PPj introduced an integrated city management system called SUMBER-PUTRA, built on Nova's PAVO™ platform solution (novaCITYNETS, 2004). The system consists of several sub-systems including Development Planning; Development Control; Building Control; Property Register and Valuation; and License Management (Wong, 2008). In addition, PPj also implemented OSC Online to support the government's aspiration, with a few enhancements to facilitate the submission of applications for Planning Permission, Building Plan Approval, Infrastructure Plan Approval and Landscape Plan Approval via the e-submission Module (PPj, 2014c).

A government initiative to re-engineer and streamline the procedure for project development via OCS has put Malaysia in 6th position among 189 countries for the ease of doing business according to the Doing Business 2014 report (The World Bank, 2014). This was achieved through the Dealing with Construction Permit indicator that recorded the most significant achievement to be ranked 43rd in 2013 from the 99th position in 2013 (The World Bank, 2014).

Application for a building plan

To date, Malaysia has 150 local authorities (LGD, 2014a) and out of these local authorities, 105 have OSC (LGD, 2014b). As of April 2014, Malaysia has received 153,529 applications for building plan approval through these local authorities (LGD, 2014c). The flow chart in Figure 2 shows the submission application for a building plan carried out by the related departments. The time frame targeted to complete every building plan approval process is also indicated in this chart.

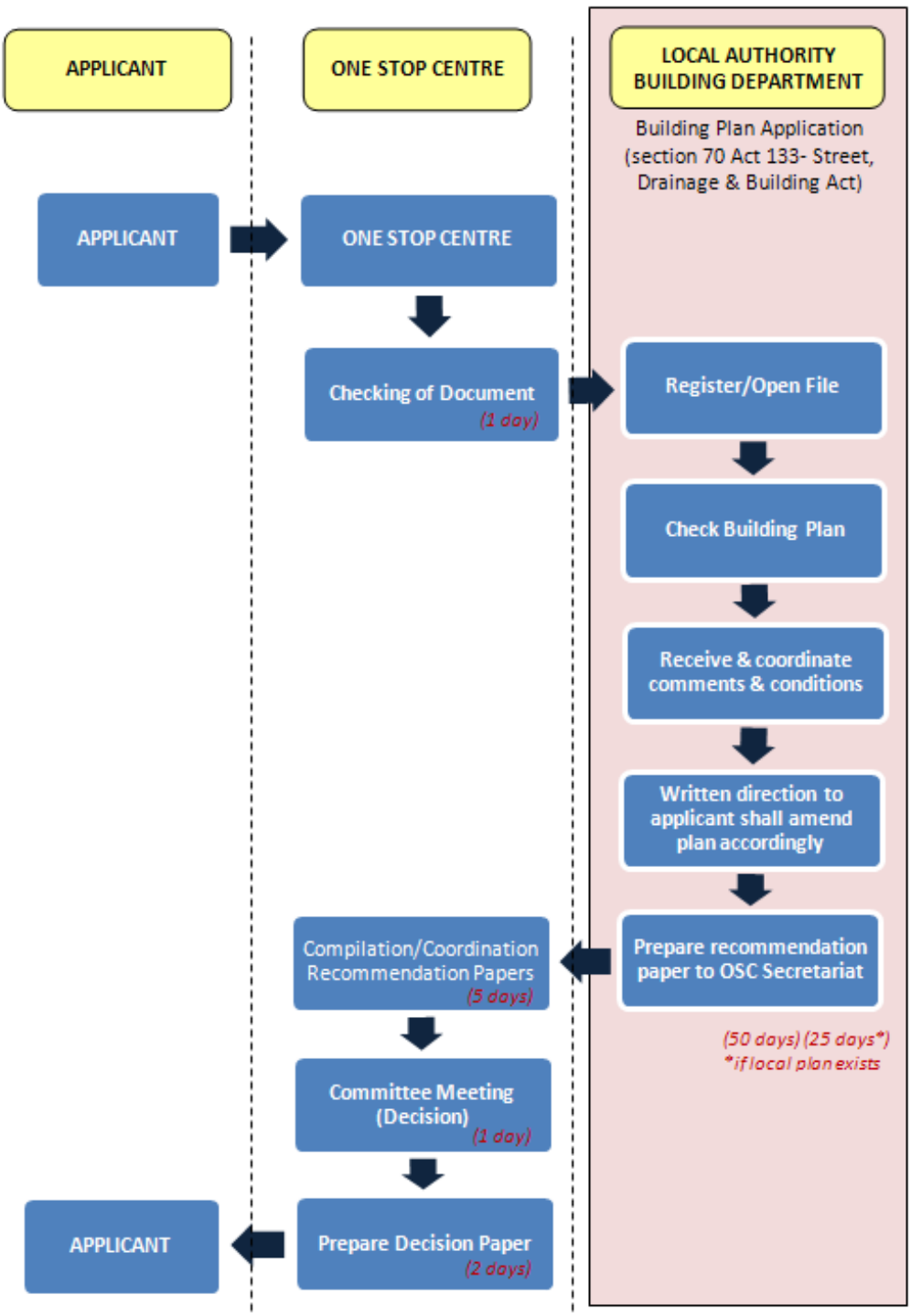

Figure 2. Building plan approval flowchart (MHLG, 2008)

The process starting point is when the applicants submit the application for a building plan to the Secretariat of OSC which is followed by checking, examining and submitting all the documents to the Building Department/Division of the Local Authority (MHLG, 2008).

The officer in the Building Department will undertake the relevant procedures to ensure that the requirements are fulfilled. The OSC will table applications to the OSC Committee Meeting when all the technical comments were ready. This includes all the comments from the technical departments/agencies at the state/federal and local level such as the Water Supply Corporation; the Department of Fire and Rescue Services; the Department of Sewerage Services; Tenaga Nasional Berhad; Internal technical departments (Department of Planning, Department of Engineering, Landscape Department, Department of Health); together with other related agencies and technical departments. Decisions from the OSC meeting will be released to the applicant with or without conditions. The OSC secretariat will inform the applicant on the result of the application, enclosing the approved layout plan, building plan as well as other relevant plans (MHLG, 2008).

BIM adoption in electronic submission

Introduction

The increased rates of BIM adoption worldwide has generated the potential for initiating automated compliance checking of building designs (Greenwood et al., 2010). As a result, many countries have considered an initiative to establish BIM electronic submission (Eastman, Lee et al., 2009). In 2008, Singapore launched the Construction Real Estate NETwork (CORENET), the world's first Building Information Modelling (BIM) electronic submission (BCA, 2011). CORONET streamlines the procedure for regulatory submission which enables the project team to submit only one building model that contains all the required information. Influenced by this accomplishment, Norway, Australia and Japan have utilised CORONET as a basic principle for their pilot projects (Khemlani, 2005). On the other hand, in the USA all General Services Administration (GSA) construction projects are required to submit BIM data via the Spatial Program Validation and Automated Design Guide Checking (Eastman al., 2009). The next sections are dedicated to reviewing the BIM based automated code checking in electronic submission systems for checking and approving building plans.

CORONET (Singapore)

In 2008, Singapore launched Construction Real Estate NETwork (CORENET), the world's first Building Information Modelling (BIM) electronic submission (BCA 2011). It has been developed by novaCITYNETS Pte Ltd for the government of Singapore (BuildingSMART, 2014). CORONET streamlines the procedure for regulatory submission which enables the project team to submit only one building model that contains all the required information (Khemlani, 2005). It includes three components for the design phase; in particular CORENET e-Submission, CORENET e-PlanCheck and CORENET e-Info. e-Submission tracks building permit actions and e-Info contains advisory information for different construction-related agencies (Eastman et al. 2009). Meanwhile, e-PlanCheck is an automated checking of new building designs against the building's codes requirements instead of manual paper based techniques (BuildingSMART, 2014; novaCITYNETS Pte Ltd 2014) and this study has basically focused on e-PlanCheck.

e-PlanCheck will process a building model prepared in a BIM application and after that exported to the IFC format which is IFC 2x2 (Khemlani, 2005). According to Khemlani (2005), the IFC format itself is incapable of performing automated code-checking because the

IFC only consists of basic building objects. Their properties modelled by a BIM application and provide minimal and static data for code compliance checking (Khemlani, 2005).

Hence, novaCITYNETS Pte. Ltd. developed an independent deployment platform called FORNAX to interpret the building codes (Eastman et al., 2009). FORNAX retrieves the IFC files which contain the basic building model information and adds higher level semantics to it that are associated with code checking requirements and encapsulating building elements into a set of FORNAX objects (Khemlani, 2005). The FORNAX platform is as shown in Figure 3.

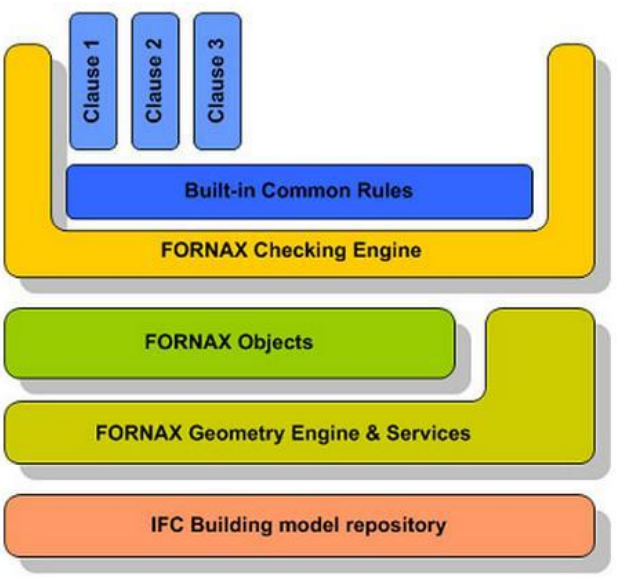

Figure 3. The FORNAX platform
Source: (Khemlani 2005)

As outlined by Liebich et al. (2002), e-PlanCheck allows the applicant to submit a partial model for checking at any stage, in order to verify the design or submit final work for approval checking. The files will be stored in a multi-user database at the plan checking server and the system will notify all related authorities. e-PlanCheck can be accessed by every inspector in order to view, comment, and run an automatic check against the clauses from the latest building code. Finally e-PlanCheck will produce the checking results in a suitable user interface (Qi, 2002). Figure 4 shows the CORONET e-PlanCheck.

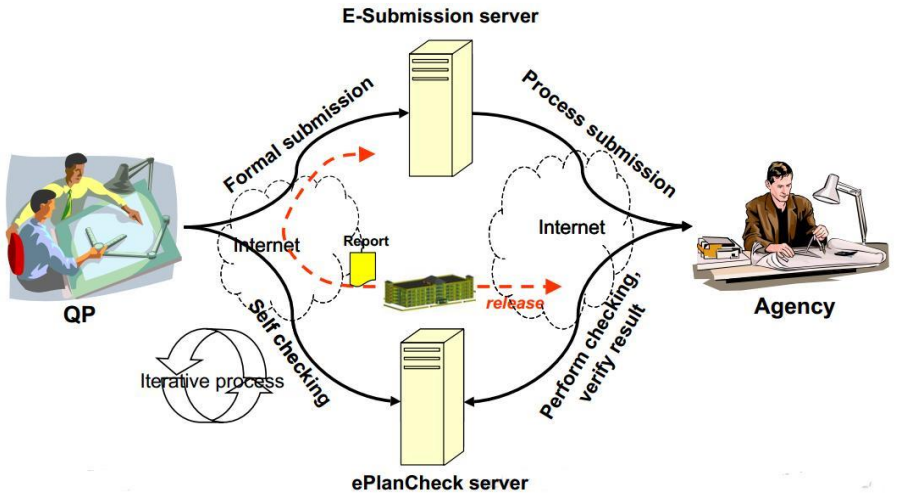

Figure 4. CORONET ePlanCheck process
Source: novaCITYNETS Pte Ltd, 2014

CORONET has adopted automatic code checking as a tool to minimise the cross-domain regulation differences and to make sure all the buildings submitted comply with up-to-date building regulations (Qi, 2002).

General Services Administration and International Code Council (USA)

The National 3D–4D-BIM Program by GSA has utilised BIM technology in six areas; in particular spatial program validation, building elements, 3D laser scanning, 4D phasing, circulation, energy performance and operations, and security validation (GSA, 2003). Therefore, AEC players who are working on one of GSA'S projects, must submit their design to the GSA in the original format of the BIM authoring application together with an IFC file (GSA, 2007).

A spatial program BIM enables GSA project teams to automatically analyse and examine whether the A/E concept design fulfils the GSA spatial program requirements including area measurements and building efficiency measurements (GSA, 2007; Eastman et al., 2009). Meanwhile, 3D laser scanning technologies are used to acquire a building's spatial data such as construction as-built development; facility condition documentation; historical documentation; and BIM development in 3D with high fidelity and low processing time (GSA, 2009a). At the same time, 4D BIM is used by GSA to support the understanding of project phasing and how the project affects them (GSA, 2009b). Other than that, Circulation and Security Validation works by using the Solibri platform to ensure all designs comply with the circulation requirements (Eastman Lee et al., 2009).

Byggsøk (Norway)

ByggSøk is based on Singapore's system, CORONET, and consists of three components: an information system, a submission of building applications system and a zoning proposals system with planning data and GIS integration (CRC, 2006; ByggSøk, 2014) and Byggsøk ePlanCheck process is as shown in Figure 5.

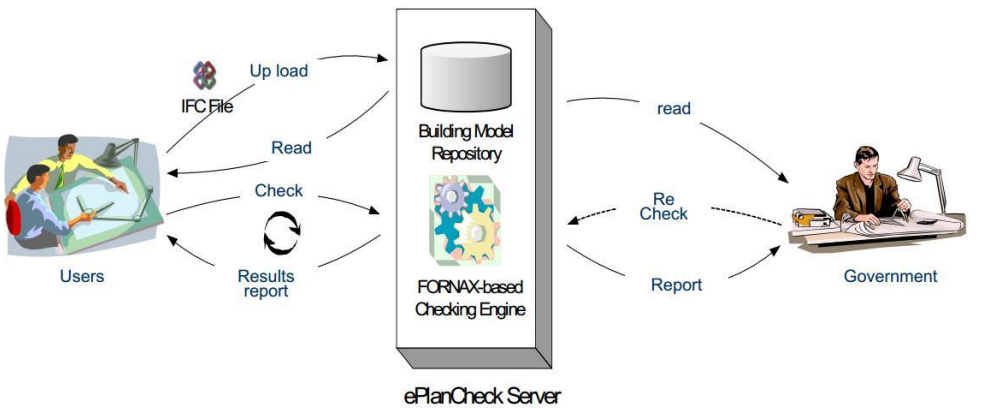

Figure 5. ByggSøk ePlanCheck process (Sjøgren, 2010)

The applicant is guided during an application process, customised to the issue concerned and will get guidance throughout the process. After that, the submission is checked once all the information has been entered (ByggSøk, 2010; ByggSøk, 2014). Subsequently, ByggSøk use an IFC BIM platform to check against general regulations, site specific regulations and building codes (ByggSøk, 2010).

If the application is complete it can be printed out on paper or submitted electronically to the local authority and all 431 local authorities in Norway are able to receive the applications (ByggSøk, 2010).

METHODOLOGY

Five semi-structured interviews were conducted with participants on different hierarchical levels within public sector bodies. The main goal of the interview is to gain knowledge of adoption of BIM, their view, barriers for use and to assess the potential of BIM for building plan approval. Since BIM technology is still new in Malaysia, no public sector has implemented BIM in their organisation. Therefore, the interviews were conducted with selected local authority officers, public sector body officers and researchers. The participants were chosen for their relevance to the conceptual questions and they have experience in processing building plans, planning permission, project development and electronic submission.

All the interviews were transcribed from the voice recorder and then content analysis was performed for each of the interviews by using a mind map. According to Gerbner et al. (1969), content analysis is an information-processing step to convert communication content into data which are then summarised and compared by using objective and systematic application of categorisation rules. Furthermore, as outlined by Kohlbacher, (2006) content analysis is a comprehensive method for data analysis which is suitable for case study research.

Therefore, data analysis was performed by using content analysis in an effort to determine the most frequent information mentioned by all participants. Following that, data gathered was organised and categorised into key features in a mind map based on the research

objectives. After that, the data gathered was summarised to enable the assessment on the potential of BIM to facilitate electronic submission for building plan approval.

ANALYSIS AND FINDINGS

The results from the interviews reflect that there is the potential for BIM to facilitate building plan approval within the electronic submission. Most of the participants claim that the use of BIM in electronic submission would be able to speed up the process for building plan approval. The applicant will only have to submit one model, hence it can be accessed by several agencies and can be used to perform various analyses. BIM-based electronic submission could be the channel for the public sector to gather BIM information in one central place which then can be easily retrieved for other purposes identified by the participants such as for operation and maintenance; to perform risk assessment and risk evaluation impact, property valuation and assessment, simulation and 3D city modelling. At the same time, indirectly this approach would be able to expedite the use BIM technology within the public sector.

Current electronic submission through OSC has successfully enhanced the delivery system of development proposal application since 2007. Consequently, this has been proven that the government has made it through the transformation period from using the complex traditional practices with paper into the utilisation of an organised system. Thus, the existing OSC could be a catalyst for the implementation of BIM based electronic submission.

Three of the participants also suggested the government should carry out a pilot project to establish and understand the utilisation of BIM before decided to fully adopt BIM in electronic submission. This is in accordance with the findings of the literature review, in that most of the countries that already have mandates for BIM have carried out a pilot project at the beginning, to identify any issues and capabilities with the use of BIM. On the other hand, the related agencies will need to start to produce a national implementation plan which requires standards, guidelines and references for effective management and communication among potential stakeholders.

Based on the literature review and interviews, the potential pilot project to be integrated with BIM is the OSC Putrajaya. This is due to the existing infrastructure having been proved to manage to perform application processing and plan checking electronically prior to the government mandating the OSC implementation. Therefore, with the advancement of using ICT technology, it is possible that BIM-based electronic submission could be implemented to facilitate building plan approval.

In addition, participant four, who has over 16 years' experience working in the IT field and currently handles OSC PPj, highlighted that they will not have any technical difficulties in implementing BIM in their existing electronic submission. This is because they have designed the electronic submission module in such a way that it is very flexible and could easily add any new technology. Meanwhile, the majority of the participants expressed the need for further discussion on the need for the development of BIM integration, such as software and hardware if they want to integrate BIM in the current electronic submission system.

Proposed concept for BIM-based electronic submission for building plan approval

Based on the literature review and the results from data analysis, the proposed conceptual design for BIM-based electronic submission for building plan approval was created. The proposed concept has taken into account the current practice of electronic submission which is the OSC online as shown in Figure 6 below.

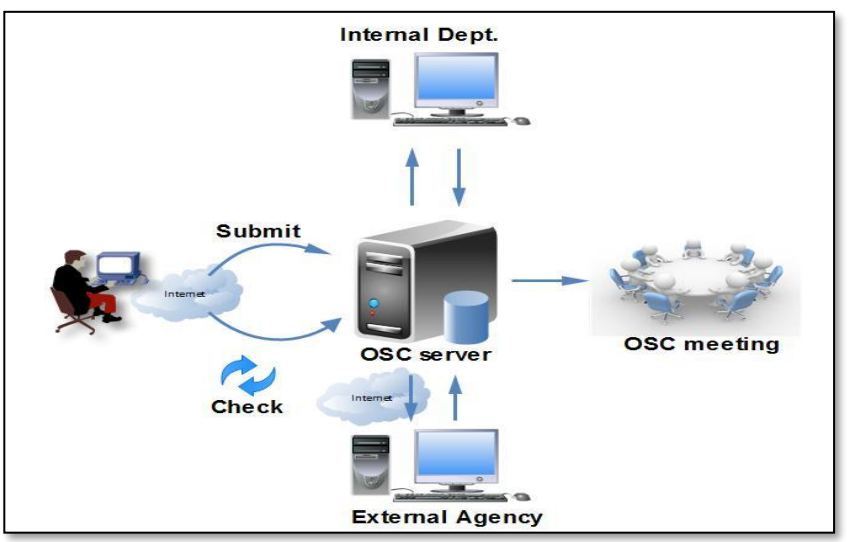

Figure 6. Proposed BIM-based electronic submission for building plan approval conceptual design

The process starts with the submission of the plan through OSC Online. The proposed enhancements offered through this system are that the applicant will be able to choose between verifying the design checking and submitting the final design for approval. Following that, the OSC server will perform automated checking of the building plan against the relevant building codes and regulations. For both selections, the system will distribute the application to internal departments and external agencies and then the officer from the related bodies can view the submission and subsequently give any feedback or comments. After that, if the applicant chooses to verify the design, the system will provide the checking results and if not, the system will compile all the technical comments and recommendations. Following that, the application will be presented to the OSC Committee Meeting for building approval.

The proposed concept is still utilising the existing workflow for building approval processing within the OSC online system. The difference lies in the capability to perform automated code checking and this is the key element in the implementation of BIM in electronic submission. Figure 7 illustrates the proposed concept for an e-submission plan checking system environment.

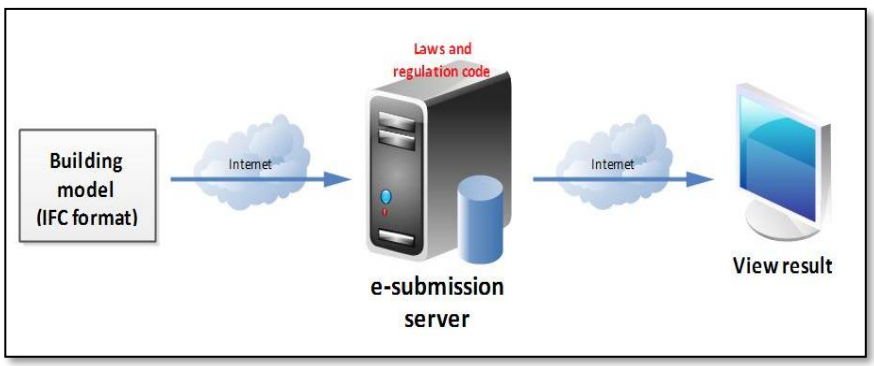

Figure 7. Proposed e-submission plan checking system environment

Automated code checking could be utilised in order to facilitate the plan approval process with the ability to easily perform cross-jurisdiction regulation validation using automated procedures. Applicants could submit IFC model data to the system over the internet at any time and from anywhere. Hence, the server will perform automated checking of a building plan against the relevant building codes and regulations such as Act A1286 Street, Drainage And Building (Amendment) Act 2007; Code of Practice for Access for Disabled People to Public Buildings; Specification for Fire Precautions in the Design and Construction of Buildings; and Code of Practice for Sanitary System in Buildings. Subsequently, an applicant will be able to view the results in a short time. Meanwhile during the whole process, all the stakeholders could provide comments if appropriate or just monitor the status and application's progress online.

CONCLUSIONS

This study has been extensively reviewed the implementation of BIM by public sectors in many countries. The literature showed the public sector in other countries such as Singapore, Hong Kong, USA, UK, Finland, Denmark, Norway and Australia are actively supporting BIM implementation to improve the approach of construction projects being delivered. At the same time, Singapore, USA and Norway have established best practice in an effort to mandate BIM requirements for their public projects. In a local context, the Malaysian Government has mandating OSC online implementation through the electronic submission. The 2D-based system has successfully processed several thousand applications for planning and building approval each year.

The primary data obtained from the five semi-structured interviews highlighted the benefits of BIM for electronic submission. The benefits include speeding up the process of project development, improving data integration and management and reducing errors. The participants are optimistic about the potential of integrating BIM to facilitate building plan approval through current practice as there is an agency that already has a basic platform to integrate BIM in the electronic submission. Thus, by having the integration, the building plan approval process is expected to be easier to be operated and managed, as well as being able to integrate all the information needed by the government agencies.

Apart from that, data gathered from the literature review and interviews were also used to suggest the conceptual design of a BIM-based electronic submission. Thus, the utilisation of BIM in electronic submission to facilitate building plan approval could be an enabling

platform for the public sector to fully adopt BIM in their work processes. At the same time serve as a catalyst in leading the construction industry towards a wider adoption of BIM.

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CURRENT BIM PRACTICES IN MALAYSIAN CONSTRUCTION ORGANISATIONS: THE STAKEHOLDERS' PERSPECTIVE

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Abstract
Building Information Modelling (BIM) is transforming how buildings are designed and constructed. At the same time, it can facilitate multi-disciplinary coordination whilst integrating 3D design, analysis, cost estimating and construction scheduling. Currently, due to poor coordination among its project participants, the construction industry is still unproductive, fragmented and lacking in collaboration. Hence, with the introduction of BIM the performance of the industry, the coordination and collaboration among the construction players and the productivity of the projects could be improved. However, the lack of understanding from the construction players about BIM, which includes the wide spectrum of benefits and barriers that could be encountered, has made industry players reluctant to proceed with its implementation. This research aims to investigate the benefits and barriers that could be encountered in BIM implementation from the construction stakeholders' perspectives. Pilot interviews with 5 participants from different organisations have been carried out followed by multiple embedded case studies to investigate the current BIM practices from the developers' perspective. Accordingly, the qualitative data gathered through the interviews are the main data sources. Content analysis was used to better analyse the data collected. As a result, most of the respondents have agreed that although there are plenty of benefits and advantages of BIM adoption, its use in the Malaysian construction industry is still in its infancy and developmental stage. The main reason is that there are still major barriers to be overcome, especially the construction players' mindset and thinking.

Keywords: *Barriers; Benefits; Building Information Modelling; Construction industry; Malaysia*

INTRODUCTION

The Malaysian authorities have turned their attention to implementing Building Information Modelling (BIM) in the Malaysian construction industry. BIM has even been highlighted as one of the strategies to transform the construction sector in the 11th Malaysia Plan (Economic Planning Unit, 2015). During the Infrastructure & Construction Asia's Building Information Modelling & Sustainable Architecture Conference on 19th August 2009, the Director-General of the Malaysian Public Works Department (PWD), Datuk Seri Dr Judin Abdul Karim, said that BIM is considered as one of the focus areas identified in its strategies ("Construction Companies Urged to Adopt ICT", 2009). On 10th September 2015 when Prime Minister Datuk Seri Najib Razak launched the Construction Industry Transformation Programme (CITP) Malaysia's last five-year plan for the construction industry before 2020, he mentioned that BIM will be made mandatory in the year 2020 (Tamboo, 2015). However, so far BIM adoption is in its earlier stages and not wide-spread (Ahbabi & Alshawi, 2015).

BIM is a technology that allows users to create an accurate virtual model of a building digitally. The model is used for the planning, design, construction and operation of the facility, thus it helps the Architect, Engineer and Contractor (AEC) to visualize the environment of the surrounding building and identify any potential construction or operational issues (Bryde

et al., 2013). For example, architects and engineers can design buildings more efficiently and precisely, contractors can construct buildings with a minimum of errors and in a minimum of time, the fabricators can provide off-site fabricated materials and owners can make decisions quicker and enjoy better facilities management. Besides, BIM also enhances communication between these stakeholders, increases the productivity and quality, reduces the project delivery time and decreases the construction cost. The AECOO industry has been fragmented in the past but with the invention of BIM, through sharing information and a building model, the gap between stakeholders is closing. Significantly, AECOO can get most of the benefits of BIM by collaborating with the other stakeholders.

Unfortunately, the majority of the built environment professions nowadays are facing significant changes to meet the current trends and needs of the construction industries. The main changes are that the job scope of the parties in the construction industry is no longer limited to cost planning, measurement, issuing Bills of Quantities and ensuring that every stage of the on-going project is completed on time; today, they must also be able to master certain information technology skills (Takim et al., 2013). Besides that, the fragmented construction industry has poor coordination among its project participants (Nawi et al., 2014a; Nawi et al., 2014b; Razif et al., 2015; Ding et al., 2015; Hughes & Thorpe, 2014; Solomon et al., 2015; Ntayi et al., 2013). Hence, despite the importance of BIM in improving coordination, the lack of understanding about BIM makes the construction players in Malaysia reluctant to adopt it. This leads to the low adoption of BIM in architectural firms which stands at 20%, and in quantity surveying firms at 10 % (Grant, 2016).

The significance of this research can be viewed from the perspectives of academia and industry. With regards to the academic perspective, this research extends the knowledge of BIM in response to the benefits and barriers of building information modelling as advocated by Yan and Damian (2008). With regards to the industry perspective, the lack of understanding about BIM is directly responsible for BIM practitioners' inability to realise the full benefits of its implementation. Therefore, this study fills the research gap in this area, especially in the Malaysian construction industry context. In addition, this research reveals the benefits and barriers faced by the Malaysian construction industry BIM practitioners during the implementation of BIM to give a clearer picture for potential BIM users.

LITERATURE REVIEW

Benefits of BIM adoption

There is an extensive literature that indicates that the adoption of BIM could substantially improve productivity and pave a new avenue for the construction industry. Wong et al. (2010) found that 70% of 36 respondents agreed and supported that BIM will bring them many benefits. They also mentioned that the purpose of BIM can be described as leading to more reliable and faster decision making, more communicable building models, better quality of project produced, higher profitability for the clients, intelligent architectural simulation and the provision of consistent and non-redundant data plus improved delivery processes. With the use of BIM, the industry's fragmentation and the high costs incurred due to inadequate exchange and use of information can be reduced, hence the efficiency of construction processes can be improved (Succar, 2009). Notably, BIM provides the function of visualisation to help in decision making, providing a better understanding of the design and

functionality of the building space. The construction planning and scheduling involve sequencing activities in space and time, considering procurement, resources, spatial constraints and other concerns in the process. 4D CAD is a combination of 3D CAD with the added dimension of time which allows the construction schedule to be linked to the 3D model in such a way as to control and monitor the work progress. The benefits of BIM adoption could be explained according to different stages of the BIM project lifecycle: the conceptual, detailed design, documentation, construction or fabrication and the as-built or facility management stages. Figure 1 shows the benefits of BIM adoption in different stages of the BIM project lifecycle.

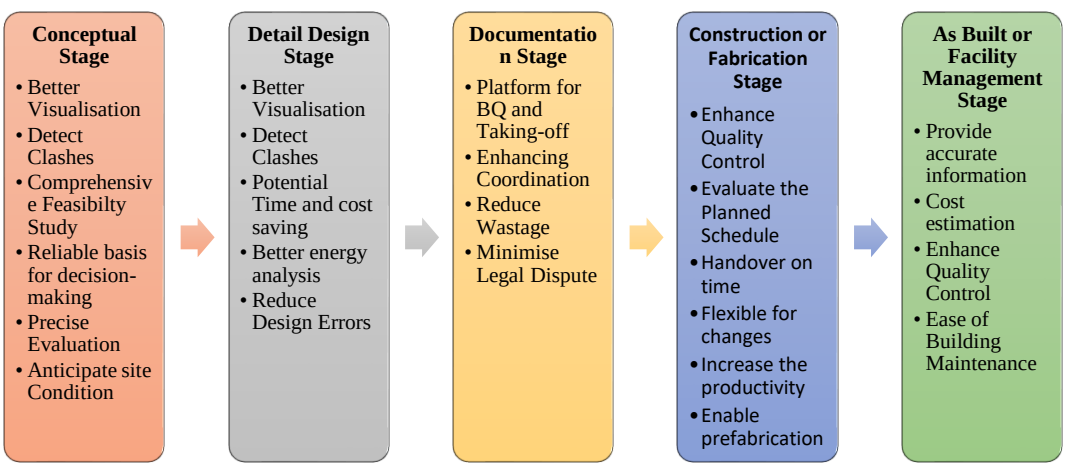

Figure 1. The benefits of BIM adoption in different stages of the BIM project lifecycle (Azhar et al., 2012; Eastman et al., 2011; Hergunsel, 2011; Rogers et al., 2015; Foster, 2008; Linderoth, 2010; Weygant, 2011; Nassar, 2007; Gu and London, 2010; Zarli et al., 2010; Krygiel and Nies, 2008)

Referring to Figure 1, with this single detailed model, BIM practitioners can embrace the full benefits of BIM adoption if all parties get involved at the initial stage. BIM can also improve the scheduling and drawing coordination. Thus, the time and cost can be well controlled (Memon et al., 2014). BIM can also overcome many construction project problems e.g. it helps to increase the construction efficiency and effectiveness (Latiffi et al., 2013). Last but not least, by implementing BIM, there is a reduction in man-hours, requests for information and rework, a greater capacity to use more pre-fabricated elements and an increase in on-time completions (Mitchell and Keaveney, 2013). The next section will discuss the barriers to BIM adoption.

Barriers to BIM adoption

Eastman et al. (2011) predicted that the industry might have to face problems of changes in practice and in the use of information. In the design stage, integration of construction knowledge is involved. For instance, the challenge which companies face when implementing BIM is that during the design stage a shared building model requires a coordinated set of building models to be used during construction and fabrication. This change will require time and education for the users and different stakeholders as it is a significant change in technology and in the work processes. Meanwhile, management issues surface during the implementation and the use of BIM. This situation accentuates problems of changes in

practice and in the use of information because there is no single document or guideline that instructs on BIM application or usage (Azhar et al., 2008).

As stated by Foster, (2008) one definite change when using BIM is that the designers would need to incorporate more information into the design sooner than with traditional design. The use of BIM requires certain assumptions to be made, such as the wall type to be used. Also, using BIM, the designers would be encouraged to spend more time coordinating the designs than with traditional design documents because conflicts could be more quickly and clearly identified. If the designers could identify these conflicts, then they should be able to resolve them before presenting those aspects of the design. The incorporation of information and additional geometry poses a challenge to owners as to what should be asked of designers when transitioning into BIM.

Garber (2009), also states that exchanging data is a challenging aspect of AEC information technology. BIM applications are evolving although standard formats to organize and share building information are far from fully matured. He has emphasized that during traditional project development, accurate, actionable costing information has been difficult to define during preliminary project phases. As stated by Garber (2009), architects typically do not provide cost estimates on projects as part of their standard services, but the native capability of BIM to quantify and calculate is changing the nature of project deliverables for all participants. Accordingly, BIM offers the capability to develop project cost information with more accuracy throughout the entire building lifecycle. The key to successful use of BIM-based costing will be the development of costable processes and methods within organizations.

Another issue to overcome is identifying who will take responsibility for controlling the entry of data into the model and bear the responsibility for any inaccuracies. Sebastian (2011), states that as data relationships are established, the unclear discrete boundaries of areas of responsibility is the present issue. When design errors occur, the Architect, as well as other design consultants, will try to keep themselves away from the responsibility, if disputes arise, the leader of the BIM - usually the Architect - will not only bear the responsibility as a matter of law but may also face difficulties in proving fault with others such as the engineer. Therefore, a BIM user will have to request complicated indemnities as the offer of warranties are limited (Azhar et al., 2008). Hence, before BIM can be fully utilized, the risk must be identified and well-allocated to prevent potentially dire consequences.

Besides, BIM needs the collaboration of many parties, hence, if the contractor is the only party using BIM, the results or benefits are hardly seen and it also wastes the time and effort of the contractor as he needs to put all parties' information into the BIM model to facilitate his use.

Migilinskas et al. (2013) have carried out research into categorising the barriers to the implementation of BIM concerning technology, norms, education and general issues. The issues relating to technology could be due to BIM being a new technology, a probable cause is the user's concern about the hardware and the complexity of model-based software. On the other hand, the general issue could lie with not having enough financial resources to invest in BIM as it is costly at the preliminary stage. The construction players have also stated that normative issues refer to producing a normative description contract which can be efficiently

and securely agreed between all the parties. Applying the BIM method does not allow for blueprints or shop drawings; the project partners are allowed to exchange the model among themselves. As for education, since people, technology and environment are always the factors affecting the implementation of BIM, the new technology of BIM may lead to a lack of knowledge on how it could be used.

BIM is a data-rich model hence the size of the data files produced can be huge. Hence, users may need to upgrade their computer hardware and corporate storage capacity and/or set a file size limit, etc. (CICRP, 2010). In Malaysia, BIM is still a new trend, so there is no standard for model integration and no standard protocol, every firm uses their own standards, which may cause inconsistencies and inaccuracies in the building model (Weygant, 2011). The next section further discusses the different issues in the implementation of BIM.

a) Legal issues

BIM has too many legal barriers and it is too costly to overcome. The legal issues are concerned with who owns the multiple design, fabrication, analysis and construction databases, who pays for them and who is responsible for their accuracy (Eastman et al., 2011). Azhar et al. (2012) said that the first legal issue is ownership of the BIM data and its protection through copyright and other laws. For example, the owner may feel entitled to own it since they are paying for the design, as such proprietary information provided to team members for use on the projects has to be protected as well. Another issue to consider is who will control the entry of data into the model and be responsible for any inaccuracies. Before BIM technology is utilized, it is necessary to request complex indemnities for BIM users such as the offer of limited warranties and disclaimers of liability by designers. Therefore, the owner must take responsibility for updating the BIM data and ensure its accuracy.

Next, the second barrier to BIM adoption is the legal chance to document ownership and production. There will be arguments about the ownership of intellectual property rights. BIM is an interoperability model which has the Architect's design, Engineer's design and analysis, Contractor's simulation model and Fabricator's model and shop drawings (Eastman et al., 2011). Actually, there is no clear guidance on the ownership of intellectual property rights (Connaughton, 2012). For example, if the Employer is paying for the design, he may feel entitled to own it, but if the design teams are adding their designs and information for use on the project, their information or design needs to be protected as well, as it is their intellectual property. Thus, the decision as to which parties should have ownership of the BIM is a difficult one (Azhar et al., 2008). The barriers faced during BIM adoption are not only limited to legal issues but also soft issues concerning people. This latter will be discussed in the following section.

b) People Barriers

Yan & Damian (2008), reported that the main barrier to implementing BIM is people barriers. Most of the respondents interviewed think that they have to spend a lot of time and allocate extensive human resources for BIM training purposes. The lack of case studies that serve as evidence of the financial benefits of BIM makes the AECOO industry reluctant to invest in BIM. More notably, they have mentioned that it is a big challenge for them to share the information or collaborate with all the parties when implementing BIM.

Research on the barriers to implementing BIM in the UK and the US carried out by Yan & Damian (2008), has stated that people are the biggest barriers to implementing BIM. Around 40% of respondents from the US and 20% of respondents from the UK think that their company has to spend a lot of time on the training process. Another research from Wong et al. (2010) in Hong Kong concluded that around 70% respondents are concerned about the additional investment needed in software and hardware for the implementation of BIM. Moreover, since BIM is a new method and technology which requires earlier collaboration and sharing information within the project team, the client's demands have to be included in the implementation consideration.

c) Client's Demands

Many of the stakeholders are worried about the changes in technology. Clients are only willing to change if the profits are proven as they believe that the request for new technology for a project will enable the bidders to increase the bid price of the project and hence will limit their potential pool of bidders (Teo, 2012). BIM is still in the innovator phase and the market is not ready to make full use of it. Many owners think that changing the contract to new delivery methods that incorporate BIM will cause them to be less competitive, limit their potential pool of bidders and greatly increase the price of the project (Eastman et al., 2011).

d) Training and learning cost

BIM is a new technology, the training and changing of work processes and workflow is costly as the cost investment in software and hardware is typically exceeded by the training costs as well as causing initial productivity losses (Eastman et al., 2011). Many of the companies do not want to spend and waste such time and cost on staff training. The service providers will only make this investment when they perceive the long-term benefits for their own business or if the owner subsidizes the training costs (Eastman et al., 2011). In addition, the lack of empirical data support will also be among the issues that have to be looked into when adopting BIM.

e) Lack of empirical data support

The lack of empirical data support on the financial benefits as surveyed by Yan & Damian (2008) has been one of the reasons for AECOO reluctance to invest further in BIM. This drawback could be due to a lack of confidence in the latest technology as AECOO are already practising the conventional working system as the norm. Some of the construction players are worried that should there be any changes, it will affect their company project workflow so they incur financial loss.

METHODS

Pilot interviews were conducted at an early stage by interviewing 5 construction players from both public and private sectors. After that, this research deployed a multiple-embedded case studies approach for the research design. Accordingly, the qualitative data was gathered through interview and observation techniques as the main data sources. A total of 21 face-to-face semi-structured interviews were conducted. Due to BIM being relatively new in the Malaysian construction industry and this study being exploratory in nature, the 21

interviewees representing 3 private and 2 public BIM-practicing organisations were selected via a purposive sampling technique (Creswell, 2007; Harvey, 2012). Only those with experiences in handling and practising BIM were invited to participate in the interview. Similar data collection techniques were found in previous BIM-related studies (e.g. Barlish and Sullivan, 2012; Chunduri et al., 2013; Omar et al., 2014; Oduyemi et al., 2017). Table 1 presents the interviewees' backgrounds.

Table 1. The background of the interviewees

Company	Interviewee ID	Designation	Profession	Industry Experience (years)
Private property developer 1	R1	Chief Operating Officer,	Civil Engineering,	30
	R2	Procurement Manager,	Quantity Surveying,	27
	R3	BIM Manager,	Architecture,	25
	R4	BIM Technical Lead,	Building in Construction, Economic,	19
	R5	BIM Project Engineer.	Electrical & Electronics Engineering.	5
Private property developer 2	R6	General Manager,	Architecture,	29
	R7	Procurement Manager,	Quantity Surveying,	12
	R8	BIM Manager,	Project Management,	7
	R9	Project Manager,	Project Management,	13
	R10	BIM Coordinator.	Engineering (Mechatronics).	2
Private property developer 3	R11	General Manager,	Business and Administration,	8
	R12	Procurement Manager,	Quantity Surveying,	5
	R13	BIM Manager,	Civil Engineering,	7
	R14	BIM Coordinator,	Architecture,	3
	R15	BIM Modeller.	Architecture.	2
Public agency 1	R16	CEO,	Structure,	13
	R17	General Manager,	Marketing,	32
	R18	BIM Programme Manager.	IT Management.	20
Public agency 2	R19	Head of BIM unit,	Architecture,	33
	R20	Senior Civil Engineer,	Civil Engineering,	15
	R21	Senior Civil Engineer.	Project Management.	10

A total of 14 semi-structured interview questions were developed to investigate the benefits and barriers of BIM adoption. These questions were developed from the literature review of the previous study. The interview guides were pre-tested by 1 researcher, 1 academic and 3 construction players who implement BIM and sent for proofreading to ensure the interview is well structured (Haron, 2013). The development of interview guides and the conduct of interview sessions followed the procedures proposed by Haron (2013). Tables 2 and 3 summarise the interview guides for this study.

Table 2. Summary of interview questions on the benefits of BIM adoption

Benefits	Sources	Questions
Time and cost control	Memon et al. (2014); Latiffi et al. (2013); Wong et al. (2010); Mitchell and Keaveney (2013); Yan and Damian (2008); Succar (2009); Hergunsel (2011).	What do you think of the BIM implementation in terms of speed, price and cost certainty?
Reduce the rework, wastage or use more prefabricated elements	Mitchell and Keaveney (2013)	In your opinion, how does BIM help in flexibility in obliging design changes?
Quality of work	Wong et al. (2010)	What do you think about BIM in terms of the quality of the project?
Complexity design	Bryde et al. (2013); Hergunsel (2011)	How does BIM implementation help in the complexity of projects?
Enhance collaboration, coordination and communication	Wong et al. (2010)	How does BIM help in risk allocation and avoidance?
Accountability	Wong et al. (2010); Succar (2009)	How does the BIM implementation help in accountability?
Increase the profit, reduce the man-hours and have better price competition	Wong et al. (2010) Mitchell and Keaveney (2013)	What do you think about the BIM implementation in terms of price competition?
Improve the drawing coordination	Memon et al. (2014)	How does BIM help in arguments and arbitration?

Table 3. Summary of interview questions on the barriers to BIM adoption

Barriers	Sources	Questions
Legal issues	Eastman et al. (2011); Azhar et al. (2012); Connaughton (2012); Azhar et al. (2008)	What do you think about the implementation of BIM in terms of legal issues?
People barriers	Yan & Damian (2008); Wong et al. (2010)	Do you think the people barriers are the reason for the slow adoption of BIM? If yes, why?
Client demand	Teo (2012); Eastman et al. (2011)	Do you think the client demand is one of the important factors for BIM implementation? If yes, why?
Training and learning cost	Eastman et al. (2011)	Do you think the training and learning cost is the reason for slow adoption of BIM? If yes, why?
Lack of empirical data support	Yan & Damian (2008)	What do you think about the empirical data support in terms of BIM implementation?

The data collection ends at 21 interviews when no new input was collected. Each interview took approximately 60-70 minutes and was voice recorded. The interviews were then transcribed and analysed via content analysis techniques. The data analysis follows the procedure proposed by Haron (2013). The following section presents the research findings.

FINDINGS AND ARGUMENTS

According to the participants, BIM is fast, effective, efficient and easier for quantity take-off and cost estimation. For the client, with more reliable and accurate quantities BIM will help the client to gauge how competitive the cost is because when it comes to the cost per unit, the client can be enlightened as to what the market competition is like. Auto computation calculations can reduce human errors in cost estimations and can help the construction participants at different stages in the construction industry. As a result, producing the cost estimation reports in different categories and elements facilitates speed and accuracy in Value Engineering and decision-making. Also, with visualisations, clients will know how the

building will look upon completion. A BIM model can improve visualisation of the elements/items for measurement whilst minimising omissions. It gives a feel for how the building looks. If the developers would like to promote the programme when selling their property, the developer would like to visualise this. BIM can enhance the communication and collaboration, for example variations. BIM can improve the database management which can reduce the loss of information, plus no-one can change the information without authorisation.

If it is a traditional contract, all would have been developed by the consultant. But if the owners go for the direct negotiation or selected tender, they will normally go for the DB projects. Therefore, the BIM model will help in assisting the design intent proposed by the contractor to match the client needs. Table 4 shows the comparison between the previous studies and the latest findings from the participants.

Table 4. Comparison between the previous studies and the new findings

Key Criteria	**Comparison between the previous studies and the findings**		
	Similarities	**Sources**	**New findings**
Speed.	Improve scheduling. Increase efficiency. Improve delivery process. Increase on-time completion. Increase effectiveness.	Love et al. (2014) Coat and Es (2013) Bynum et al.(2013) Latiffi et al. (2013)	Fast quantity take-off, Fast cost estimation. Auto-computation. Reduce double handling work.
Certainty.	Controlling time. Controlling cost. Reliable and fast decision making.	Hergunsel (2011) Bataw et al.(2016) Reeves et al.(2015)	Effective cost estimation. Minimize omission. Reduce the variation orders.
Flexibility in obliging design changes.	A greater capacity to use more prefabricated elements, Reduction of rework,	Kehily (2016) Reza et al. (2014) Chen (2015)	Improve the database management, Ease in design review process,
Quality.	Better quality.	Gu and London (2010)	Better quality in terms of value engineering, Minimize errors in design and construction, Minimize rework, wastage, Site logistic planning with construction sequence,
Complexity	Visualisation	Gerrish et al. (2017)	As-built drawing would be accurate, Constructability,
Risk allocation/avoidance.	execute early responses to the potential risks	Chien et al.(2014)	Match back the client needs, Reduce the risk of designers using wrong information,
Accountability.	Provide consistent and non-redundant data. Real-time collaboration.	Liu et al. (2017)	Can enhance communication and collaboration, More collaborative working environment, Reduce work-in-silo environment.
Price competition.	Higher profitability. Reduction of man-hours.	Chelson (2010) Hergunsel (2011) Coat and Es (2013)	More reliable and accurate quantities, Help to know the price competition,
Arguments and Arbitration.	Improve drawing coordination.	Charehzehi et al. (2017)	Minimize miscommunication, Resolve clashes and major issues before construction, Mitigate design intent misunderstanding, Reduce reworks & conflicts at site.

Referring to Table 4, there are many similarities between the previous studies and the research findings. However, this research explored more benefits of BIM adoption from the Malaysian construction industry context.

All the participants gave constructive opinions; for example, R2 mentioned that conventionally, the as-built drawing provided by the contractor may not be that accurate. They just modify the design drawing. Therefore, with BIM, the as-built drawing would be accurate. According to R5, BIM can help to reduce double handling of work by enabling systematic and detailed coordination between different trades with the help of clash analysis tools. As such, the speed of projects could be improved. Meanwhile R7 said, "What is more important to me is the process, if BIM can be observed or can be used all the way on the production in the construction cycle, then we are looking at the perfect use of the resources, manageability as well as constructability in the best way so that to me is the major ability of BIM not only the savings that we made." It means that the benefits of cost and time saving might not be the main advantages to be considered by the construction players. Whereby R16 mentioned: "I think the best part we can control things before what happens on site." As such, the construction project can progress well only if the managerial level is able to control or monitor the construction properly. However, according to the participants who have been interviewed, there are plenty of barriers or challenges in terms of BIM implementation in their organization. The next section will discuss the barriers to BIM adoption.

Lack of cooperation

A well-integrated construction knowledge is essential and a shared building model requires a coordinated set of building models during construction and fabrication (Eastman et al., 2011). Hence, it is crucial for the current implementation of BIM in Malaysia, from the theoretical aspect, to have close coordination between the stakeholders such as the consultant, client and contractors. However, there is still a lack of cooperation between the structural or M&E consultants, architects and designers. This finding is similar to the previous literature (Succar, 2009; Succar and Sher, 2013; Zanni, 2017) in agreeing that the biggest challenge faced is the lack of coordination among people, tools deliverables and information requirements. Furthermore, all the respondents agreed that the Malaysian construction industry parties refused to share their information with other parties to enable the coordinated model to be established. The Asian business culture has not usually got used to sharing information. All the respondents claimed that the consultants in Malaysia do not coordinate with each other, especially their drawings. For instance, one of the developers in the case study has certain requirements that they set for the consultant and contractor, so they are expecting when they see the model to have fulfilled all their requirements. Therefore, the developers should consider putting in one of the requirements in their Employer Information Requirement (EIR) that the consultant needs to give the full set of drawings and coordinated models to the developer or owner. If the consultant failed to do so, the developer has the right to drawback and return the model and/or reject it.

Lack of understanding and knowledge

A lack of understanding of how BIM impacted the design and construction process was agreed as concerning and worthy of continued attention (Rogers et al., 2015). Kehily (2016), has reported that many clients have a limited understanding of the process and are not informed about the benefits of BIM adoption. Furthermore, limited to design and project management teams on the east coast of the peninsula, the responses of ninety-three individuals identified that lack of understanding and lack of senior management buy-in were the principal barriers to greater adoption of BIM (Rogers, 2013). The findings of this research support the

previous literature that the consultants, architects, contractors and designers currently still lack understanding and knowledge about the implementation of BIM, and this has led to misconceptions concerning the adoption of BIM. If the developers are still tied to the traditional methods, all the parties could not embrace the full benefits of BIM adoption as BIM adoption requires a shared culture. Therefore, developers as the paymaster, should take the lead by using the top-down method to encourage their consultants, contractors or engineers to take the initiative to learn about BIM.

An immature culture of sharing

It is essential to transform the traditionally conservative and confrontational culture into a more collaborative environment where the building project information is ready to be shared via an integrated digital model (Kimmance, 2002). According to Chen (2015), culture is one of the priorities when adopting the BIM approach. However, he also mentioned that the current culture in the construction industry is not easy for information sharing. This previous finding is similar to this research whereby in the current construction industry, there are plenty of discrepancies that cannot be resolved because the core issues currently lie with the sharing culture among all parties which is still at a developmental stage and has yet to mature. Therefore, people's mindset should be educated to raise their awareness about the importance of sharing information. It is also important to create a win-win situation for all parties so that the willingness to adopt an information sharing culture could be nurtured and enhanced.

Lack of communication between main contractor and subcontractor

Much of the previous literature agrees that the lack of communication is one of the big barriers for BIM implementation (Nawi et al., 2014c; Gu and London, 2010; Zanni, 2017; Sackey, 2014; Bhargav, 2013; Rajendra, 2015; Almarshad, 2014). Unavoidably, this research has a similar finding. Most of the participants argue that it is difficult to secure the input, especially from the subcontractor. Some problems, especially the clashes in piping, can be discovered and identified by the Nominated Subcontractor (NSC) only post-construction. The respondents further explain it is because normally the NSC will be invited to get involved in a project only in the later stages. If they were invited to participate in the initial or conceptual stage, then the developers or the contractor would need to pay them extra and it will increase the project cost eventually. However, architectural and structural parts do not have such problems. Anyway, the researcher suggests that the developers or the contractor should consider the use of BIM in their project. If they want to continue the BIM usage up to the highest level - the facility management and/or as-built - they should invite the NSC to get involved at the very early conceptual stage. With sufficient communication between the main contractor and subcontractor, the whole BIM lifecycle can then be implemented smoothly.

Lack of guidelines

According to Coat and Es (2013), the lack of guidance is one of the reasons why small architectural practices are reluctant to implement BIM. Chen (2015), also states that there is a lack of guidance on implementing BIM so that the BIM users could embrace the wide spectrum of BIM benefits in a more efficient way. A proper guidance and framework to help SMEs in decision making about BIM adoption remains inadequate (Lam et al., 2017). As such, this research has a similar finding in that the most critical issues lie with the fact that

there is still a lack of guidelines and enforcement to cater for the construction players. Although some guidelines can be sourced from developed countries, they can only be used as a reference because there are many differences in terms of construction industry culture, project type, project size, project objectives and BIM goals. However, the government agency is taking the lead and is currently in the process of establishing a guideline which is more suitable for the Malaysian construction industry. Anyhow, every organisation should also establish a standard of practice internally so that all the involved parties could have a clearer picture of the BIM implementation within their own organization.

Late involvement of Client

This finding has similarities with the previous studies (e.g. Dowsett, 2016; Evuri and Amiri-arshad, 2015) that the early involvement of the client is important. While Alwan and Gledson (2015), argue that if a client desires to achieve a certain standard of BIM adoption, the client has no choice but to become involved as early as possible. This finding also highlights an appropriate approach that requires certain consultants to monitor and control the project, which means that all parties concerned must expedite the projects in a more appropriate way. Accordingly, the client should take part from the beginning and cater for all significant issues and routes. In such a way, most issues and disagreements can be resolved. In the event of any future development, such as the extension of the building, the client gets the best results by being involved from the beginning.

Lack of statement or enforcement

This finding has little attention in the previous literature. But most of the participants argue that this is one of the biggest barriers to BIM adoption faced by the Malaysian construction industry. They highlight that all parties involved are concerned about costs. But in their contracts, there is no statement that addresses the mandatory requirement for the use of BIM. There is also no solid procurement project delivery that specifies that BIM must be used. Moreover, all projects must be contractually based. Therefore, there is a necessity to amend the construction contract by adding a certain statement to incorporate BIM adoption rather than just put BIM as an addendum.

Lack of a previous record on BIM

Little previous research can really provide the benefits of BIM with convincing data or actual profit. From this research, most of the construction players have acknowledged that BIM is beneficial for coordination; however, there is no tangible data to prove that the implementation of BIM is problem-free. It makes the construction players hesitate to really put in the effort to fully implement BIM. Therefore, tangible data or results would be a good supporting point to make the construction players more willing to invest in BIM adoption. As such, future research work could look at this area and produce tangible data about the benefits of BIM adoption.

The above-mentioned barriers are the challenges facing by the Malaysian Construction players practically. Managers or BIM practitioners should really look into the barrier issues. They should have proper consideration and long-term planning before BIM can be adopted successfully in their organizations.

CONCLUSION

This paper provides insights as to the benefits of BIM implementation and the barriers that could be encountered. Notably, BIM specifically highlights a lot of current issues and problems that could be minimised. There is also evidence that the Malaysian government has taken initiatives, namely by making BIM mandatory in CITP. However, the adoption of BIM in Malaysia's construction industry is still very slow. Therefore, based on previous studies and gleaning from the perspectives given by the interviewees, this research is a critical review on the comparison of the benefits that can be gained by the adoption of BIM in its different stages and also the barriers. Conclusively, the construction stakeholders have acknowledged the wide spectrum of benefits through the adoption of BIM albeit the fact that its implementation in the Malaysian construction industry is still in its infancy. They have, however, unanimously agreed that the main challenge could be the construction players' mindset and thinking. The other critical challenge could be the legal issues. However, as this research focused on the soft issues such as people and policy aspects, future research will investigate ways of getting the softcopy legalised and how to solve the interoperability issues.

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FACTORS OF NON-COMPLIANCE WITH OCCUPATIONAL, HEALTH AND SAFETY LEGAL REQUIREMENTS AMONG MALAYSIAN CONTRACTORS

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Abstract
The purpose of this study is to analyze factors leading to non-compliance with the legal provisions on occupational safety and health (OSH) by Malaysian contractors and to identify ways to improve level of compliance. Focus group discussion was conducted to gather data from key officers of Department Occupational Safety and Health (DOSH) Penang. The result shows that the main factors contributing to non-compliance to the OSH regulations are lack of management commitment, cost, time, training, knowledge and supervision. This study provides good insights to the Department Occupational Safety and Health (DOSH), National Institute of Occupational Safety and Health (NIOSH) and Construction Industry Development Board (CIDB) and Non-Government Organization (NGO) in identifying factors of non-compliance with the occupational safety and health (OSH) acts and regulations among contractors.

Keywords: *Contractors; Health and Safety; Legal Requirements; Non-Compliance*

INTRODUCTION

The construction industry is known worldwide as one of the most dangerous activities. Numerous individuals were slain and permanently disabled annually, due to accidents related construction industry. The major causes of the accident are related to the unique nature of the industry, comprise of the behavior of the worker, insecure working location conditions, and the poor safety administration which resultant the insecure work procedure, equipment and methods (Jannadi & Bu-Khamsin, 2002).

According to DOSH statistic, construction industry score most fatal cases, as compared to other industries. Besides, the statistical data also shows that there is an increment in fatal cases from year 2011 to 2015.

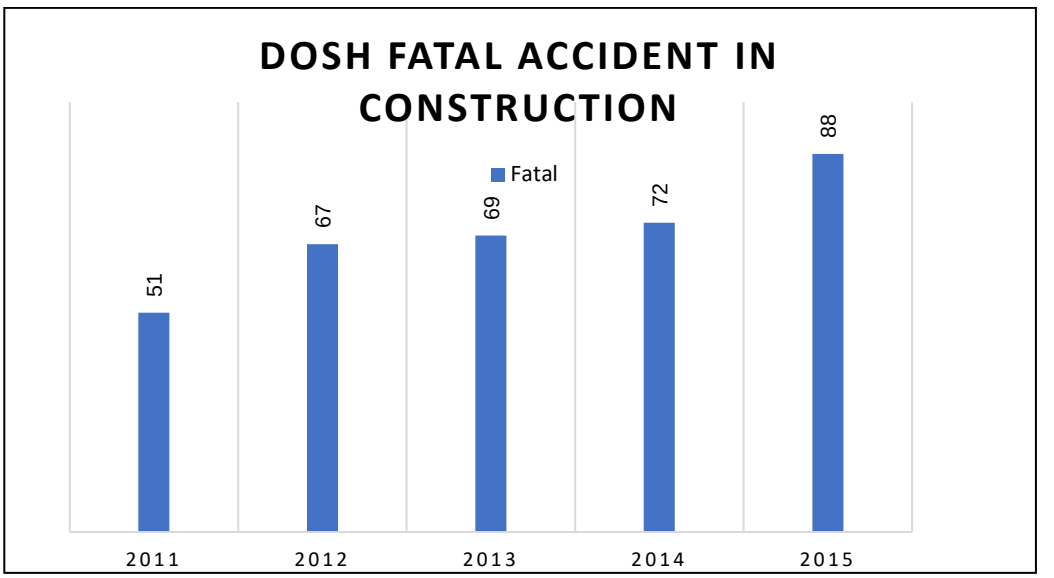

Figure 1. Department Occupational Safety and Health Fatal Accident Statistic Source: Statistic of Fatal accident in Construction. Department of Occupational Safety and Health

Table 1. DOSH fatal accident by Sector (Occupational Accidents Statistics by Sector until July 2016)

No	Sector	Death											Total
		Jan	Feb	March	April	May	June	Aug	Sept	Oct	Nov	Dec	
1	Manufacturing	1	2	4	4	8	6	4					29
2	Mining and Quarrying	0	0	0	2	1	1	0					4
3	Construction	5	5	7	19	7	9	2					54
4	Agriculture, Forestry, Logging and Fishery	2	6	1	2	2	10						14
5	Utility	0	0	0	0	0	0	0					0
6	Transport, Storage and Communication	2	0	0	1	1	1	2					7
7	Wholesale and Retail Trade	0	0	0	0	0	0	0					0
8	Hotel and Restaurant	2	0	1	0	0	0	0					3
9	Financial, Insurance,Real Estate and Business Services	1	1	1	5	2	1	0					11
10	Public Services and Statutory Bodies	1	1	0	0	0	0	1					3
	Total	**14**	**15**	**14**	**33**	**21**	**19**	**9**					**125**

Despite a number of interventions and approaches being implemented when it comes to improving health and safety issues, why the mortality rate still increasing? Tan Sri Lee Lam They highlighted that "Safety should not be compromised, but so often, despite there being regulation to obey to, this typically just lip service by the contractors, until such catastrophic incidents occur (Star, 2016).

The above issue raised a question as to what are the factors leading to non-compliance to OSH legal requirements. Accordingly, this study is conducted with the aim of analyzing the factors leading to non-compliance with OSH regulations by Malaysian construction industry players.

Laws regulating health and safety practices of Malaysian Construction Industry

A prehistoric code adorned on stone commands that any individual who is guilty of triggering the death of an individual shall be hanging by death (Deros et al., 2014). After more than four eras, the safety regulation had progressive with most variations happened after the industrial revolution (Deros et al., 2014).

In our modern world, industrial safety aspect is no longer viewed as unimportant and any accident is no longer being recognized simply as fate. All the stakeholders are taking more positive efforts to improve the level of compliance of occupational safety and health legal requirements.

Occupational Safety and Health Act (OSHA) 1994 has established the accountable self-management by occupational and extended duties to company decision makers. The safety and health system is based on the value of evaluating the risks and handling them reasonably, encouraging the employers to stress their energy and resources more on the significant hazards that can cause harm. The main principles of this Act are self-regulation, consultation, and cooperation between employers and employees (DOSH, 2006).

The objectives of OSHA 1994 are to secure the safety, health and welfare of persons at work against risks, to protect persons at a place of work other than persons at work against risks, to encourage an occupational environment for individuals at work which is adapted to their physiological and psychological needs, and to provide the means whereby the linked occupational safety and health legislations gradually substituted by a system of regulations and legalized industry codes of practice (Hui-Nee, 2014).

Another relevant legal provision in relating to the practice of safety at construction site is the Factories and Machinery (FMA) Act, 1967. The Act is widely used by the Department of Occupational Safety and Health (DOSH) to make sure the safety, health, and welfare at the workplace. FMA 1967 clearly emphasized on the safety and health at different elements of construction such machinery, working and load platform, scaffolding, floor opening and electrical safety. One of the regulations under FMA 1967 is Building Operation of Work Engineering, and Construction (BOWEC). BOWEC is created specifically to emphasis on the activities within construction industries.

Agencies responsible for health and safety practices of Malaysian Construction Industry

Department of Occupational Safety and health (DOSH)

The Department of Occupational Safety and Health (DOSH) is a department under the Ministry of Human Resources. This department is responsible for ensuring the safety, health and welfare of people at work as well as protecting other people from the safety and health hazards arising from the activities sectors which include manufacturing, mining and

quarrying, construction, hotels and restaurant, agriculture, forestry and fishing, transport, storage and communication, public services and statutory authorities, utilities - gas, electricity, water and saitary services, finance, insurance, real estate, and business services, wholesale and retail trades.

As a government agency, the department is responsible for the administration and enforcement of legislations related to occupational safety and health of the country, with a vision of becoming an organization which leads the nation in creating a safe and healthy work culture that contributes towards enhancing the quality of working life (DOSH, 2006).

National Institute Occupational Safety and Health (NIOSH)

Registered in June 1992 as a company limited by guarantee under the Malaysia Companies Act 1965. The Board of Directors is the administrative body that makes policies and decisions and its members are individual from government, unions, and the industrial sector. NIOSH was established with an endowment fund from the Social Security Organization Malaysia (SOCSO) and from the Government. Started operation in March 1993 (NIOSH, 2013). Besides, it is a company limited by guarantee owned by the Government of Malaysia. “In the words of the Minister of Human Resources, Malaysia, NIOSH would be a "critical catalyst" in the promotion of occupational safety and health that would also serve as the "backbone" to create a "self-regulating occupational safety and health culture" in Malaysia.”

NIOSH Malaysia conducts regular Occupational Safety and Health-related training around the country. As the “training arm” of the Department of Occupational Safety and Health (DOSH), International Medical Health Organization (IMHO), the courses offered by NIOSH is recognized. In Addition, NIOSH is providing a training to public in term of several competencies such Site Safety Supervisor, Safety & Health Officer, Authorize Gas Tester, and Others.

Construction Industry Development Board (CIDB)

The Construction Industry Development Board (CIDB) is an unavoidable existence for those engaged in the construction industry within Malaysia, largely through the levy which it imposes on all major construction projects, and the obligatory courses which it conducts.

The CIDB is a body corporate which was created by the “Akta Lembaga Pembangunan Industri Pembinaan Malaysia 1994”. Its mission is to change the Malaysian Construction Industry in line with an idea to be a reliable organization in evolving a World Class Construction Industry.

CIDB Malaysia is accountable for developing and enhancing the development of the construction industry in Malaysia. CIDB has also commenced initiatives to enhance current procurement measures such as drawn in the Construction Industry Master Plan 2006-2015.

CIDB encouraged the award of construction contracts based on “value for money”. Contractors who are listed with CIDB are also obligatory to attend integrity training set up by CIDB.

CIDB also has issued a book on the Procedure for the Application Certificate Procurement in Govenment Works. It has come out with some best practices procedures and resolutions such as the Quality Assessment System in Construction, which is a system or technique to measure and assess the quality of workmanship of a construction work based on the applicable approved standards, Safety and Health Assessment System in Construction and others.

Compliance with OSH legal requirements non-compliance factors

Management commitment

Management commitment plays an important role in conformity to the Occupational Safety and Health legal requirements, as the management uphold power to influence others especially employees of the organization. Several researchers have come out with different findings regarding this matter. Some of the researcher evidence shown that, management commitment influence the conformity to the regulation and their roles influence the organization attitudes towards dealing with this regulation. The Construction environment is more hazardous than the others industries, this is due to the usage of machinery, tools, and materials, therefore, focused dedication and efforts towards safety is needed from construction at all level, safety management role is vital for the success (Abudayyeh et al., 2006).

Furthermore, management commitment is indispensable to the achievement of such a mediation if no other explanation than its impact on eyewitness duty, nature of objective settings and other handy issues (Marsh et al., 1998). Increasing employee insights of management personal apprehension for employee security over a devotion to safety will be upshot in constructive outcomes beyond better safety performance (Michael et al., 2005). By showing management interest in safety and abide by the regulation can direct and indirectly influence employee to followed.

In addition, a total of management commitment to the organizations Occupational Safety and Health program connects the message that safety is treasured as a main urgency, even at the outlay of productivity, and ensures that employees are not reprimanded for stumbling on the side of safety matters (Crumbley, 2014).

Different combination of management commitment exerted an increasingly cumulative effect on the performance, this implies the influences of management commitment is dynamic, management commitment has the authority to forward any matters in the organization (Cooper, 2006). When the management become a player in conformity the safety regulation it can attract employee to start abide with it as the management have the authority to control it.

Furthermore, organizational environment regularly changes rapidly in the upshot of an important incident but the underlying corporate culture not change adequately to stop further incidents. Thus, management will perform to implement change, commonly by establishing controls (Van Dyke, 2006). Management commitment to safety is clearly proved over action, employee insights of the safety management process have completely influenced. When management shown their commitment in safety and health issues, It will directly give a positive reaction to the employees to conform with it (Amponsah-Tawiah & Mensah, 2016).

Weak legal structures

A weak legal structure will leads to poor conformity by the people. Many employer complying with the health and safety regulation, however do they complying the regulation accordingly (Idoro, 2008). It was suggested that the law need to change not the stricter but to the law that is enforceable (Idubor & Oisamoje, 2013). Absence of practical and rigorous health and safety regulation could destructively influence on health and safety in the organization (Diugwu et al., 2012).

For instance, according to section 15 of the Occupational Safety and Health Act (OSHA) 1994, every employer is under a duty to ensure as far as practicable, for the aspect of safety, health and the welfare at the workplace for all of their employees in all range. A person who contravenes the provision of the section shall be liable to a fine not exceeding RM50,000.00 or an imprisonment not exceeding 2 years or both (DOSH, 2006). It is arguable whether the penalty is still relevant and alarming to the contractors, when the industry is booming with profits reaching multi billion dollars per annum.

Lack of Knowledge

Knowledge is the major factor of non-conformity by employer and employee with OSH legal requirements at construction working site, usually causing accidents or fatalities (Haupt & Smallwood, 1999). Many workers in the construction industry tend not to follow the regulation as stated (Diugwu et al., 2012).

Windapo & Oladapo, (2012) shown that, lack of training can cause lack of knowledge resulting to unsafe work environment. Employee do not generally have appropriate information on the effects that working under risky atmosphere can affect their health (Idubor & Oisamoje, 2013). If workers do not understand every aspect in safety and health regulation, they will not know that their privileges have been violated (Puplampu & Quartey, 2012).

When staffs are equipped with sufficient training, they can gain knowledge useful to understand various aspects in occupational safety regulation (Umeokafor et al., 2014). OSHA 1994 Section 3(b) stated that, the company should provide a practicable working environment. It means that, the employer should provide information about hazard or risk and any way of removing or mitigating the hazard or risk (DOSH, 2006).

Cost of Compliance

Different organizations in term of size, profit and demographic is having different fund to operate. When it came to safety and health issues, many contractors do not comply with the occupational safety and health regulations, due to cost factors. Even some contractors do not include a budget for safety and health regulations (Windapo & Oladapo, 2012).

In addition, due to the rises of cost in running a business after spending considerable amount on the operation, contractors start to cut capital expenditures by overlooking the need for a safe place of work for their workers (Idubor & Oisamoje, 2013). According to Diugwu et al. (2012), if the organization is having lack of resource to operate, they might obstruct an effort to comply with the safety regulations.

Lack of Training

Lack of training is another major cause of non-compliance by the workers with the OSH regulations. Workers who are not well trained will not have the sufficient competencies and awareness. To perform any related task in organization, a training is necessary and must be conducted effectively for the staff to able to perform what they have been thought.

Idubor et al. (2013) stated that, it is vital to provide staffs with training to meet any challenges of increasing workplace hazard globally. Section 15(2) (b) of OSHA 1994 stated that, the information, instruction training and supervision is necessary to be provided by the employer in order to ensure the so far as practicable. Training shown an impact on performance of the employee with regards to their jobs due to pre and past experience in conducting task given (Nassazi, 2013).

RESEARCH METHOD

Based on reviews of secondary data related to the subject matter, a proper research design has been structured to suit the research needs. Accordingly, this study uses focus group discussion method, adopting open-ended questionnaire. The session was conducted at Department Occupational Safety and Health (DOSH) Office in Pulau Pinang.

Some of the researcher stated that, the focus group discussion is the method of interview but its "in-depth group interviews employing relatively homogenous group to provide information around the topics specified by the researcher. The focus group also define as a carefully planned discussion design to obtain the perceptions on defined environment (Hughes et al., 1993).

Besides, a way of analysing the group process is by considering group process opinion which constructed collectively. The collective voice which group process of collaboratively constructing a joint perspective, argument, opinion which emerges as a collective procedure. It leads to the consensus rather than individuals view. Focus group is appropriate when a researcher wanted to explore the depth and nuances opinion regarding the research issues (Casey & Krueger, 1994).

Focus group are a form of group interview that capitalises on communication between the researcher/moderator and participants to generate data (Edmunds, 2000). Focus group is suitable to use when the research wanted to understand better how people consider an experience, idea or event because the discussion of the focus group is effective in supplying information about what people think or how they feel (Kitzinger, 1995).

Focus group discussion was chosen because of (Krueger & Casey, 2002); Focus group can be relatively low cost and producing a quick result.

Focus group are flexible assessment tool. Interaction between moderator and participants that allow the moderator to probe issues in depth. Futhemore, participant more comfortable talking in a group than individuals. The data is from the respondent and easily to analyse.

Focus Group Data Collection

Participants

The data collection start with the exploratory method were used in focus group discussion were arranged with the Department Occupational Safety and Health officer and enforcer. The participants of the focus group discussion were choose based on the assistant from the Manager Building and Construction and several officer and enforcer in the DOSH office. Focus group discussion could produce result derived from broad experiences and thus more comprehensive and robust evidence can be collected. This is because the nature of interaction of the group allows the participants to comment and build on emerging issues in this research. (Kitzinger, 1994). Besides, a Narrative data obtain from the focus group discussion is related to the content of the questionnaire will enhanced the validity and reliability.

Focus group discussion questions

The questionnaire in the focus group discussion should be clear, honest, stimulating and appropriate in well manners (Casey & Krueger, 1994).

In this research focus group discussion, the design of the question is based on the fact and not from the participant's opinion. This is because, the issues that has been discussed in the focus group are real issues involving data and statistics. Probing were used to ask the participants regarding matters that they have not mentioned. There are 31 numbers of question were prepared for the sessions.

Number of focus group discussion, sample size and sampling procedure

There is no absolute explanation regarding the suitable number of focus group discussion to be undertaken. Given facts that the focus group discussion is not the only method used for the research. However, the composition of the focus group discussion has been addressed carefully. It's to enhance the interaction among participants and the data (Creswell, 1994; Williams, 2011; Casey & Krueger, 1994).

In this research, there were only one (1) session of focus group discussion were conducted. This is due to the focus group participants having experience and exposure to the Health and Safety matters, thus all participants are experience and knowledgeable in Health and Safety fields.

Several researchers debated that, a hierarchical level of participants is an issue in the focus group. This is because, some participants could not feel comfortable to disagree with the certain issues with the present of their "Boss" which risky to disagree (University, 1999).

The discussion about the sample size was based on the growing debate between several researchers about this issues. A larger sample size more than 15 would provide a richer data in data collection, but it's difficult to ensure that all participants would contributing to the focus group discussion. It was stated that, the sample size less than 4 would confine the dynamic and diverse interaction among the participants (Kitzinger & Barbour, 1999). The sample size should not be too small nor too big for the participants to interact during the focus

group discussion. In relevance for this research, there are 5 participants including researcher as the moderators.

Initially the process start with contact made to the Head of Department Building and Construction, DOSH Penang. The contact was made to seek for assistance in gathering the participant for focus group discussion and the usage of the discussion room in DOSH office. As a moderator, the researcher has requested the participants from the DOSH in different department and position.

Moderators

The moderator conducting the research focus group discussion have 5 years' experience in construction industry and in the process of being certified as "Green Book" Safety and Health Officer. It is important for the moderator to have significant knowledge and experience while conducting a focus group discussion. According to (Smithson, 2000), this is to minimize biasness from the moderator, it is important to ensure that the moderator is from the similar field or background to the participants.

Necessary preparation and format of the focus group discussion

The discussion was held at the DOSH office in Penang with air conditioner, proper ventilation, and a supper (Coffee and tea). The question was asking one by one to each of the participants and there are freely to answer it. At the end of the discussion, a verbal summary was produced and recorded. It's synthesized and the themes is found on the discussion. It took two (2) hour thirty (30) minutes for the focus group discussion.

ANALYSING FOCUS GROUPS DISCUSSION FINDINGS

The analysis of focus group data can take into a broad form. These may range from the highly subjective impressionistic analysis to a very sophisticated computer analysis. There is no absolute and good approach, but the selected approach should be consistent with the purpose of the research and the information needed.

The focus group analysis initiate since the group of participants start. This is due to the largely discretionary, opportunities the moderator terminate a topic, expand the discussion, and probing the question involve (Onwuegbuzie et al., 2009).

Direct Qualitative analysis technique

The most crucial part of analysing focus group data is to have a deep understanding on the notes taken. The summarise of the key ideas should be noted. Find the broad ideas by examining the participants choice of words, group context and consistency among the group member (University, 1999).

In this research, the technique of analysing used are the direct qualitative analysis from the transcribe gather from the focus group discussion. This is because, as mention earlier the focus group participants consists of experience and knowledgeable on the issue of Health and Safety.

The conversation during the focus group discussion were recorded and after that it go into transcribe process. The transcript was analyse directly. During the qualitative research analysis, data was converted to information and knowledge. There is limitation in transcribed analysis which is the nonverbal information is lost. The pacing , intonation, and the emphasis in the talk are not capture in the transcription (Polkinghorne, 2005). However, since there is only one (1) focus group discussion were conducted, the moderator can remember and understand well the participant pacing and intonation.

RESULT

The respondents of focus group discussion, involving key personnel from Department Occupational Safety and Health (DOSH) Penang, were asked about a list of factors contributing to non-compliance with health and safety requirements among Malaysian contractors.

From the discussion, all respondents agreed that management commitment, lack of training and high cost to comply with health and safety requirements as main factors contributing to non-compliance by the contractors.

On the contrary, the respondents disagreed with the submission that weak legal structure and lack of knowledge contributed to non-compliance.

The respondents were also asked whether there are additional factors causing non-compliance by the contractors. Accordingly, the additional factors of non-compliance are time pressure to complete the work, communication barriers between the parties, lack of supervision and culture differences.

To following table sum up the focus group discussion results.

Table 2. Focus group discussion results

Factors contributing to non-compliance with health and safety requirements by contractors	Factors not contributing to non-compliance with health and safety requirements by contractors
Management commitment	Weak legal structure
Lack of training	Lack of knowledge
High cost	
Time pressure	
Communication barriers	
Lack of supervision	
Culture differences	

DISCUSSION

The first factor contributing to non-compliance with health and safety requirements is the management commitment. From the discussion, all respondents stated that this factor was the main reason for the contractor not to comply with the health and safety requirements. Generally, the management level of the organization always emphasize on "Dollar and Cent" before implementing or abide by any safety measures. The result from the discussion revealed that the management always tried to find the cheapest ways to comply with the OSH regulation. However, well established companies, such as G7 companies under CIDB in general have higher level of compliance as compared to smaller companies. The reason to this

is the existence of several parties in making sure the health and safety requirements is complied with, which is the client, dedicated safety & health officer, and site supervisor. The role of Safety & Health Officer and Site Safety Supervisor have been cited in OSHA 1994, namely to ensure necessary safety and health measures are well illustrated and the organization follows such measures. Their roles also to advise the organization to abide by the OSH regulations and stated the consequences if the organization fail to comply.

Secondly, lack of training also named as a factor of non-compliance with health and safety requirements. Basically, lack of training is a root cause of accident, because when then the worker with zero knowledge performing a task requiring knowledge, training and experience, there is a chance that the worker will involve in an accident. According to section 15(2) (c) OSHA 1994, training is compulsory. Accordingly, Malaysia has developed lots of training centre providing training on Health and Safety. DOSH itself provides free consultation to the contractors. Contractors can gain knowledge directly from DOSH if there is any doubt regarding safety compliance. Nevertheless, it is left to the contractors to attend the training. Contractors play important roles in ensuring their workers are equipped with necessary skills and sending them for training. Some of the contractors thought that sending their workers to training would cost them high expenses and they just rely on the workers working experience to perform the task. It's clearly wrongful understanding, as with proper training the workers are provided with proper safety measure and skills to perform any related task.

To make sure all contractors complied with the OSH acts and regulations in providing training to the workers, DOSH consistently visit on-going project site to inspect whether the workers at site have a certificate of competencies to perform their works.

Thirdly, the cost involved in adhering to health and safety requirements also contributed to not- compliance by the contractors. For instance, providing sufficient netting in the construction of high-rise building to protect from falling debris requires substantive amount of expenses. Although there might be additional cost involved, the client and contractors is responsible to make sure safety at work site is followed as far as practicable and the parties complied with all regulations. An employer must comply with section 15 (2), to provide information, knowledge, monitor, orders to the employees. If the contractors fail to follow, the authority is may charge the contractors for failing to provide safety measures as far as practicable.

The contractor should be able to understand and mitigate the cost involved in adhering to health and safety requirements. Sometimes cost mitigation also depending on several elements, such as mitigation plan, engineering control and others that can resulted in lowering the costs.

For example, occasionally, the contractors view providing PPE's to the workers is a waste of investment because the workers working environment is less dangerous. Nevertheless, if accident occurs, more documentation and procedure are required, which requires additional cost to the contractor. In unfortunate event where a person dies during construction work, the total cost to handle death cases is very high. The authority will take around 1 month to investigate a fatal accident and there is a need to seal off the construction site. When this happen, contractors will lose lots of money, including penalty and late submission charge by the client. The cost involve is higher than the initial cost of providing PPE’s to the workers.

This is because, the participants informed that, when there is a law, it's a mandatory to be followed. Besides, the Department Occupational Safety and health have appointed a competent person regarding their specialties, such as scaffolder, safety and health officer and site safety supervisor and many mores.

However, the respondents stated that weak legal structure and lack of knowledge do not contribute to non-compliance with the health and safety requirements.

During the focus group discussion, all respondents agreed that weak legal structure does not contribute to contractors' non-compliance with health and safety requirements. The respondents submitted that OSHA 1994 is complete and having all sufficient requirement regarding safety at workplace. OSHA 1994 is very general and understandable by every level of people, which all safety matters should be considered as far as practicable.

There are arguments that certain matters in the law is not specific. According to Section 15 (1) of OSHA 1994, it is the employers' duties to make sure that working environment and all employee is safe, as far as practicable. The term "as far as practicable" does not specified how safe it should be, thus resulting to different understanding of industry. Nevertheless, this argument was rejected by the respondents, since there are numerous avenues to ensure practicable measures on safety at sites. The officer involved in site inspection is still continuing their job for inspection from day to day. Competent person appointed by DOSH, namely the safety and health officer and site safety supervisor has a duty to inform and advise their employer. They also must ensure compliance to health and healthy requirements.

In addition to the above, the respondents also submitted that legal structure is amended from time to time, to suit the development of the construction industry. For example, when FMA 1967 was amended, the penalties has changed from RM2, 000 to RM250, 000. Besides, the penalties were charge based on per offense convicted, which cost of RM2, 000 per offense. In future, there is a plan for FMA 1967 and OSHA 1994 to be merged into one act, and it will be compulsory for the contractors to comply with it.

Lack of knowledge was also rejected as a health and safety requirements non-compliance factor by the contractors. According to the respondents, contractors should have adequate knowledge on health and safety requirements. Nevertheless, they are having a denial attitude when it comes to complying with it. For instance, when the contractors registering their project using DOSH JKKP Form 5, all safety requirements are clearly stated in the form. All information was disseminated effectively via the Form, and the contractors should have acted accordingly.

The respondents also contended that the contractors should know every laws regulating the industry, as they opted to be involved in the industry. Laws relating to health and safety in construction industry are clear. For instance, the preamble of FMA 1967 (BOWEC) has specifically cited that, "this regulation is made for the contractors and construction industry." On another note, it is the duty of the Safety and Health Officer and Site Safety Supervisor to furnish information regarding health and safety to the employer. Accordingly, information on health and safety requirements should be known by the contractor. As such, it is submitted

that the contractors cannot cite ignorance of the law as an excuse not to observe legal requirements on health and safety.

This study also identified several other factors contributing to the non-compliance of OSH regulations. Respondents of the focus group discussion revealed few other factors as follows.

Time

It is a normal practice for the contractors to finish their job as fast as possible, with the intention of avoiding paying extra salaries to their workers. While aiming for faster completion of their works, there are practices by the contractors not to comply with the OSH regulation by skipping certain elements in construction.

Communication

With the nature of construction industry involving foreign workers from various nations and backgrounds, language barriers is a true problem when it comes to efficient communication. It is hard to disseminate information to workers who does not understand Bahasa Malaysia, and sometimes they just pretend to listen to the order given by the contractors without understanding what the contractors want, which include matters related to health and safety.

Supervision

It is important for the contractor to send their workers for proper training, especially on health and safety practices. Nevertheless, the employer should supervise their worker and monitor whether the skills and knowledge obtained from training is applied in their work. It is a normal practices among the contractors to supervise their worker only on day 1, but left the workers unsupervised and unmonitored afterwards.

Culture

Prioritising health and safety practices has yet to become the culture among workers in Malaysia. There are various reasons to his, which include the background, origin, awareness and understanding of the workers on the importance of health and safety.

Measures to improve OSH regulations compliance

Focus group discussion session highlighted several measures being implemented to improve compliance to OSH regulations. DOSH has in its pipeline a master plan as known as OSHMP 2020, with the objective of improving compliance to OSH regulations. There are 5 strategies implemented to build safety culture, and targeted to be embedded by the industry by the year 2020.

One of the strategies in OSHMP 2020 is government leadership. The government will set a standard benchmark to be followed by all contractors involved in the construction industry. “STAR” rating system is implemented as it can increase the safety culture among government

agencies. The government will also revamp the "E-Perolehan" system procedure, where "Safety" will be a requirement for tendering process. "Mentoring" system will also be introduce in OSHMP 2020. It will be focusing on mentoring smaller contractors/sub-contractors by established contractors. All sub-contractors must prove safety culture been practiced in compliance with the OSH regulations before a tender or works been conferred. In short, the sub-contractors will have to follow the good practice of the main contractor when it comes to compliance to OSH regulations.

CONCLUSION

Non-compliance of health and safety acts and regulations by contractors in Malaysian construction industry is caused by various factors. This study was conducted to analyze the factors and ways to improve compliance to health and safety requirements. Factors of non-compliance are related to management commitment, cost, time, lack of training and supervision. On the contrary, the respondents of the research stated that lack of knowledge on health and safety and weak legal structure does not contributed to non-compliance of health and safety requirements. Various means to improve compliance were suggested. Although the suggestions could have improved the matter, it is important for all parties involved to take part and play their roles. It is interesting to see the improvement, which will benefitted the industry and nation as a whole.

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SPATIAL ANALYSIS MONITORING ON DENGUE IN MALAYSIA: FROM THE PERSPECTIVE OF THE CONSTRUCTION INDUSTRY

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Abstract
Dengue has become a public health concern worldwide. The disease has grown rapidly in tropical and subtropical countries such as Malaysia. The number of dengue cases has increased in the period starting from year 2015 until March 2017. Preventing and controlling the dengue outbreak will help reduce the number of dengue cases in Malaysia. Spatial analysis monitoring on areas that face high risk of dengue will help control the number of dengue cases. It has been identified that the construction sector is one of the main contributing sectors of dengue cases in Malaysia. Construction activities were found to provide breeding areas for mosquitoes, thus causing the increase in dengue cases. This paper seeks to determine the high-risk areas of dengue breeding sites in Malaysia by using the geographical information system (GIS) and remote sensing method. By adopting the GIS and remote sensing analysis, potentially high-risk areas can be determined, and the data obtained can act as a guide for public health in Malaysia.

Keywords: *Dengue; Spatial Analysis; Geographical Information System*

INTRODUCTION

Dengue cases have been found to continuously increase in the recent decades. According to the World Health Organisation, the number of dengue cases reported has increased from 2.2 million in 2010 to 3.2 million in 2015. The rapid increase in the number of dengue cases reported has certainly become a global burden. Climate change may not be the only factor that has caused the sudden increase in the number of dengue cases in Malaysia (Ong, 2016). The increase in number of dengue cases in the tropical and sub-tropical regions may also be influenced by complex factors such as changes in the environment, weather, degree of urbanisation and quality of vector control service in urban areas (Cheong et al., 2013).

Malaysia has recorded an increase in number of dengue cases every year since 1980 and it has been declared as a national health threat to the public (Mia et al., 2013). Since 1901, it was reported that dengue has become endemic, particularly in urban areas (Dom et al., 2012). According to Chandramogan (2017), the common breeding habitats at the construction site are canvas or plastic sheet, water paddles or ground depression, containers, receptacles, hollow metal rod as shown in the Figure 1. To control the problem, various prevention efforts have been implemented to reduce larval breeding sites (Sumayyah et al., 2016). One of the great efforts by the Construction Industry Development Board (CIDB) Malaysia is though the implementation policy of adoption the Industrialised Building System (IBS) in all the Government's projects towards the sustainable construction practice (Nawi et al., 2015).

Figure 1. Common Mosquito Breeding Habitats

Due to various factors that may influence the increase in number of dengue cases, various efforts have been made to prevent this such as campaigns among the community and the enforcement of law (Nani, 2015). However, in order to effectively prevent the spread of dengue cases, a control and monitor process is the major option to be implemented. Therefore, a spatial analysis on dengue will help identify the localised cluster areas that contribute to the rise of dengue cases in Malaysia (Dom et al., 2016). Spatial analysis is used to have a better understanding of the distribution of dengue cases from the data generated by the Geographical Information System (GIS) which incorporates an environmental model to identify hotspot dengue zone areas.

The Geographical Information System (GIS) and remote sensing system are identified as potential enabling technology to be used in public health sector studies as they can be used to give near real-time access data on precise geographical incident location just by using highly-applicable technology (Zahawir et al., 2008). The purpose of GIS and remote sensing is to act as infectious disease surveillance and control vector-borne diseases.

The implementation of the geographical information system (GIS) and spatial analysis method shows an effort to promote the prevention and control of public health issues (Dom et al., 2016). Spatial analysis should be able to enhance the effectiveness and efficiency of dengue surveillance control (Nazri et al., 2011). Thus, to reduce the number of dengue cases in Malaysia, spatial analysis had been implemented in this study in order to reduce the total number of dengue cases. Rapid population growth has caused a high potential of dengue outbreak due to the ability of human to move from one place to another as well as the increase in probability of human reservoir which is proportional to population density (Nazri et al., 2011).

Construction sites had been identified as the main breeding ground for Aedes mosquitoes (Louis, 2015). Selangor and the Federal Territory of Kuala Lumpur are known to have a high number of population in Malaysia and various type of construction projects had been develop for the areas in contemplation towards urbanisation (Basar & Ismail, 2016). Malaysia is known to be one of the worst affected countries with a high number of dengue cases, thus, the spatial analysis is conducted in order to reduce the number of dengue cases by striving on the reduction of dengue cases.

Therefore, in order to analyse the distribution of dengue cases in Malaysia, spatial analysis has been implemented in the study. The purpose of spatial analysis is to determine the risk

zones of dengue cases in Malaysia and evaluate the risk of environmental factors on dengue incidence.

STUDY AREA

The state of Selangor is located on the west coast of Peninsular Malaysia and bordered by the state of Perak to the north, the state of Pahang to the east, the state of Negeri Sembilan to the south, and the state of Malacca to the west (Figure 1). It is located at 3°20'N and 101°30'E. Selangor is the largest and most rapidly growing state in the country due to modernisation. The state has an area of approximately 8,104 km2 (3,129 sq. mi). The population in Selangor numbers roughly at 6,073,180.

Selangor is Malaysia's biggest economic contributor as it houses the most rapid development in the industrial, agriculture, forestry, commerce and tourism sectors which contributed to the increase in the state's revenue. Moreover, the state of Selangor is the largest contributor towards the economy in Malaysia in terms of gross domestic product (GDP) and has the largest population in Malaysia. The population enjoys a high standard of living, and the state has the lowest rate of poverty in Malaysia.

The study took place in Selangor because the state has the highest number of development areas and population. According to Malaysia's Ministry of Health, Selangor records the highest number of dengue cases compared to the other states in Malaysia (Table 1).

Table 1. Total of Dengue Cases Reported in Malaysia (Ministry of Health, 2017)

States	Total of Dengue Cases Reported from January 2016 to December 2016	Total of Dengue Cases Reported from January 2017 to 14 March 2017
Selangor	**46,406**	**10,102**
Perak	3,218	1,711
Federal Territory of Kuala Lumpur & Putrajaya	7,719	1,551
Johor	9,880	1,378
Kelantan	5,296	984
Negeri Sembilan	2,458	741
Pahang	2,502	510
Sabah	3,178	462
Melaka	1,996	433
Pulau Pinang	2,331	416
Sarawak	2,414	378
Kedah	834	291
Terengganu	1,902	74
Perlis	161	43
Federal Territory of Labuan	11	3
MALAYSIA	**90, 506**	**19,077**

Data Collection

Data on the reported dengue cases was obtained from the iDengue online database and contains information as follows; (1) location; (2) number of dengue cases; (3) date start and last case recorded; and (4) hotspot location of dengue case. A map of the Selangor state was obtained from the Department of Surveying and Mapping, Malaysia and Google Maps.

In order to analyse the percentage of construction project that contributed towards dengue cases in Malaysia, the data was obtained from Construction Industry Development Board (CIDB). The data is used for a better understanding of the contribution of construction projects on dengue cases in Malaysia.

METHODOLOGY

The study was conducted through using a comprehensive secondary data analysis based on the Geographical Information System (GIS) on the "iDengue for the community" created by the Ministry of Health of Malaysia. The iDengue system is used by the community as a platform to gather the latest information on dengue cases.

Based on the iDengue online database, various data on dengue cases are analysed such as the daily number of dengue cases reported for each state in Malaysia, the total number of dengue cases in Malaysia according to each state, the list of locations of reported dengue cases, and a list of dengue hotspot locations.

In order to analyse the occurrence of dengue cases in Malaysia, it is important to review the spatial information on dengue distribution. GIS analysis and remote sensing are used in this study to identify the highest contributor towards dengue cases in Malaysia. The total number of dengue cases was obtained from the GIS analysis system and the total number of construction projects in Malaysia was obtained in order to make a clear analysis of the data acquired.

DATA ACQUISITION

Landsat imagery acquired in March 2017 was used in this study for the dengue analysis. Landsat is a United States' scientific satellite that studies and photographs the earth's surface by using remote-sensing techniques. The details of the spatial data used in this research were obtained from iDengue Malaysia as dengue represents a health problem in Malaysia. Since 1982, Malaysia has faced a significant dengue outbreak which gradually increases each year (Sumayyah et al., 2016). Analysis on the hotspot locations by using geographical information system and remote sensing for dengue cases will help prevent and reduce the number of dengue cases in Malaysia by the process of indicating the locations that may possibly become high-risk areas for dengue cases. A dengue hotspot is designated after a case is protracted over more than a period of 31 days from the date of the dengue outbreak (Health, 2013). By implementing the GIS and remote sensing method, the study will be able to analyse the hotspot locations of dengue cases.

Data in Table 1 indicate that Selangor has the highest number of dengue cases recorded from January 2017 to March 2017. On that note, this paper will focus on the state of Selangor

since it is the highest contributor towards the number of dengue cases in Malaysia. Recorded data from GIS and remote sensing will be analysed, as well as the cumulative number of dengue cases.

However, there are a few constraints in this study such as errors in processing data which can degrade the quality of the data collected, and the complexity faced in obtaining some imagery of the Earth's land and water surface.

Selangor is a rapidly urbanised state with a high number of population and has the highest rapid economic growth among the other states in Malaysia, which are the situations most developing countries have gone through (Yakob et al., 2012) (Figure 1). However, the number of dengue cases has kept on increasing, causing a major health problem (Nazri et al., 2011). In 2016, the total number of construction projects is 6,855 (Table 2). CIDB has also recorded a total number of 1,381 construction projects from January 2017 to March 2017. Environmental changes are a major contributor towards the pattern of dengue incidence distribution. High temperatures and changes on demography have influence the level of mosquito survivorship which in turn affect the increase in dengue cases in Malaysia (Roslan et al., 2016). Rapid development and high-density population areas will have higher numbers of dengue incidence cases (Umor et al., 2007). Therefore, evaluating the imagery taken from Landsat and plotting the dengue incidence by using geographical information system and remote sensing will help prevent the increase in number of dengue cases in Malaysia.

Table 2. Number of Project Awarded in 2016 and 2017 (Construction Industry Development Board (CIDB), 2017).

Year	Total number of project in 2016	Total number of project in until March 2017
Jan	492	435
Feb	466	425
Mar	604	521
Apr	649	
May	605	
Jun	740	
Jul	451	
Aug	699	
Sep	549	
Oct	544	
Nov	534	
Dec	522	
Total	**6,855**	**1,381**

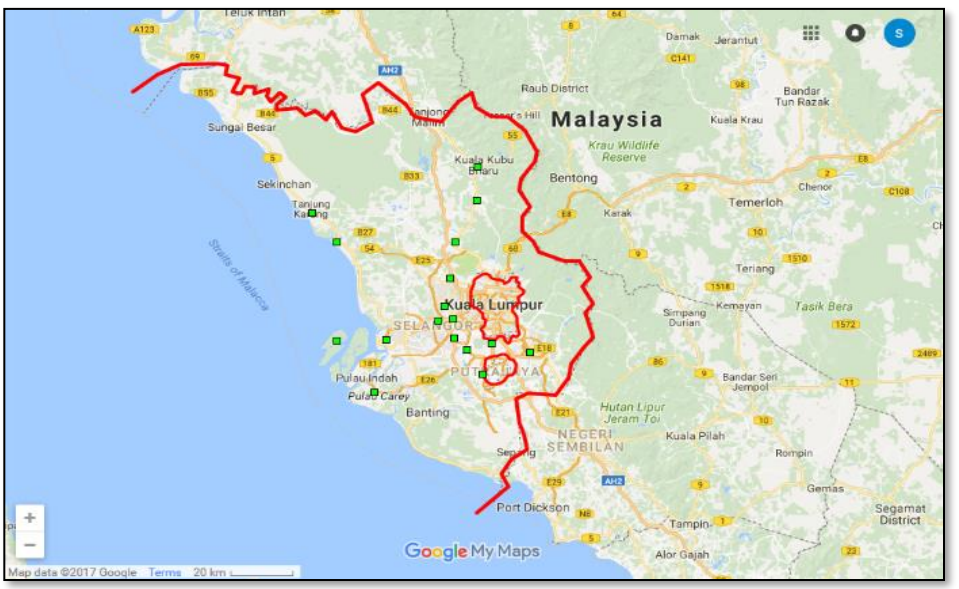

Figure 1. Map of Selangor, Malaysia (Map of Selangor, 2017)

Based on the data collected from iDengue on GIS and remote sensing, Selangor has the highest number of dengue incidence with a total of sixty-one (61) hotspot locations in the state. This is followed by Perak, which has a total of thirteen (13) hotspots; Negeri Sembilan with four (4) hotspot locations, the Federal Territory of Kuala Lumpur with a total of three (3) hotspot locations, and one (1) hotspot location each in Johor and Sabah.

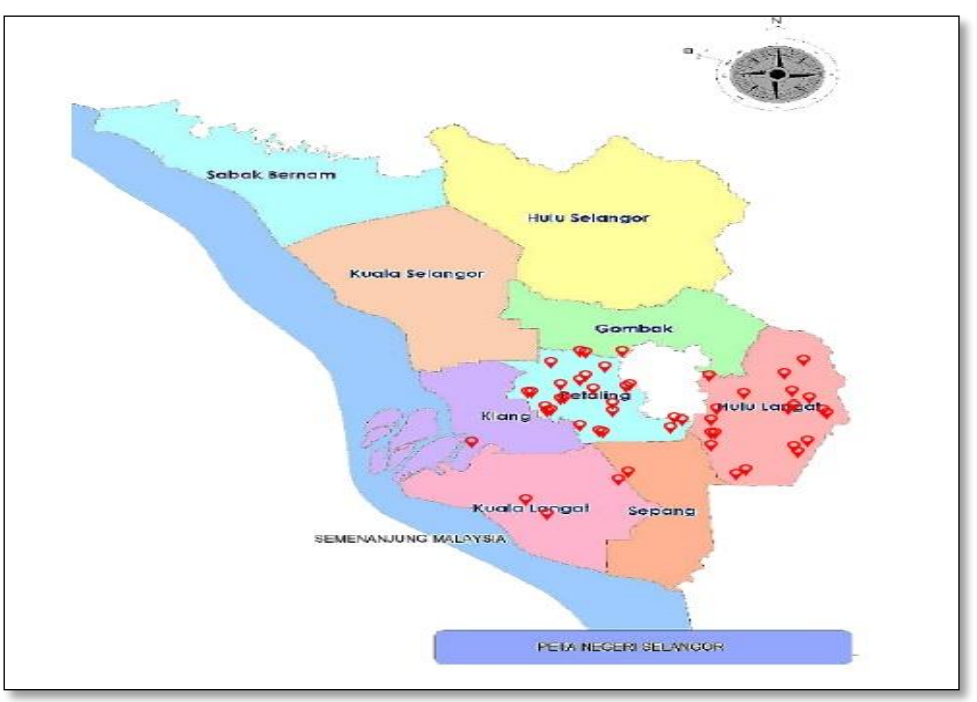

Figure 2. Map of Selangor, Malaysia showing all district with dengue hotspot location

Table 2. Total number of hotspot location and cumulative number for dengue cases in Selangor, Malaysia (Ministry of Health, 2017)

No	District	Number of Hotspot Location	Cumulative Dengue Cases
1.	Petaling	26	676
2.	Hulu Langat	20	283
3.	Gombak	10	145
4.	Kuala Langat	3	35
5.	Klang	1	9
6.	Sepang	1	17
	Total	**61**	**1,165**

There are nine (9) districts in the state of Selangor (Figure 2). However, only six (6) of the districts are found to be hotspot locations for dengue cases. Figure 2 and Table 3.0 indicate that Petaling is the highest contributor towards dengue cases in Selangor, and has a total of twenty-six (26) hotspot locations with a total of six hundred and seventy-six (676) cumulative cases. This is due to the high number of people in the Petaling area. After that, Hulu Langat is considered to have the second highest recorded number of dengue hotspot locations with a total number of twenty (20) hotspots and two hundred and eighty-three (283) cumulative cases found. This is followed by Gombak with ten (10) hotspot locations and one hundred and forty-five (145) cumulative dengue cases.

As for Kuala Langat, only three (3) hotspot locations and thirty-five (35) dengue cases were recorded for this district. Both Klang and Sepang share the same total number of hotspot locations which is only one (1). For Klang, the total number of dengue cases is nine (9) cases, and Sepang recorded a total of seventeen (17) cumulative cases.

The analysis of this study is that Selangor has the highest recorded number of dengue cases with a total of sixty-one (61) hotspot locations. Petaling is considered the biggest contributor with the highest number of hotspots for dengue cases with a total of twenty-six (26) areas. The high number of dengue cases in because of the urbanisation that happens rapidly in the state of Selangor. Changes in the environment are considered as a factor towards the increase of dengue cases in the area. Since land use can change according to the economic activity, population and size of urban area, the number of dengue cases will keep on increasing too. As the population number keeps on increasing, the demand for land for residential use which is known to be the biggest consumer of land changes in the country will also keep on increasing (Gwamna et al., 2014).

Therefore, the increase in number of dengue cases caused by rapid urbanisation can be prevented or reduced by taking precaution methods towards the breeding of the Aedes mosquito. It is important for the public to show concern towards their surroundings to prevent the increase in number of dengue breeding areas. As for developers, it is said that developers should implement and control the probability of breeding sites at construction areas from ensuring a proper solid waste management and making sure a clean environment for the site area (Arumugam, 2016). This is to tone down the high number of dengue cases in Malaysia.

DISCUSSION

The paper has sought to determine the high-risk areas prone to dengue cases in Malaysia. Therefore, the purpose of analysing the data for this paper is to get a clear understanding of the contribution of construction projects towards the rise of dengue cases in Malaysia.

Some limitations of this study are that data on the most recent year in 2015, 2016 and 2017 could not be obtained from the Ministry of Health's official Annual Report. The updated Annual Report found is in year 2014. Thus, raw data from year 2014 were used in the study. This is to replicate the total number of construction projects that has contributed towards the rise of dengue cases in Malaysia. Since complete data for year 2014 can be obtained, Table 3 below shows the raw data used in the study's data analysis (Ministry of Health, 2014).

Table 3. Total number of dengue cases and construction projects in Malaysia (2014); percentage obtained from Annual Report from Ministry of Health Malaysia.

Reported dengue cases in Malaysia (2014) (Department of Statistic Malaysia, 2016)	**Total number of construction projects in Malaysia (2014)** (Construction Industry Development Board, 2014)	**Percentage of the dengue cases contributed by construction projects in Malaysia (2014)** (Ministry of Health, 2013)
35, 749	5,790	18%

Total reported dengue cases 2014: 35, 749
Construction Projects in 2014 : 5,790
Percentage : 18%

$$\frac{18}{100} \text{ x Total reported dengue cases} = 6,434.82$$

$$\frac{\text{Total number of construction projects in Malaysia}}{6,434.82} = X$$

$$\frac{5,790}{6,434.82} = 0.89 \approx 1$$

∴ 1 construction project contribute to 1 dengue cases in Malaysia

Total reported dengue cases x 18% = Number of dengue in construction projects

35, 749 x 18% = 6434.82

Construction projects = number of dengue cases

5,790 = 6434.82

$$\frac{6436.82}{5790} = 1.11$$

$$1\frac{1}{10} = 1.11$$

∴ 1 construction project = 1 dengue cases contribute by a construction project

From the data analysed in the calculations above, it can be concluded that 1 construction project in Malaysia contribute to at least 1 dengue case. Based on the annual report by the Ministry of Health Malaysia, construction projects has been identified as one of the highest

contributors towards dengue cases in Malaysia (Ministry of Health, 2014). In the year 2014, construction projects have contributed 18% towards dengue cases. From the 18% raw data, the total number of reported dengue cases 2014 in Malaysia and total number of construction projects in year 2014 in Malaysia can be analysed in order to get a more clear view of how urbanisation and globalisation have contributed towards the increase in dengue cases. Urbanisation and globalisation have caused the increase in number of construction projects in Malaysia. Thus, dengue cases will eventually increase in number if there is lack of prevention and control towards the dengue disease.

Therefore, it is crucial for construction projects to take proper prevention and enforcement measures towards combatting dengue issues in construction sites. Proper planning, on-site management and the environment are factors that need to be considered to make sure that projects are free from being breeding sites. Controlling and preventing the issue will help reduce the number of dengue cases in Malaysia.

CONCLUSION

Selangor is one of the developing cities which is going through urbanisation. As it is going through urbanisation, the number of dengue cases keeps on increasing following the development trend. This issue has become a health problem faced by Malaysia, and Selangor is known to be the highest contributor towards the high number of dengue cases in Malaysia. Therefore, to reduce the number of dengue cases, Malaysia needs to take rigid prevention and control measures to eliminate dengue health issues, especially in the construction sector. Hence, proper land planning and safety measures need to be implemented to control the issue. By controlling the issue, the number of hotspot locations for dengue may be reduced.

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THERMAL PERFORMANCE EVALUATION OF DOUBLE PANEL GLASS WINDOWS

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Abstract
Technology of glass used in double glazing window for thermal insulation is known as Low Emissivity Glass (Low E). It has a transparent metallic coating that works into the heating energy. The U-value of a double glazing window in this experiment is the calculated by using software programs developed at Lawrence Berkeley National Laboratory (LBNL) called WINDOW 7.3. This software can determine which the double glazing windows Low E Glass or Clear Glass and with the lowest U-value are the most efficient and show in result. The goal of this research was to assess the thermal surface performance and daylight penetration of Double Panel Window (DPW) with difference type of glass. The U-Value, thermal transmittance and relative solar heat gain coefficient values obtained from both experiments with computer simulations. This can lead to a reduction of about 50-70% direct solar heat and still maintain high visibility by using low emissivity glass.

Keywords: *Double Glazed; low Emissivity Glass; Heat Thermal; U-Value*

INTRODUCTION

Construction sector departs with the flow of modernization. Sustainability and technology are developing in simultaneously. Meanwhile, Green technologies are brought forward, and the usage is being increased day by day. Aligned with the concept of sustainable development, the green building is being promoted as a high potential solution to reduce gas emissions and natural resource depletion (Byrne et al., 2016).

Achieving a green building prominence is a virtuous by selecting the proper building materials. The selection of glazing window is able to save energy (Ware, 2011). The advantages of windows are indisputable, creating visual contact with the outside environment and letting in natural light in buildings. In contrast to these advantages, windows denote building energy system with high thermal losses and high solar heat gain leading to increased heating or cooling need respectively (Ware, 2011).

The common arguing among stakeholder is how to make a building is comfortable with less energy consumption. The window selection is a crucial obligation. The heat gained from the outside through the window increased indoor temperature to a level that most owners uncomfortable without mechanical ventilation. Current conventional residential windows are responsible for around 47% of the heat loss from building fabric (Cuce et al., 2015). Due to the significance of windows in reducing the heat requirement and energy consumption of buildings, considerable attention is given to improve its performance. Heat lost through window by conduction, convection and radiation. The technology type of using window single or double glazed window make the different result. The lower the window U-value the better its thermal insulation and more energy it can conserve.

Ministry of Energy Commission (MEH, 2016) has carried out a series of survey and educational program to study the consumption pattern and raise the level of awareness among consumers on the importance on energy savings. One of the ways to reduce the energy wastage is mainly from reducing the wastage of electricity. Household appliances such as air conditioner, computer, television and refrigerator are some of the area of interest as these appliances are used by consumer in a daily basis.

The major energy consumptions in buildings are heating, ventilation, and air conditioning. The 35% of total building energy lighting, then 11% major appliances such as air conditioner, refrigerators and freezers, dryers and others. In each case there are opportunities both for improving the performance of system components such as improving the efficiency of lighting devices (MEH, 2016).

Table 1. The Final electricity consumption (MEH, 2016)

Final Electricity Consumption (ktoe)			
Year	**Commercial**	**Industrial**	**Residential**
2010	3020	3994	1937
2011	3172	4045	1974
2012	3325	4509	2126
2013	3466	4809	2262
2014	3566	5072	2346

Energy in the buildings mainly utilised for cooling, heating and lighting. In Malaysia, the air conditioning and lighting are the major energy consumers in the buildings. Hence, it will incur very high costs if the energy is not managed properly. The buildings, both residential and commercial, have contributed between 20% and 40% towards energy consumption for developed countries and exceeded the other major sectors such as industrial and transportation as describes in Table 1 (MEH, 2016).

Double panel window is the best solution to create and build and reduce heat in the building (Cuce et al., 2015). Therefore, this paper aims to determine the thermal performance characteristics of thermal surface performance and daylight penetration of Double Panel Window (DPW) with difference type of glass.

LITERATURE REVIEW

Window Properties

Window selection involves various considerations such as appearances, energy performance, human factor, technical performance and cost. This part provides an overview of many of these properties. First section of this window properties is energy performance characteristic of window unit. There is a brief introduction to the basic mechanisms of heat transfer and how they apply to window. Then, description of the energy related to window such as insulating value, overall U-factor, determine the and solar heat gain (Cuce et al., 2015).

Non-solar heat flows through a window is a result of difference level of indoors and outdoors temperature. Windows lose heat to the outside during the heating season and gain heat from the outside during the cooling season, adding to the energy needs in a home. The effects of non-solar heat flow are generally greater on heating needs than on cooling needs

because indoor-outdoor temperature differences are greater during the heating season than during the cooling season in most regions of the United States. For any window product, the greater the temperature difference from inside to out, the greater the rate of heat flow. U-factor is a measure of the rate of non-solar heat flow through a window or skylight (Camody, 2007).

The origin of solar heat gain is the direct and diffuse radiation coming from the sun and the sky or reflected from the ground and other surfaces. Some radiation is directly transmitted through the glazing to the building interior, and some may be absorbed in the glazing and indirectly admitted to the inside. Solar Heat Gain Coefficient (SHGC) represents the solar heat gain through the fenestration system relative to the incident solar radiation. Although SHGC can be determined for any angle of incidence, the default and most commonly used reference is normal incidence solar radiation (Camody, 2004). Essentially, the lower the window's SHGC, the less solar heat is transmitted (Camody et al., 2007).

Double Panel Window (DPW)

Simple glass windows are venerable to incident solar radiation penetrating easily through a simple clear glass sheet whose transmittance is of the order of 90% (Ismail et al., 2009). The development of new materials, new technologies and new strategies for reducing energy consumption led to enhance research and development of more efficient windows. Windows having selective solar radiation characteristics are examples of thermally efficient windows. The selective properties due to deposited films on the glass sheets allow changing the transmittance, reflectance and absorbance of the window.

Peer researchers also pointed that the use of double glazed window still the most common method of providing a reasonable level of thermal resistance. A variety of studies considering DPW have been developed over the years. For example, double glazing with air at atmospheric pressure (Aydin, 2009: Xaman et al., 2014) or with some inert gas (Muneer & Han, 1996: Weir and Muneer, 1998), with water as thermal fluid (Chow et al., 2011; Chow et al., 2011b), with natural convection (Chow et al., 2009), DPW with enclosed slats (Chawiwatworakul, 2013), with transparent solar cells (Han et al., 2010), and those that use Phase Change Materials (PCM) (Ismail et al., 2014). Among DPW mentioned above, those manufactured with air enclosed between the panels are the most commonly used because their low cost with respect to other DPW configurations.

Low-emissivity or Low-e coating is invisible, but they are remarkably well suited for increasing thermal comfort and controlling solar impact. By sing a low-e coating to improve a double glazed window's performance has little effect on daylight transmissivity (Saidur et al., 2008)

Meanwhile, spacer bar normally has a profile depth of 6–8 mm and the width can be varied to give a cavity of 6–20 mm. The larger gap between the panes of glass gives better thermal insulation, although, benefits of having more than 12 mm are marginal unless low-e coated glasses or gas-filling is included. (Garvin and Wilson, 1998) Therefore imperative to find the optimum gap width required for the lowest thermal transmittance possible for the glazing unit. The optimum gap width for air and Argon fills is 12 mm, and Krypton is 6 mm based by Lawrence Berkeley National Laboratory (LBNL) (Van Der Bergh et al., 2013). Some studies have shown less than 0.5% leakage per year in a well-designed and well-

fabricated unit, or a 10% loss in total gas over a 20-year period. So, the overall effect of a 10% gas loss would change the U-factor by only a few percentage points (Camody & Hagund, 2012).

METHODOLOGY OF EXPERMIENT

Physical Properties of Window

Figure 1 illustrated several parts of the window panel. It contains numerous of glass sheets separated by air gap. Yet, this research only provides single gap of window panel. The glass sheets are mounted directly in the frame, which is making the glazing accessible from both sides.

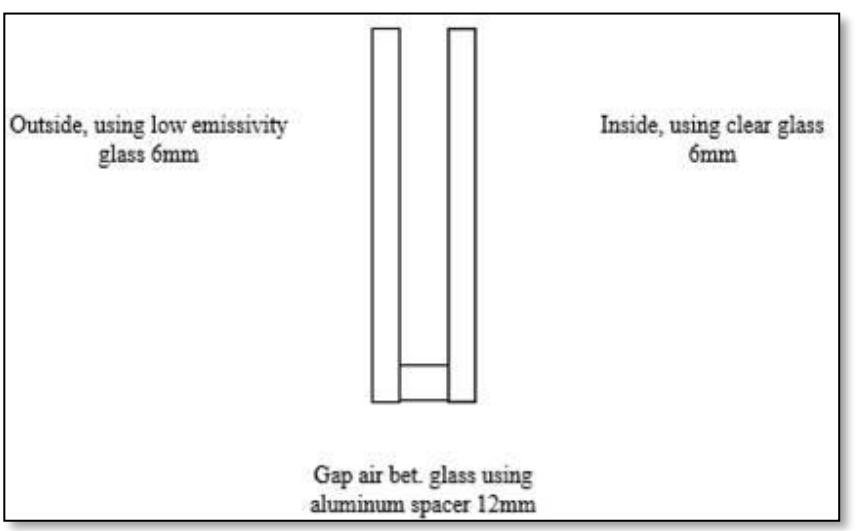

Figure 8. Cross Section of the Double Glazing

A glazing unit with the size of 1 ft. x 1 ft. was chosen as the test specimen. The test box for the glazing unit was built by using the thickness 1 inch. of plywood as shown in Figure 4 and Figure 5 to prevent heat losses inside the box and just focusing attention on the thermal performance of the glazing unit. The double glazing unit was built with a 24mm thickness glass including the spacer 12mm.

Figure 9. The actual picture of the testing view in front

Figure 10 . Both glass low emissivity and clear glass at testing

Double Panel Window Performance and Measurement

The Fluke Thermal Imager Ti20 brings the power diagnostic capabilities of infrared thermal imaging technology within reach of a wider range of industrial applications. The unit is fully radiometric for detailed temperature analysis and tracking of critical components. The included Inside IR software facilitates setting up an inspection route using unique location names, measurement setup data and high/low temperature alarms. These routes can be uploaded to the imager for use as a routing guide. Figure 4 shown the experiment is resumed.

Figure 11. Experiment is resumed.

Recording images is a simple process but before starting you should note the current image location number. If you have not stored any images, the location number should be set at default and the location descriptor will be blank. Each captured image is numbered, so you may refer to images by number. The Imager can store up to 50 images. The Ti20 imager views a portion of the scene that is 15 º high by 20 º. This scene is displayed on the LCD on the back of the Imager. The single temperature displayed numerically at the lower edge of the display. However, the best shot and result you can see at Figure 5.

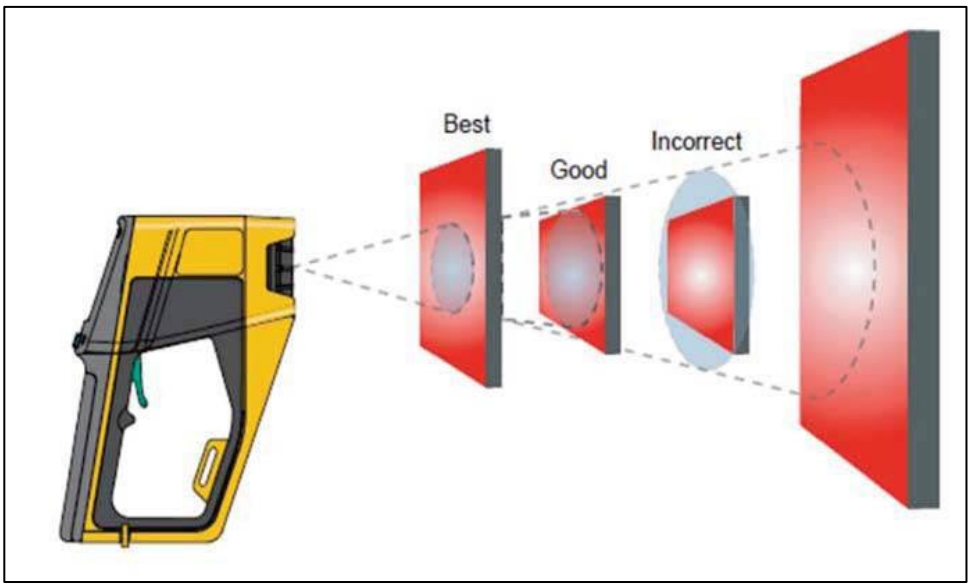

Figure 12. The best layers of the Ti20 can detect

SOFTWARE LBNL WINDOW 7.3

This result analysed by WINDOW 7.3. It is a software programs developed at Lawrence Berkeley National Laboratory (LBNL) utilized to determine the thermal and solar optical properties of glazing and window systems.

ANALYSIS OF RESULT AND DISCUSSION

Pulau Pinang are located between 05° 35' 02" - 05° 07' 23" N and 100° 10' 33" - 100° 33' 02" E, is a state of Malaysia, hot-humid climate zone country. Pulau Pinang is composed of two parts - island and mainland. However, being an island, the atmospheric temperature is often higher than the mainland, reaching as high as 38°C during daytime. In general, the range of atmospheric temperature is between 29°C to 38°C during daytime and 24°C to 28°C during night time (Makaremi et al., 2012)

Experiment took place during sunny day to avoid a higher percentage scattering of the sun's radiation. The set of data, which was tested on April 19, 2017 between 11a.m. to 2p.m. acquire the maximum level of temperature that bear on the indoor and outdoor glass surface.

Thermal Fluke Imager Analysis of Result

Data was taken from 11 a.m. to 12.00 p.m. At every 5 minutes of interval. This experiment required to get the performance of clear glass versus low emissivity double glazing glass window. Table 2 shows of interest were the surface temperatures of the double glazing window by using clear glass and low emissivity glass on the outside, inside surface and the temperature inside the box. Figure 6 and Figure 7 shows pattern of thermal movement and Surface temperature in ASG Dark Blue Glass (Clear Glass) at 11:15am.

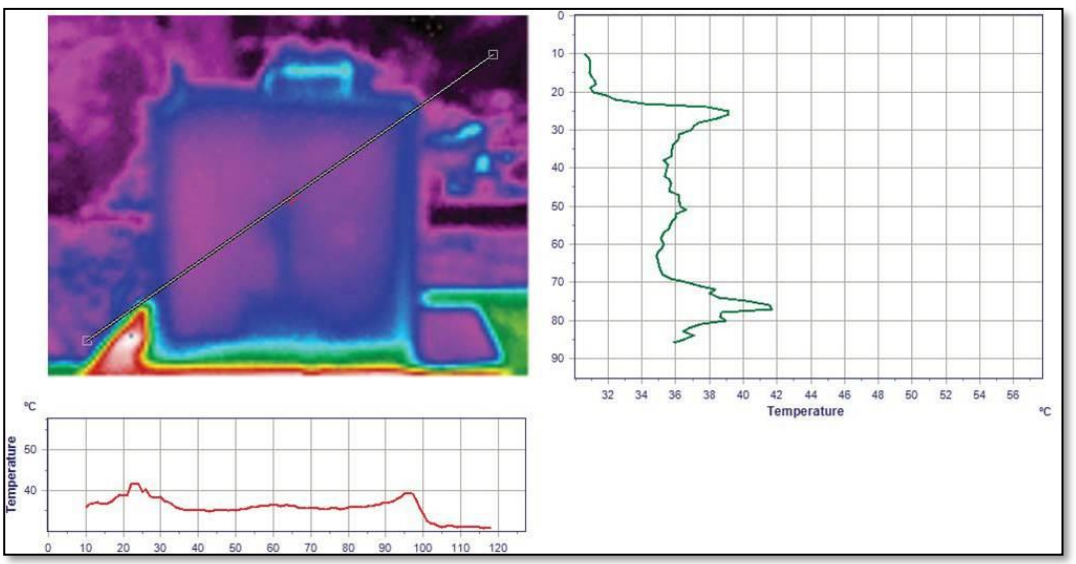

Figure 13. Show that result by using Fluke Thermal at 11:15am

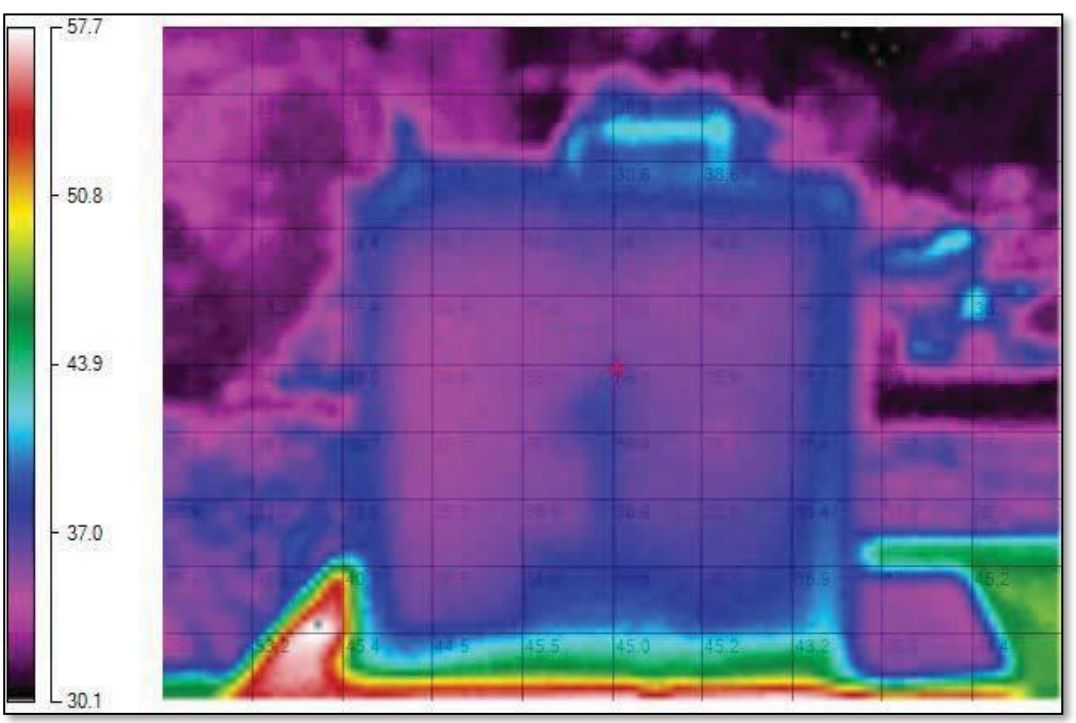

Figure 14. Surface temperature outside layer of ASG Dark Blue Glass (Clear Glass) at 11:15am.

Table 2. Result of Double Glazed Dark Blue Glass (Clear Glass) vs Low E Glass

	Temp Outer Surface °C	Temperature inside °C		Temp Inner Surface °C	
		A	B	A	B
11:00 AM	35.59	34.4	33.20	36.28	37.73
11:10 AM	35.63	34.55	33.41	37.05	38.82
11:15 AM	36.59	35.47	33.82	37.63	39.22
11:20 AM	37.47	36.32	34.42	38.32	39.61
11:25 AM	38.24	37.05	36.27	38.63	39.92
11:30 AM	41.13	40.05	38.09	41.02	38.17
11:35 AM	41.63	40.31	38.47	41.21	38.67
11:40 AM	42.25	41.02	38.97	41.52	39.2
11:45 AM	42.21	41.25	39.36	42.31	39.67
11:50 AM	42.25	41.32	39.67	42.44	40.05

A: 6mm ASG Dark Blue Glass + 12mm Air Space + 6mm ASG Clear Glass
B: 6mm SNGY Green Low E Glass + 12mm Air Space + 6mm ASG Clear Glass

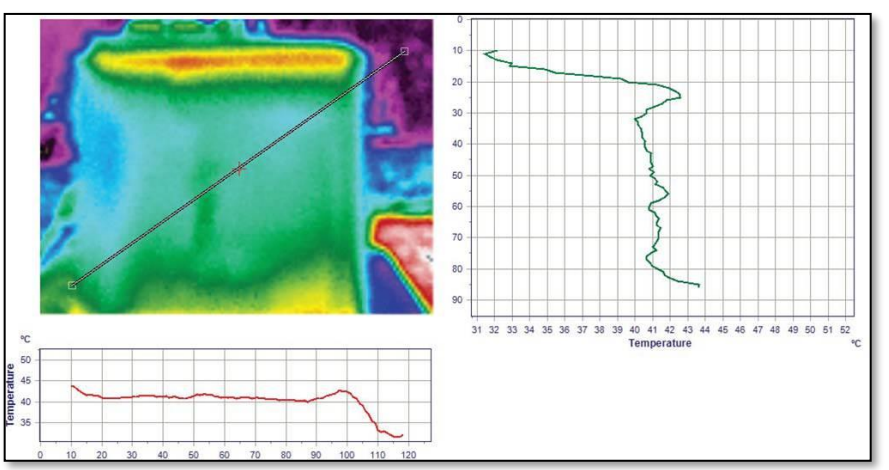

Figure 15. Result SNGY Green Low E Glass by using Fluke Thermal 11:45am

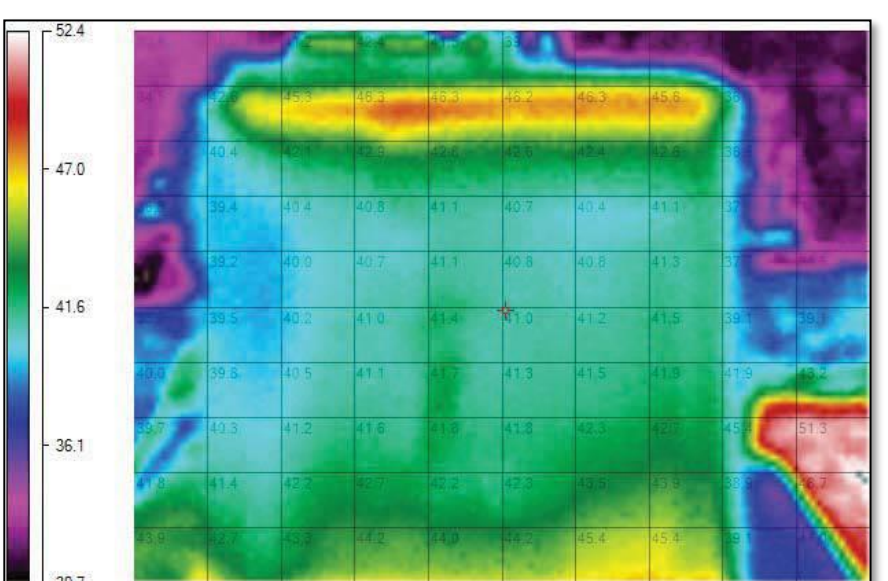

Figure 16. Surface Temperature outside layer of SNGY Green Low E Glass at 11:45am.

Table 3. Temperature of Double Glazed Dark Blue Glass (Clear Glass)

Date	Temperature Inside °C	Temp Outer Surface °C	Temp Inner Surface °C
12:05:00 PM	40.01	41.09	40.36
12:10:00 PM	40.47	41.21	40.82
12:15:00 PM	40.70	41.32	41.05
12:20:00 PM	40.90	41.44	41.44
12:25:00 PM	41.05	41.59	41.86

12:00PM – 1:00PM20/04/2017 (THURSDAY)
6mm ASG Dark Blue Glass + 12mm Air Space + 6mm ASG Clear Glass

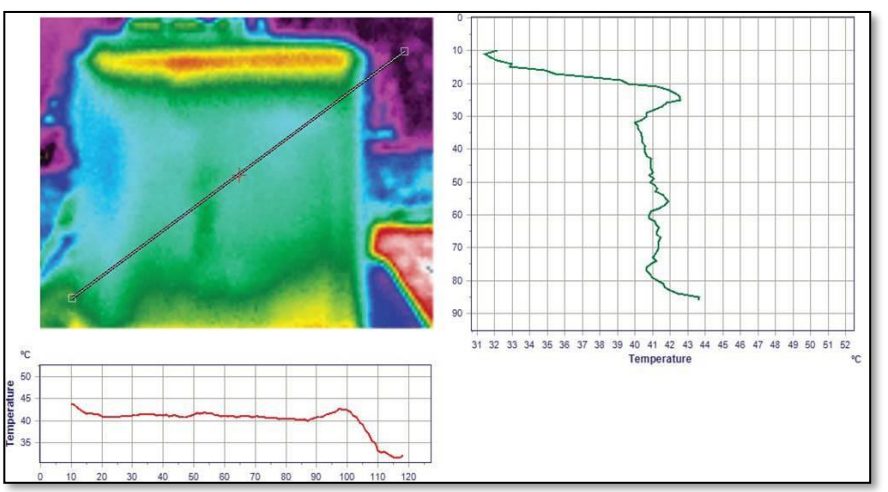

Figure 17. Temperature performance for 6mm ASG Dark Blue Glass + 12mm Air Space + 6mm ASG Clear Glass

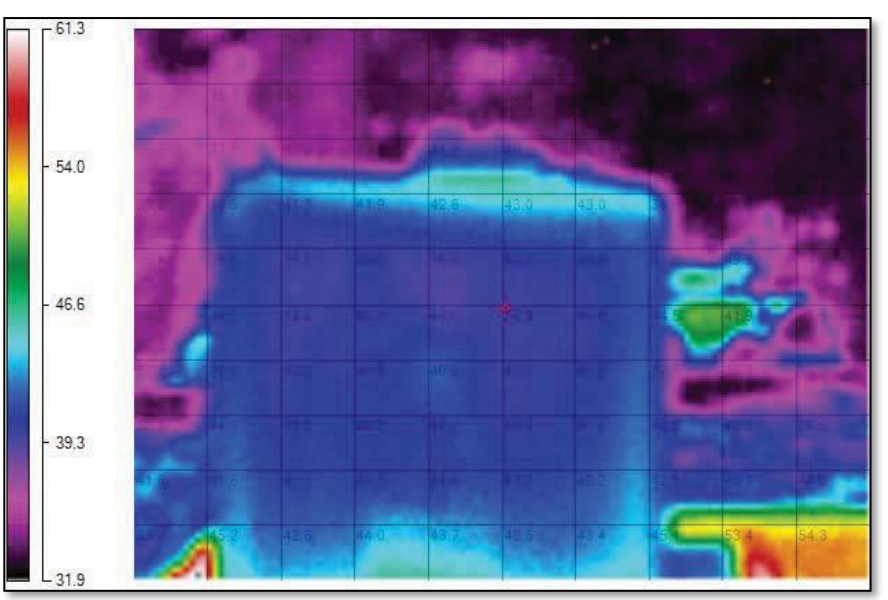

Figure 18. Surface temperature outside layer of ASG Dark Blue Glass (Clear Glass) at 12.15pm.

Table 4. Result of Surface Temperature Double Glazed Low Emissivity

Date	Temperature Inside °C	Temp Outer Surface °C	Temp Inner Surface °C
12:35:00 PM	41.59	42.67	41.67
12:40:00 PM	41.40	42.01	41.67
12:45:00 PM	41.24	42.13	41.59
12:50:00 PM	41.28	43.29	41.74
12:55:00 PM	41.47	44.25	41.94

SNGY Green Low E Glass + 12mm Air Space + 6mm ASG Clear Glass

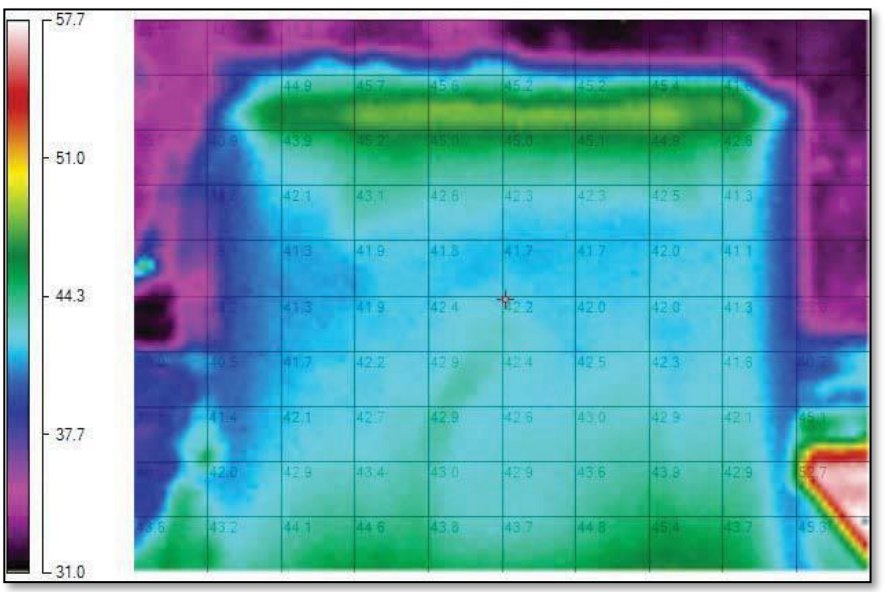

Figure 19. Surface temperature outside layer of SNGY Green Low E Glass at 12:45pm

Table 5. Results of surface temperature of Double Glazed Dark Blue Glass (Clear Glass)

Date	Temperature Inside °C	Temp Outer Surface °C	Temp Inner Surface °C
1:05:00 PM	42.94	41.53	41.47
1:10:00 PM	42.01	40.82	41.97
1:15:00 PM	41.28	40.86	41.17
1:20:00 PM	41.01	40.78	41.90
1:25:00 PM	41.01	40.94	40.17

1:00PM – 2:00PM 20/04/2017 (THURSDAY)
6mm ASG Dark Blue Glass + 12mm Air Space + 6mm ASG Clear Glass

Table 6. Result of Double Glazed Low Emissivity

Date	Temperature Inside °C	Temp Outer Surface °C	Temp Inner Surface °C
1:35:00 PM	39.69	40.36	38.82
1:40:00 PM	39.74	40.09	38.36
1:45:00 PM	39.43	39.86	39.32
1:50:00 PM	39.47	39.86	39.38
1:55:00 PM	39.67	39.97	39.67

SNGY Green Low E Glass + 12mm Air Space + 6mm ASG Clear Glass

The surface temperature of the experiment shown in Figures 6 to Figure 12. The glass surface temperatures by using low emissivity were higher than the room inside the box and the inside surface, this also explained that the low emissivity glass is able to collect and retain heat from the sun and allows some amount to be transmitted compared to the clear glass.

Lawrence Berkeley National Laboratory (LBNL Window 7.3)

For analysis of the data was done by using Window 7.3 simulation software designed by the Lawrence Berkeley National Laboratory (LBNL Window 7.3), which is an open source software. Computation simulations were run with Lawrence Berkeley's Window 7.3 at the same environmental conditions to determine the thermal transmittance, solar heat gain coefficient, and visible light transmittance for both glazing units. Table 7 show design data for double glazed window based previous studies (Muneer et al., 2000).

Table 7. Window Performance Design

Window Design	U-Value (W/m²k)
Clear Glass with air	2.8
Low emissivity glass with air	1.8
Low emissivity glass with argon	1.5
Low emissivity glass with Krypton	1.0

By using LBNL Window 7.3 the glazing units were calculated based on the glazing configuration 6mm-12mm-6mm (6mm glass, 12mm air space, and 6mm glass) and the result at table 8 below.

Table 8. Centre of 6mm ASG Dark Blue Glass + 12mm Air Space + 6mm ASG Clear Glass Results from LBNL Window 7.3 Simulation

Term	Value
Solar transmittance	39%
Solar reflectance	7%
Visible transmittance	52%
Visible reflectance	9%
U-Value (W/m²k)	2.8
Relative heat gain (W/m²)	**362**

Table 9. Centre of 6mm SNGY Green Low E Glass + 12mm Air Space + 6mm ASG Clear Glass Results from LBNL Window 7.3 Simulation

Term	Value
Solar transmittance	25%
Solar reflectance	7%
Visible transmittance	50%
Visible reflectance	10%
U-Value (W/m²k)	2.2
Relative heat gain (W/m²)	250

Table 8 and 9 illustrated thermal transmittance, relative heat gain, and visible light transmittance for both type of glazing systems was evaluated using the LBNL Window 7.3 software. The results obtained from the LBNL Window 7.3 simulations are consistent with the results obtained from the field experiments. Both results show that type glazing units with low emissivity have better thermal properties as compared to glazing units with clear glass. The data are calculated using spectral measurements that are confirm to standards EN410 (1998) and ISO 9050 (1990).

CONCLUSION

In this paper, an experimental attempt is made to investigate the thermal performance characteristics of Low Emissivity glass and clear glass and the result are compared with conventional commercial glazing technologies. It is observed from the analyses that Low Emissivity Glass is a very good thermal insulator as well as being a power producer. The calculated U-value of Low Emissivity Glass is about 2.2 W/m2, which is remarkably lower than that of conventional Dark Blue double glazed window. As a consequence of the remarkable temperature difference between inside and outside, Low Emissivity glass can provide a significant amount of energy saving in extreme weather conditions. Besides its outstanding features such as electricity generation, sound insulation, self-cleaning and energy saving, having a competitive U-value of Low Emissivity glass with other technology such as triple glazing technologies enables it to become wide spread in the near future for both energy-efficient retrofitting of residential building sand new-build applications.

- Proved that using Low Emissivity Glass the inside temperature can reduce.
- The U-Value and Relative Heat Gain better than using Clear or Normal type of Glass.

ACKNOWLEDGEMENTS

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STUDY OF FACTORS AFFECTING THE COMPRESSIVE STRENGTH OF KEDAH'S SOIL STABILIZED WITH GEOPOLYMER

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Abstract

Geopolymerization technique was implemented in stabilization of Kedah's laterite soil with the different of solid to liquid ratios, sodium silicate to sodium hydroxide and various molarity in order to obtain the optimum result of compressive strength. Kedah's soil fly ash and alkaline activator were mixed together with the solid to liquid ratios in range of 1.5 – 3.0 which produce an aluminosilicate gel. The preparation of alkaline activator has been done by mixing sodium silicate and sodium hydroxide in range of ratios 0.5 -3.0. The results carried out that the compressive strength of stabilize soil by geopolymerization was affected by solid to liquid ratios, sodium silicate to sodium hydroxide ratios and molarity of sodium hydroxide. The optimum compressive strength of the stabilize Kedah's soil by geopolymerization technique was achieved at solid to liquid ratio of 3.0, sodium silicate to sodium hydroxide ratio of 2.5 and 12 M sodium hydroxide concentration which is 5.58 MPa in seven days curing at room temperature.

Keywords: *Geopolymerization; Laterite soil; Stabilization; Compressive strength; Construction*

INTRODUCTION

Soil stabilization is an alteration or the process of improving of one or more engineering properties of soil by mechanical or chemical means, to obtain some predetermined targets or the desired soil properties. According to ASTM 1992, there are three objectives for soil stabilization which are to enhance the soil resistance to the weathering process and traffic usage among others, to increase the strength of an existing soil to enhance its load bearing capacity and permeability improvement (ASTM Standards on Soil Stabilization with Admixtures, 1992). Malaysia is home for a variety of soft soil deposits which is lack sufficient strength. Soft soil which is inadequacy to hold up the loading either throughout the service life or during construction are frequently happened on many civil engineering works (Barden et al., 1973). Soft soil, also known as problematic soil as a result has low shear strength and high compressibility. It is regarded as poor quality soil to accommodate the construction, because characteristics that have low bearing pressure and high moisture content. Various researches have been worked about the use of by-product materials such as cement kiln dust, rice husk ash, and fly ash to improve the geotechnical properties of varied soil types. The high-calcium and low-calcium fly ashes affecting on highly expansive soil was studied by Mir and Sridharan (Mir & Sridharan, 2013). Maaitah (2012), stated that the mixing sodium silicate and lime could be improved the engineering properties of treated soil. Prabakar et al. (2004)

studied the effectiveness of fly ash on the engineering properties against various types of soils. Ali et al. (1992) assessed the durability and engineering properties of rice husk ash with lime mixtures and rice husk ash with cement for soil stabilization in Malaysia and concluded that rice husk ash with lime is the more effective as material for soil stabilization. In highway construction, Baghdadi and Rahman (1990) found that cement kiln dust (CKD) can be used to stabilize sand and can be applied for base materials. This research prove the significance of partial or total replacement of Portland cement by-product materials and by waste. After all, each type of replacement may also provide a lot of economic and environmental benefits. By-product material such as fly ash can be used as an alternative material in soil stabilization that has been implemented in this study by using geopolymerization technique. Geopolymer was first applied term by Davidovits in 1978 which means the mineral polymers resulting from geochemistry or geosynthesis and the chemistry concept was found in 1979 (Davidovits, 2002). Geopolymerization is a reaction that involve a silico-aluminates sources by integrates minerals chemically. The process of geopolymerization occurred when the alkali hydroxide and/or alkaline silicate solution dissolve amorphous aluminosilicate materials to form reactive silica and alumina. The dissolvent then polycondense into semi crystalline oligomers or amorphous that farther polymerize and harden into synthetic aluminoslilicate materials (Duxson et al., 2007; Khale, 2007). In addition, geopolymer or also known as inorganic geopolymer is an environmental friendly product that developing very expeditiously as a special engineering material. It has magnificent mechanical properties in term of compressive strength and stiffness and exceptional resistance to acids, heat and organic solvents. Geopolymer also can be synthesized from a wide range of industrial wastes such as fly ash, metakaolin, red mud, rice husk ash and furnace slag and low-cost aluminosilicate materials (Zhang et al., 2010; Giannopoulou et al., 2009; Mymrin et al., 2001; Pan et al., 2003; Detphan et al., (2009).

EXPERIMENTAL METHOD

Raw Materials. Kedah's soil, fly ash, sodium hydroxide and sodium silicate are materials that were used in this study.

Kedah's Soil. The evaluation were carried out on the soil recovered in Kedah which is residual laterite (IAEG, Commission on Engineering Geological Mapping, 1981). The amounts of oxides is high and the physical is reddish colour clayey soil. The soil composition of chemical was presented in Table 1. According BS classification this laterite soil can be classified as silt of high plasticity (MH) and the physical properties of this soil was showed in Table 2 (Marto et al., 2013). This type of soil is found ordinarily in tropical areas (Britis Standards Instituition, 1990). Before the soil comprehensively mix, it was sieved down by using 300 μm sieve after oven dried process was completed.

Table 1. Chemical composition of laterite soil in Kedah

Chemical composition (oxides)	Percentage (%)
Fe_2O_3	8.24
Al_2O_3	21.50
SiO_2	66.50

Table 2. Physical properties of laterite soil in Kedah

Properties	Percentage (%)
Liquid Limit	77
Plastic Limit	42
Plasticity Index	35
Sand	11
Silt	52
Clay	37
Optimum Moisture Content	35
Maximum Dry Density	1.3
Specific gravity	2.63

Fly Ash

The low calcium content of fly ash that collected from Manjung Power Station in Lumut, Perak was used in this assessment and it can be classified as class F fly ash. The chemical compositions of the fly ash, Hamzah et al., (2016) as found out by X-Ray Fluorescence (XRF) analysis was described in Table 3.

Table 3. Chemical composition of fly ash

Chemical composition	SiO_2	Al_2O_3	Fe_2O_3	CaO	P_2O_5	TiO_2	K_2O	MgO	Na_2O	SO_3
Percentage (%)	52.11	23.59	7.39	2.61	1.31	0.88	0.80	0.78	0.42	0.49

Sodium Hydroxide (NaOH)

Sodium hydroxide (NaOH) that supplied from the Formosa Plastic Corporation, Taiwan was used in producing geopolymer material as a liquid solution. The characteristics of NaOH are tabulated in Table 4.

Table 4. Characteristics of Sodium Hydroxide

Items	Specifications
Colour	White
Physical Form	Pellets
Water Solubility	100%
Purity	99%
Sodium Hydroxide Content	More than 99%
Molecular Weight	40 g/mol

Sodium Silicate (Na_2SiO_3)

Another ingredients that used for producing material of geopolymer is Sodium silicate (Na_2SiO_3) which acquired from the South Pacific Chemicals Industries which is located in Selangor, Malaysia. The characteristics of Na_2SiO_3 are shown in Table 5.

Table 5. The characteristics of Sodium Silicate liquid

Items	Specifications
SiO_2/Na_2O Ratio	3.2
Viscosity at 20°C	0.40 Pa·s
Sodium Oxide	9.4%
Silica	30.1%
Water (H_2O)	60.5%
Specific gravity at 20°C	1.40 g/cm^3
Molecular Weight	122.06 g/mol

Mixture Proportions and Mixing Process

There are three parameters affected in the design of soil stabilization by geopolymerization for this soil that was tabulated in Table 6. The parameter design is synthesized by probable experiments and errors to obtain optimum results for soil-based geopolymer compressive strength. The sample of stabilize soil with geopolymer was produced by mix together all the materials. Each samples that has been mixed consisted of laterite soil with a particular ratio of alkaline activator and fly ash based on the design parameters and then mixed by mixer to get homogeneous mixture and good workability. The mixture has been cast into a cylindrical mould and left to stand 24 hours before extrusion process. After extrusion, the plastic cover was used to wrap a soil samples for seven days for curing purposes at room temperature. The samples of soil based geopolymer were subjected to unconfined compressive strength test through a low testing speed that is 0.25mm/min. It is because of to reduce any impact of this parameter on the test outcomes.

Table 6. Design of geopolymer stabilized soil

Description	Design
Solid to Liquid Ratio	1.5 – 3.0
Sodium Silicate to Sodium Hydroxide Ratio	0.5 – 3.0
Molarity of Sodium Hydroxide Concentration	6M, 9M, 12M, 15M

RESULT AND DISCUSSION

The outcomes presented on Kedah's soil stabilization with geopolymer show significant enhancement in their load bearing capacity as represented in the increment of its compressive strength. The results of unconfined compressive strength on the seventh day were used as index of stabilized soil performance. The performance of Kedah's soil supported a means of assessing of the effects of the solid to liquid ratio, sodium silicate to sodium hydroxide ratio and concentration of sodium hydroxide molarity.

Solid to Liquid Ratio

Figure 1 presented results of compressive strength for different ratios of solid to liquid. The effects of different ratios were evaluated on the seventh day. The highest compressive strength of 5.58 Mpa were discovered at solid/liquid ratio of 3.0 which is 41.4% higher than solid/liquid ratio of 2.5. The solid/liquid ratio of 3.5 cannot be accomplished due to low workability of the geopolymer slurry as such difficult to compact during the moulding process (Yao et al., 2009; Kong et al., 2007). The compressive strength of the geopolymer soil stabilized for solid/liquid ratio of 1.5 is the lowest with 0.77 MPa. When low solid/liquid ratio was used, so the mixture was less solid content than the fluid medium. The connection between the reaction material and the activating solution is far and wide because of the large amount of liquid medium. The dissolution of alumina-silicate is considered passive. It goes on to explain why low compressive strength of soil stabilized based geopolymer with solid/liquid ratio of 1.5. On the other hand, when a higher solid to liquid ratio is used, solid content increases. The connection between the reaction materials and the activating solution were resulted improve thereby indicating an increase in compressive strength measured.

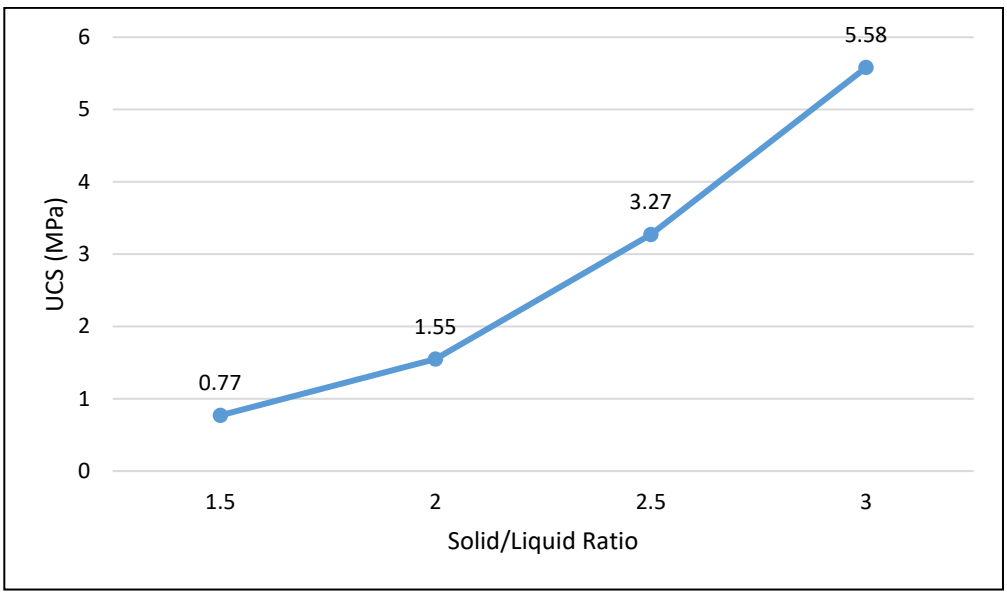

Figure 1. Compressive strength for different ratios of solid to liquid

Sodium Silicate to Sodium Hydroxide Ratio

Figure 2 showed the compressive strength of Kedah's soil stabilized by geopolymer with numerous Na_2SiO_3/NaOH ratios at constant solid to liquid ratio of 3 and constant 12M of NaOH. The optimum compressive strength was obtained at Na_2SiO_3/NaOH ratio of 2.5 with 5.58 MPa which is 0.9% higher than Na_2SiO_3/NaOH ratio of 3. The compressive strength will be increased as concentration of the activator solution and fly ash content were increased (Sathia et al., 2008; Hardjito et al., 2004). This is on account of the increment of sodium oxide content in a geopolymerization reaction that mainly required. The reduction of compressive strength at the ratio of sodium silicate 3.0, could be caused by the excessive hydroxide concentration in the mixtures. The process of polymerization can be disturbed when the exceeded sodium content of sodium carbonate is formed by the atmospheric carbonation (Barbosa et al., 1999).

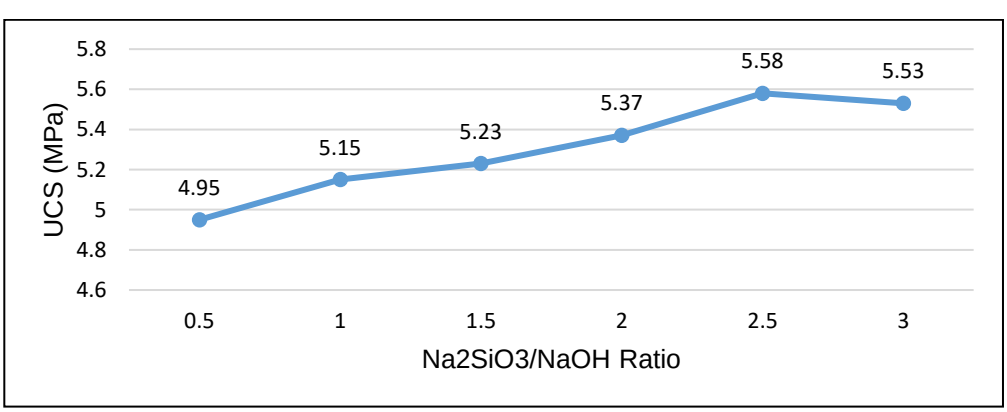

Figure 2. Compressive strength of Kedah's soil

Molarity of Sodium Hydroxide

The results of compressive strength for numerous concentration sodium hydroxide solution in terms of molarity are shown in Figure 3. It is recognized that the compressive strength of soil stabilized with geopolymer increases with increase in the solution concentration of sodium hydroxide. However, after 12 M concentration sodium hydroxide solution, the compressive strength of soil stabilized with geopolymer decreased due to lesser degree of geopolymerization that caused by the high viscosity hinders the leaching of the silica and alumina (Chindaprasirt et al., 2011). The optimum and highest compressive strength of Kedah's soil stabilized with geopolymer is 5.58 MPa at 12 M concentration of sodium hydroxide solution. This is the result of the increase in Na ions in the system used to compensate for charges and form alumina-silicate networks as binders in a mixture of geopolymerization processes. The lowest compressive strength was obtained at 6 M concentration of sodium hydroxide due to low of geopolymerization process which is low concentration at base as a consequence less leaching of alumina and silica from source of the material.

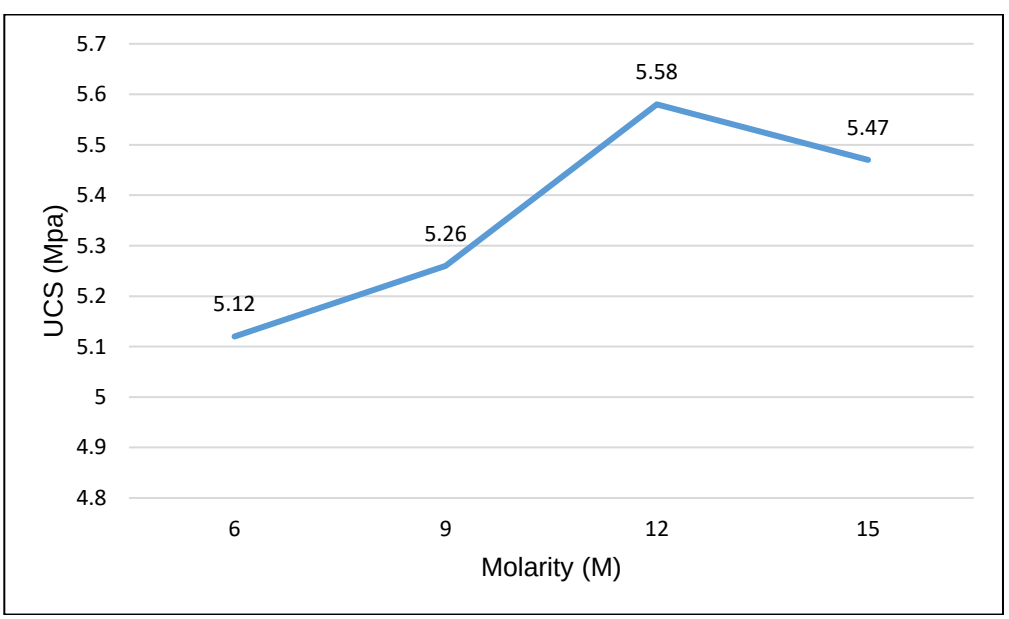

Figure 3. Results of compressive strength for numerous concentration sodium hydroxide

CONCLUSION

Experimental works have been carried out to study the effects of solid to liquid ratios, sodium silicate to sodium hydroxide ratios and molarity of sodium hydroxide on the unconfined compressive strength of Kedah's soil stabilized with geopolymer. All of the solid to liquid ratios, sodium silicate to sodium hydroxide ratios and molarity sodium hydroxide affected tremendously the compressive strength of the resulted soil stabilized by geopolymerization. The solid to liquid ratio of 3.0 contributed to the highest compressive strength of 5.58 MPa. When the ratio is increased then the compressive strength of the laterite soil stabilized by geopolymerization process also increases. The sodium silicate to sodium hydroxide ratio of 2.5 resulted the most value optimum compressive strength with 5.58 MPa

where the decreases of ratios tend to low strength due to excessive alkali content which retards the geopolymerization process. The higher sodium hydroxide molarity does not decide definitely the higher of compressive strength. The Kedah's soil stabilized with geopolymer with molarity concentration of 12 M showed the best results and optimum compressive strength with 5.58 MPa. Kedah's soil stabilized with geopolymer has an excellent properties due to the high compressive strength and geopolymerization technique is suitable for new technique and next generation soil stabilization.

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VENDOR SELECTION IN INDUSTRIALISED BUILDING SYSTEM (IBS) WITH TOPSIS UNDER FUZZY ENVIRONMENT

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Abstract
Industrialised Building System (IBS) has been a focus of research work in Construction Management area. However, little attention was given to the role of vendor selection for successful implementation of Malaysian IBS project. Due to the variety of vendors offering many services in the industry, there is a need to aid decision making for vendor selection for IBS project. Thus, this paper discussed the application of Multi Attribute Decision Making using Fuzzy TOPSIS for vendor selection in IBS project. We deploy a case study approach to investigate the scenario and demonstrate our analytical approach. The decision model was implemented and validated using a real IBS case project in Malaysia. The finding indicates an improvement of the decision making process and a comparable result with current practice for IBS vendor selection. The result yields an effective approach that is applicable to minimize time, risk and also lead to efficient supply chain management.

Keywords: *Industrialised Building System; Multi Attribute Decision Making; Fuzzy TOPSIS*

INTRODUCTION

Over the past decades, the construction Industry has contributed significantly to the Malaysian economy. As the nation progressively marches towards industrialization, the role of the building and infrastructure are greatly enhanced, with the idea of transforming the aspiration and needs of the people to turns into reality. There is an urgent need to mass-produce a quality housing that is affordable to all Malaysians. Thus, an innovative technology approach namely Industrialised Building System (IBS) has been introduced in Malaysia. The IBS represents the elements of industrialisation, prefabrication component, control environment and mass production of building component. Although there are some barriers in the implementation of IBS, the government is strategizing to capitalize the benefit IBS to enhance Malaysian construction industry. Table 1 illustrates the advantages of IBS for construction project.

In order to enhance the overall IBS process particularly the supply chain and purchasing, the availability of competent and quality vendors are essential. The evaluation and selection of vendor is the foundation of an effective decision process in purchasing (Rezaei, Naeeni, & Motlagh, 2013).There are many studies dedicated to effective purchasing vendor management in construction management that has been carried out in the past (Hartmann et al., 2012; Rezaei et al., 2013; van der Vaart & van Donk, 2008). Most of the previous studies indicate the importance of vendor selection approach for the construction project. Based on a case study in Iran, an effective decision making process in vendor selection is not only reducing cost of material, but also increase corporate competitiveness (Rezaei et al., 2013). The benefits for conducting a proper vendor selection evaluation are as follows;

- Increase profitability (Hartmann et al., 2012)
- Increase Quality (Hartmann et al., 2012; Monczka et al., 2009)
- Increase overall performance (van der Vaart & van Donk, 2008)
- Increase cooperative competitiveness (Othman & Rahman, 2010; Rezaei et al., 2013)

Table 1. Advantages of IBS

Authors	Advantages of IBS							
	Reduce labor	Reduce time	Productivity and quality	Reduce safety risk	Reducing project wastage	Low resources depletion	Low Environmental effect	Cost reduction
(CIDB, 2003)	✓	✓	✓		✓			✓
(Mydin et al., 2014)	✓	✓	✓		✓			
(López-Mesa et al., 2009)							✓	
(Ayağ & Özdemİr, 2007)				✓				
(Tam et al., 2007)					✓			
(Nawi, 2012)	✓	✓	✓					✓
(Jaillon et al., 2009)				✓	✓			✓
(Aye et al., 2012)						✓	✓	

The use of IBS in construction project is currently growing. Thus, this situation has led to an increasing numbers of IBS vendors in Malaysia. This situation has contributed to the complexities and dilemma in selection of the right vendor for IBS project.

VENDOR SELECTION

Vendor evaluation is the foundation of an effective decision process in purchasing (Rezaei et al., 2013). Vendor evaluation is identified as a complex decision making due to its nature (Vrijhoef & Koskela, 1999). For instance, supply chain in construction industry involves a wide range of component with different requirement based on variety of project (Mohd Nawi et al., 2014). On the other hand, other authors highlighted the involvement of large number of key participants such as client, consultant, contractor and vendors in one project has increased the complexities in construction vendor selection (Meng, 2012).

In a construction project, construction material occupies an essential part of construction value contributing almost 50% from overall cost. This percentage is higher in IBS construction project where the process depends on the prefabrication material (Tam et al., 2007). Any disturbance of supply chain relationship in IBS can led to major problems in construction such as project delay and overrun cost (Kamar & Hamid, 2011). In comparison with other fields, the needs of effective vendor selection is more critical in construction industry (Benton & Mchenry, 2009). According to Benton & Mchenry (2009), decision making process in vendor selection has been considered as a foundation for the success or failure of a project. Safa et al. (2014) asserted that the issue of selecting the right vendor is a difficult task in construction industry due to the different set of criteria. With the growing number of vendors in the market will essentially increase the complexity of a critical decision making to appoint the right vendor for the right project. Vendor selection problem is an example of a classical Multi Attribute Decision Making (MADM). Hence, analytical decision making is needed to assess the vendor capability for the IBS project.

MADM IN VENDOR SELECTION

MADM has been defined as a decision making technique that allows decision maker to determine the best alternative through evaluation and comparison process between the alternative (Alias et al., 2008; Yang & Tzeng, 2011). Research has shown an extensive evidences of implementation of MADM as a solution for vendor selection problem in various of fields such as manufacturing (Orji & Wei, 2014), communication (Önüt et al., 2009), electronic (Gencer & Gürpinar, 2007), textile (Yücel & Güneri, 2011), automobile (Haldar et al., 2012), and including construction field (Schramm & Morais, 2012). MADM was also widely implemented in construction problems(Omar et al., 2009). For example, an implemented AHP for a real case of construction company in Turkey and presented with sensitive analysis to select the best vendor (Bayazit et al., 2006). Other authors has developed an integrated construction material management model by development of virtual inventory management, feasible material management network and a vendor selection process (Safa et al., 2014). Vendor selection process in their model was developed based on TOPSIS and demonstrated with real construction project. Schramm and Morais (2012) have proposed a new decision support model that based on SMARTER method for civil construction company in Brazil. This model has been applied to real construction project and has been proven capable to encourage a high collaboration among project stakeholders. These studies suggest that MADM is an effective tool for vendor selection type of problem in construction field. However, in literature there is limited study attempt to thoroughly investigate decision process to select the right vendor in IBS construction project(Omar et al., 2016). Thus, due to the absent of decision technique, it is desirable for the industry to develop an effective decision technique for IBS vendor selection.

Fuzzy Topsis

There are several MADM method that has been widely discussed in the literature such as Weight Product Method (WPM), Elimination Et Choice Translating Reality (ELECTRE I, II, III and IV), Analytical Hierarchy Process (AHP), Analytical Network Process (ANP) and The Technique for Order Preference by Similarity to an Ideal Solution (TOPSIS) (Nursal et al., 2015b; Omar et al., 2014; Sulaiman et al., 2016; Sulaiman et al., 2015). Each of these techniques has their own advantages based on problem nature. In our approach, TOPSIS has been chosen as analytical technique for vendor selection due to its advantages of assessing a set of finite alternatives and the nature of the problem (Nursal et al., 2014, 2016b; Omar, et al., 2016).

TOPSIS has been proposed by Hwang and Yoon (1981), to determine the alternative that is closest to ideal solution. The basic concept of TOPSIS is to choose the alternative that has the shortest distance from positive ideal solution (PIS) and the farthest from the negative ideal solution (NIS). MADM method such as TOPSIS is considered as an effective method in solving selection problem. However, in order to represent a real-world scenario, MADM has been critics due to the involvement of crisp data (Nursal et al., 2015a). Under many circumstances, crisp data are inadequate to model real life situation (Chen, 2000). Human judgment in decision process is always resulted in vagueness and uncertainty (Nursal et al., 2016). Through the TOPSIS process, it caused a difficulty for the decision makers to give exact numerical values for weighting and rating assessment.

In order to overcome this problem, Zadeh (1997), has develop fuzzy set theory with linguistic variables by providing a constructive and effective evaluation process. In this paper, our model is develop based on the extension of TOPSIS method with fuzzy numbers proposed by Chen (2000). Basically the "selection" problem in MADM consists of p alternatives $A_1, A_2, A_3, \dots A_P$ and q criteria $CR_1, CR_2, CR_3, \dots CR_q$. Each of alternatives will take a consideration with respect to criterion q. The rating of criteria and weight with respect to each criterion can be accurately represented in the form of matrices such as

Fuzzy Decision Matrix, $D = \left(x_{ij}\right)_{p\times q}$ (1.1)

Fuzzy weight Matrix, $W = \left(w_1, w_2, \dots w_q\right)$ (1.2)

Where $x_{ij}(i = 1, \dots, p; j = 1, \dots., q)$ and $w_{j=}(j = 1, \dots., q)$.

Fuzzy TOPSIS is executed by using the following steps:

Step 1:

Construct a fuzzy weight matrix, W and fuzzy decision matrix, D where x_{ij} and w_j are linguistic variables that can be shown by triangular fuzzy number as the followings:

$$X_{ij} = \left(a_{ij}, b_{ij}, c_{ij}\right) \quad (1.3)$$

$$w_j = \left(w_{j1}, w_{j2}, w_{j3}\right) \quad (1.4)$$

Step 2:

Perform normalized fuzzy decision matrix. Linear scale transformation is used to transform into comparable scale. The normalization approach preserves the property that range from [0,1] in normalized triangular fuzzy numbers. It is noted by

$$\widetilde{R} = \left[\tilde{r}_{p\times q}\right] \quad (1.5)$$

Where B and C are the set of benefit attributes and cost attributes, respectively and

$$\tilde{r}_{ij} = \left[\frac{a_{ij}}{c_j^+}, \frac{b_{ij}}{c_j^+}, \frac{c_{ij}}{c_j^+}, \right], j \in B; \quad (1.6)$$

$$\tilde{r}_{ij} = \left[\frac{a_j^-}{c_{ij}}, \frac{a_j^-}{b_{ij}}, \frac{a_j^-}{a}\right], j \in C; \quad (1.7)$$

$$c_j^+ = \max_i c_{ij}, j \in B; \quad (1.8)$$

$$a_j^- = \min_i a_{ij}, \text{if } j \in C; \quad (1.9)$$

Step 3: Construct weight normalized fuzzy decision matrix, $\tilde{V}$

$$\tilde{V} = \left[\widetilde{V_{ij}}\right]_{p\times q} \quad (2.0)$$

Where $\tilde{v}_{ij} = \tilde{r}_{ij}(.)w_j$

Step 4:

This step attempts to determined distance measurement between the Fuzzy Positive Ideal Solution (FPIS), A^+ and Fuzzy Negative Ideal Solution (FNIS), A^-. Having $\tilde{V}$ as a normalized positive triangular fuzzy that ranges from 0 to 1, we can easily group the member as follows;

$$A^+ = \left(\tilde{v}_1^+, \tilde{v}_2^+, \ldots \tilde{v}_q^+\right) \quad (2.1)$$

$$A^- = \left(\tilde{v}_1^-, \tilde{v}_2^-, \ldots \tilde{v}_q^-\right) \quad (2.2)$$

Where $\tilde{v}_j^+$= (1.0, 1.0, 1.0) and $\tilde{v}_j^-$= (0.0, 0.0, 0.0). Thus, the distance measurement can be obtained by using the following equation;

$$d_i^+ = \sum_{j=1}^{q} d\left(\tilde{v}_{ij}, \tilde{v}_j^+\right), \forall i = 1,2, \ldots\ldots, p \quad (2.3)$$

$$d_i^- = \sum_{j=1}^{q} d\left(\tilde{v}_{ij}, \tilde{v}_j^-\right), \forall i = 1,2, \ldots\ldots, p \quad (2.4)$$

Step 5

Calculated relative closeness coefficient. Choose an alternative with the maximum CC_i or rank alternatives to CC_i in descending order based on the following expression;

$$CC_i = \frac{d_i^-}{(d_i^+ + d_i^-)}, \forall i = 1,2, \ldots\ldots, p \quad (2.5)$$

APPLICATION OF FUZZY TOPSIS IN IBS VENDOR SELECTION

A semi structured interview with IBS officer from Malaysia IBS Center has been carried out. Our finding indicates that there is no available decision support tool for IBS vendor selection. Most of the contractors incline to depend on the recommendation from IBS center or other construction company. From the document analysis, it shows that until January 2016 there were 205 registered IBS vendor available in Malaysia as illustrate in figure 1.

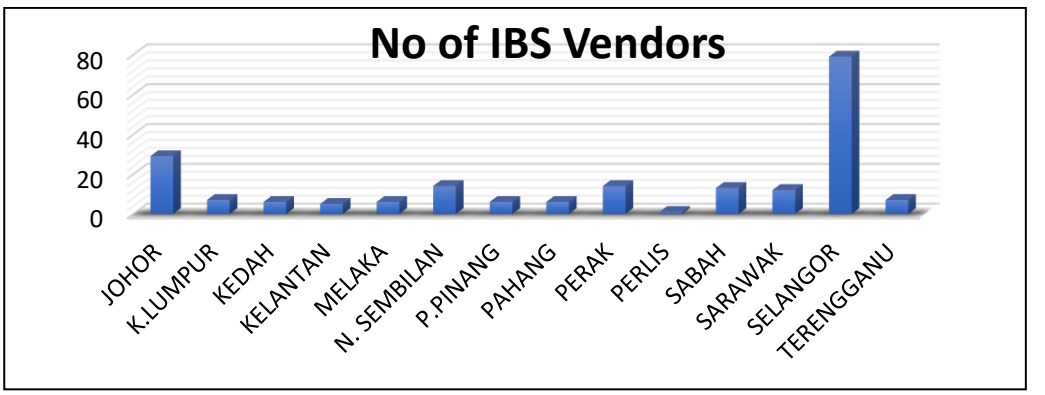

Figure 1. Number of IBS vendors in Malaysian states.

This highlight the needs of decision aid for IBS vendor selection. To demonstrate our Fuzzy TOPSIS approach, we select a real IBS case project located at Penang, Malaysia. The case project was selected based the following judgement i.e. (1) The case project is a government IBS project, and (2) The case project is a completed project (2015-2017). For data collection purposes, a semi structured interviews have been conducted with Decision Makers (DM) namely DM1, DM2, and DM3. They possess vast experience in conventional / IBS project and also involved in the vendor selection process for this project. Table 1 below describes the DMs profile.

Table 1. Decision Makers Profile

Decision Makers	Position	Experiences (Years)	Number of IBS project involved
DM1	Contractor	16	2
DM2	Project Engineer	13	2
DM3	Project Manager	20	2

A set criteria of vendor selection were gathered and filtered from literature to develop the questionnaire (Nursal et al., 2016a). During the interview session, DMs were asked to select set of criteria from the literature or new/additional criteria that are relevant to take into consideration (Nursal et al., 2016a). Table 2 illustrates the selection of criteria from the DMs. In Table 3, the operational definition for each criterion and its coding (label) are described.

Table 2. IBS Vendor Selection Criteria

Criteria Categories	Sub Criteria	Lebel	DM 1	DM 2	DM 3
Cost	Cost effectiveness	C1	✓	✓	✓
	Term of Payment	C2	✓	✓	✓
Quality	Certification	Q3	✓		
	Warranty	Q4	✓	✓	✓
	Product quality	Q5	✓	✓	✓
Delivery	Delivery	D1	✓	✓	✓
	Time flexibility	D2	✓		
	The level of information sharing	D3	✓	✓	✓
Financial	Vendor Financial	F1	✓		✓
	Situation of assets and liabilities	F2	✓	✓	
Capability	Design	A1	✓	✓	✓
	Problem treatment	A2		✓	✓

Criteria Categories	Sub Criteria	Lebel	DM 1	DM 2	DM 3
Organisation background	Vendor reputation	O1	✓	✓	✓
	Business references	O2		✓	✓
	Trust	O3		✓	✓
Additional criteria	Mobility	A3	✓	✓	✓

Table 3. Description of Selection Criteria

Criteria	Label	Descriptions
Cost effectiveness	C1	Cost effectiveness refers to the effectiveness of expenses required for IBS project component proposed by vendor. It is included logistic cost, product cost and etc.
Term of Payment	C2	Term of payment refer to payment Procedure agreement between vendor and contractor.
Certification	Q3	Vendor must require all certificated and been acknowledged by Malaysia CIDB as IBS vendor
Warranty	Q4	Warranty of IBS component by vendor
Quality	Q5	Quality of IBS component by vendor
Delivery	D1	Delivery refers to the delivery accuracy of IBS product according to project timetable.
Time flexibility	D2	This is related to the changes the construction company needs to make in its order system as far as delivery time is concerned
The level of information sharing	D3	Level of information sharing between vendor and other project stakeholders.
Vendor Financial	F1	This sub criterion refers to vendor financial background.
Situation of Assets and liabilities	F2	This sub criterion refers to vendor assets and liabilities.
Design	A1	The availability of innovative design of IBS product among vendor.
Problem treatment	A2	The initial plan, ability and response of vendor Towards solving and dealing project problems.
Mobility	A3	The ability of vendor in term of mobility. For example, set up a temporary IBS factory closes to project site.
Vendor reputation	O1	The reputation of Vendor in term of vendor performance particularly in previous project in Malaysia construction industry.
Business references	O2	References from previous client of vendor previous project.
Trust	O3	The level of trust and confident towards vendor

In this case project, three vendor candidates are considered as the potential alternatives. Table 4 summaries the list of alternatives for the project.

Table 4. Vendor's Profile

Vendor	Profile
Vendor 1 (V1)	The Company has been established in 2007. The company provide specialist precast services and product. Its core expertise is in the design and builds IBS superstructure and also manufacturing of precast Segmental Box Girlder (SBG), tunnel lining segment and special structures. The company has vast experience in government project and has involved in more than 50 IBS project.
Vendor 2 (V2)	Vendor 2 is Malaysian Bumiputra company. As established to undertake design, I.B.S Consultations and I.B.S vendor and install of pre-cast concrete building components. Board members of the Company possess the required experience in the execution of any construction works to be carried out in the form of IBS. Each member is specialized in the respective scope of works involved in pre-cast system construction. Number of completed project is 28 and the current project is 12 in private and government project.
Vendor 3 (V3)	The company is a wholly owned Malaysian Bumiputera. The company was established in year 2009 with expertise in manufacturing of precast concrete products to respond to the government initiative through the implementation and expansion of IBS construction systems. The company core business is construction and engineering works where we are among the companies

providing Industrialised Building System (IBS) supply chain linked contractor and manufacturer in Malaysia. The IBS factory is located on 4 acres of land in Nilai 3, Seremban, Negeri Sembilan. The company has involved in 15 of IBS government project since 2009. The company product System is a revolution as it offers better building solution in meeting today's construction industry. Part of IBS features of IBS product as follows,

- Fabrication concept of IBS, which is easy and quick,
- Uses metal moulds as a prefabricated mould.
- Have uniform element sizes in respect to columns, beams, slab / floor etc.
- Factory production standards of high quality.
- Saves the management the cost of labour and machinery / equipment.

The above table shows that the vendors possess a comparable professional capability and experience in Malaysian IBS project. Two of the vendors are Bumiputra (Malaysian with indigenous Malay origin). Figure 2 illustrates a decision hierarchy based on the opinion from the DMs.

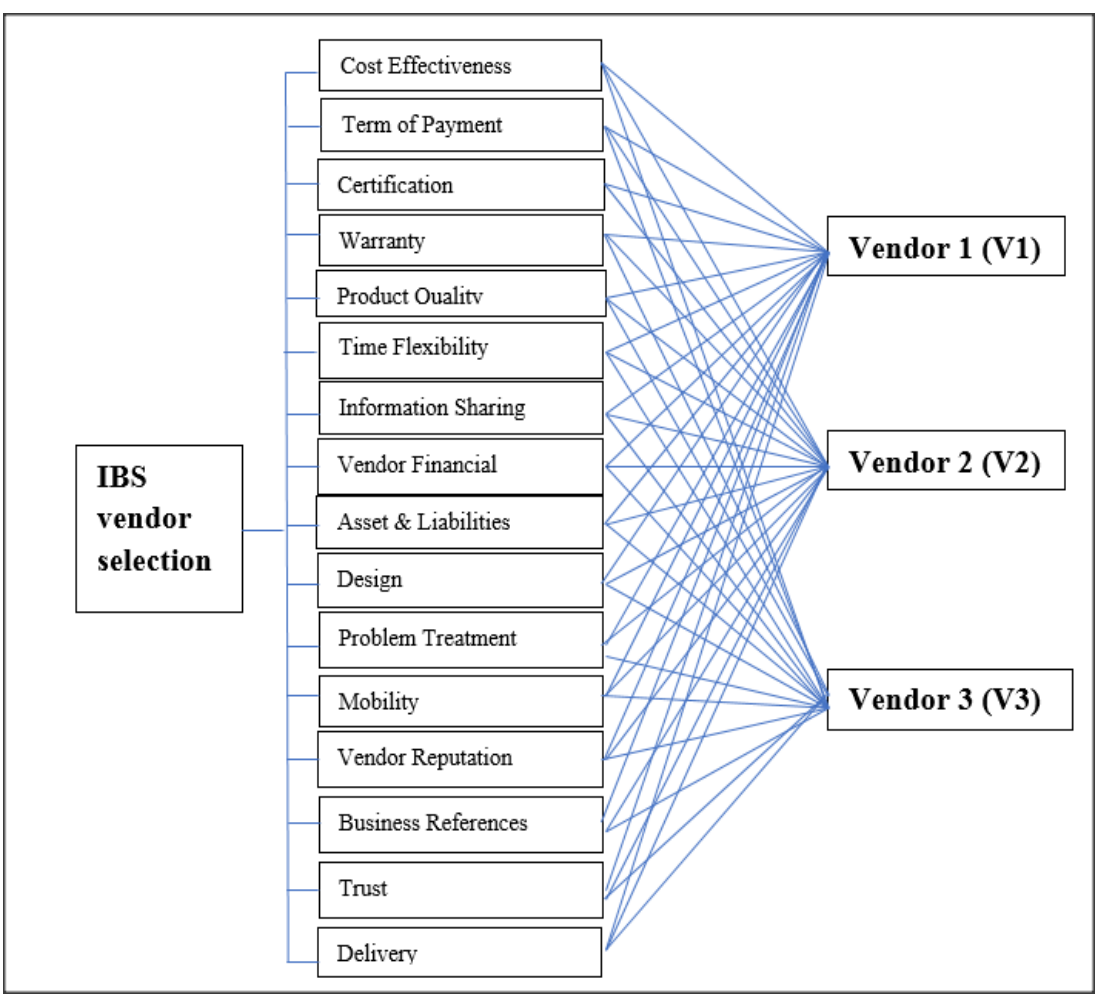

Figure 2. IBS decision hierarchy

Then, the DMs were required to set the weight and rating assessment in the fuzzy TOPSIS instruments using the linguistic scale as proposed by Chen (2000) (See Table 5). Weighting and rating result are shown in Table 5 and Table 6.

Table 5. Weight and rating scale based on Fuzzy Linguistic Variables

Weight		Rating	
Linguistic variables	**Fuzzy Number**	**Linguistic variables**	**Fuzzy Number**
Very Low	(0,0,0.1)	Very Poor	(0, 0, 1)
Low	(0,0.1,03)	Poor	(0, 1, 3)
Medium Low	(0.1, 0.3, 0.5)	Medium Poor	(1, 3, 5)
Medium	(0.3, 0.5, 0.7)	Fair	(3, 5, 7)
Medium High	(0.5, 0.7, 0.9)	Medium Good	(5, 7, 9)
High	(0.7, 0.9, 1.0)	Good	(7, 9, 10)
Very High	(0.9, 1.0, 1.0)	Very Good	(9, 10, 10)

Table 6. Weight of Criteria

Criteria	Linguistic variable		
	DM1	**DM2**	**DM3**
Cost Effectiveness	VH	VH	VH
Term of Payment	VH	VH	VH
Certification	H	-	-
Warranty	VH	H	VH
Product quality	VH	VH	VH
Delivery	VH	H	MH
Time flexibility	MH	-	-
The level of information sharing	ML	MH	MH
Vendor Financial	M	-	H
Situation of assets and liabilities	VL	MH	-
Design	VH	VH	VH
Problem treatment	-	VH	VH
Mobility	VH	VH	VH
Vendor reputation	VH	H	H
Business references	-	H	MH
Trust	-	MH	MH

Table 7. Rating of alternative

Criteria	Vendor alternatives	Rating		
		DM 1	**DM 2**	**DM 3**
Cost Effectiveness	1	VG	VG	VG
	2	G	G	G
	3	F	F	MG
Term of Payment	1	MG	G	MG
	2	MG	MG	MG
	3	MG	MG	MG
Certification	1	G	G	-
	2	MG	G	-
	3	G	G	-
Warranty	1	G	G	G
	2	F	MG	G
	3	G	MG	G
Product quality	1	G	G	G
	2	G	G	G
	3	G	G	G
Delivery	1	VG	G	VG
	2	MG	MG	MG
	3	G	MG	G

Criteria	Vendor alternatives	Rating		
		DM 1	DM 2	DM 3
Time flexibility	1	G	-	-
	2	G	-	-
	3	G	-	-
The level of information sharing	1	VG	VG	G
	2	MP	F	G
	3	G	G	MG
Vendor Financial	1	F	-	MG
	2	F	-	MG
	3	F	-	G
Situation of assets and liabilities	1	G	G	-
	2	MG	G	-
	3	MG	G	-
Design	1	VG	VG	VG
	2	MG	MG	G
	3	VG	VG	G
Problem treatment	1	-	G	G
	2	-	MG	G
	3	-	G	VG
Mobility	1	VG	G	G
	2	F	F	F
	3	F	F	F
Vendor reputation	1	VG	G	G
	2	G	G	MG
	3	VG	VG	G
Business references	1	-	G	G
	2	-	G	G
	3	-	G	G
Trust	1	-	G	G
	2	-	G	MG
	3	-	G	G

The opinion of DMs are taken into account as part of decision model computation to rate each vendors based on fuzzy TOPSIS. The results of closeness coefficient and group aggregation are shown in Table 8 and Table 9 respectively. The group aggregation result shows that; Vendor V1>V3>V2. The result yield that V1 as the best vendor for this case project.

Table 8. Result for Each Decision Makers

Vendor	DM 1		DM 2		DM 3	
	cc	Rank	cc	Rank	cc	Rank
V1	0.6811	2	0.7948	1	0.7646	1
V2	0.5267	3	0.6686	3	0.69596	3
V3	0.6836	1	0.7863	2	0.76280	2

Table 9. Final Result of IBS Vendor Selection

Vendor	DM 1	DM 2	DM3	Group cc	Group Rank
	cc for each DMs				
V1	0.681	0.7948	0.7646	0.74686	1
V2	0.527	0.6686	0.6959	0.63047	3
V3	0.683	0.78633	0.76280	0.74426	2

EVALUATION OF PROPOSE DECISION MODEL

The purposes the decision model development is not for predicting value or replacing human judgment for making decision. The main objective of the model is to structure the decision-making process and assist decision makers. Thus, in order to fulfil the objective and to ensure the decision model quality by providing an effective decision, the proposed decision model needs to be validated. Thus, we compare the current practice (without any decision tool) and the proposed decision model. The DMs were asked to rank the vendor based on their judgement. Thus, in order to determine its weight, Rank Order Centroid (ROC) has been utilized. Table 10 demonstrates the DMs result without decision model and with decision model.

Table 10. Result Comparison

Decision Approach	Software	Group ROC	Group Rank
Without Decision Model	V1	0.5	1
	V2	0.11	3
	V3	0.39	2
	Software	**Group Cc value**	**Group Rank**
Decision Model	V1	0.744	1
	V2	0.629	3
	V3	0.743	2

The comparison table shows that decision model yields similar result compare to the current practice. It was vendor V1 that has been rewarded as vendor in this case project. Therefore, it shows that the decision model can be considered as a comparable tool with human judgement. Second validation process is performed using sensitive analysis. Sensitive analysis is deployed to verify the weaknesses of the final result. Performing sensitivity analysis is very important for practical decision making, sometimes it is regarded as an important tool to find the best solution. Sensitivity analysis is performed by gradually changing some parameter such as the weight of criteria in decision model. In the case project, criteria such as cost effectiveness, term of payment, product quality, design and mobility has been considered as very high (VH) among the DMs. Thus, to evaluate the result in what-if scenario, the weights of these criteria are changed descending from very high (VH) to very low (VL).

Table 11. Sensitivity Analysis

Vendor	Situation 1	Situation 2	Situation 3	Situation 4	Situation 5
	Closeness coefficient				
V1	0.835	0.667	0.628	0.606	0.603
V2	0.716	0.550	0.523	0.483	0.520
V3	0.789	0.663	0.621	0.598	0.631

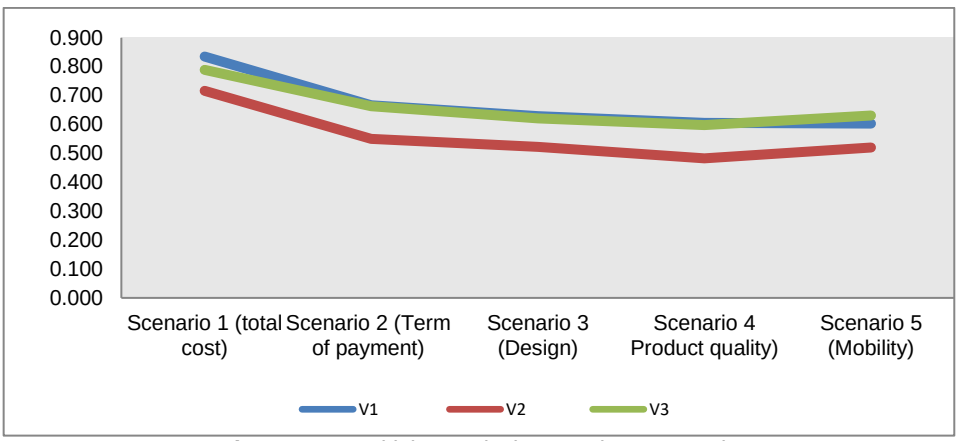

Figure 3. Sensitivity Analysis Based on Scenario

The result shows that Vendor 1 outperforms other vendors where most decision from DMs score with higher Closeness Coefficient, CC value under hypothetical change in the priorities of the four main criteria.

CONCLUSION

IBS has become prevalent especially in government construction project. Competition to offer services in supply chain is becoming competitive with the support from the government where incentives were given to boost the construction industry. Hence, contractors or developers are facing a market with an array of alternatives from the IBS vendors. High number of IBS vendors offers different design of IBS product with a variable cost. Moreover, the selection of the right vendor for IBS project is the most important factor to ensure successful project. It is identified that the decision making process and tools available in this problem are often overlooked. Thus, this research developed a decision model using Fuzzy TOPSIS to cater the IBS vendor selection problem. We demonstrate our approach with a real case project. A total of 16 criteria has been selected as follows; Cost Effectiveness, Term of Payment, Certification, Warranty, Product Quality, Delivery, Time flexibility, the Level of Information Sharing, Vendor Financial, Situation of Assets and Liabilities, Design, Problem Treatment, Vendor Reputation, Business References, Trust, and Mobility. Mobility is an additional new criteria suggested by a decision maker. These criteria were used in our decision hierarchy for IBS vendor selection among contractor and construction companies. This paper also demonstrates the validation process through comparison of results between current practice and our proposed decision model. Second validation is using the sensitivity analysis method. The analysis was performed by changing the weight of some important criteria. Based on the validation, reflection and feedback from decision makers, our decision model shows a potential to provide a more structured decision making process, quality decision making, transparent and reliable decision outcomes.

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THE USE OF SUPPLY CHAIN MANAGEMENT TO OVERCOME LOW LABOUR PRODUCTIVITY ISSUES IN THE TENTH MALAYSIA PLAN PUBLIC SECTOR PROJECTS

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Abstract
Low labour productivity is a critical problem for Malaysia Plan implementations including the Tenth Malaysia Plan. These poor performances could be tracked back on the inefficient traditional practices that have been dominating the local construction industry for decades. This paper presents part of a Ph.D. research aimed at developing a validated framework that utilizes beneficial Supply Chain Management (SCM) tools to improve the low labour productivity issues that have hit the Tenth Malaysia Plan public sector projects. The potential of SCM to overcome labour productivity issues has been proven and that it has been supported as the way forward for the construction industry deficiencies. Encouraged by the proven success in few implementations such as in the UK, there is a cautious optimism that it could prove successful should it be implemented in Malaysia. This paper considers low labour productivity as a problem during the Tenth Malaysia Plan, establishes the need to embrace SCM and proposes a theoretical framework for successful SCM implementation to succeed the endeavour of improving labour productivity. A literature review, research approach and mechanism is elaborated in this paper as well as the important contributions it can make in term of enriching the existing body of knowledge. The final research framework will tackle labour productivity issues by utilizing beneficial SCM tools to address distinctive root cause / factors affecting low labour productivity.

Keywords: *Construction Industry; Labour Productivity; Malaysia; Public Sector; Supply Chain Management; Tenth Malaysia Plan*

INTRODUCTION

Construction industry stands among the main sectors in Malaysia. Not only does the sector contribute directly to the GDP, socio-economic growth and job creation, but it also affect other industry whether directly or indirectly thus the performance of the sector as a whole pose serious chain reaction to other industries that rely on it. Looking at past statistics, Malaysian construction industry is obviously a massive sector in term of economic activity (Ibrahim et al., 2010; CIDB, 2012) however, their performance have been diverting off-track with inefficiencies being rather a normal sighting, one of which is the low level of labour productivity, which has led to among others a major delay phenomenon in few Malaysia Plan implementations – 78% delay rate during the Eight Malaysia Plan (Abd. Karim, 2008), 80% delay rate towards the end of Ninth Malaysia Plan (Joshi, 2009) and even the latest ending Malaysia Plan which is the tenth badly failed to meet its "Zero Delay" ambitions being hit with hundreds of sick project (Nurul et al., 2016).

Project delay has a strong connection with poor labour productivity (Yi & Chan, 2013) and in fact, labour constitutes to up to 50% labour cost (Rivas et al., 2010) as well as up to 50% efficiency (Thomas & Napolitan, 1995). These reasoning have therefore motivated the

path of this research and the Tenth Malaysia Plan was chosen as the main focus area as part of an initiative towards improving the performance of future government's Malaysia Plan implementations. Looking at the poor labour productivity statistics (refer Figure 1 and 2) and the incessant delay dilemmas hitting the Tenth Malaysia Plan implementations support the need for research on the contributors and possible solutions.

The research described in this paper presents part of a an on-going Ph.D. research which ultimately aims to develop a validated Supply Chain Management (SCM) framework to overcome low labour productivity issues in Tenth Malaysia Plan public sector projects. Past research supports the ability of SCM to improve productivity in construction and that many "calls for improvement" worldwide have supported SCM as the way forward for the industry. Few applications have also proved successful (Brady et al., 2006; Potts, 2009) leading to a positive anticipation that the labour productivity issues in public sector projects could be improved should SCM be infused in the local practices.

OVERVIEW OF MALAYSIAN CONSTRUCTION INDUSTRY AND ITS DILEMMA

Following the independence in 1957, Malaysian construction industry has started to make progress towards generating wealth, economic development and uplifting lifestyle of citizens, and these initiatives were manifested via a number of initiatives such as inaugural economic plans, Master Plans, Transformation plans, etc.. Being an industry, which contributes mostly to the capital formation of the country (Lewis, 1955), it has a multiplier effect on the growth of other industries (CIMP, 2007) for example when a project is initiated, automatically other industries such as the manufacturing will start to benefit from it such to manufacture the construction material and tools. Other industries such as the transportation would gain from getting jobs to transport materials to site while and obvious result of these scenarios are that many people would gain in term of job creation which subsequently affects the quality of lifestyle of the people. Beyond that, many other benefits are attainable, but these represents only a fraction to be mentioned; which is why when economic downturn hits a nation, one of the sectors that will start to get focused is the construction industry. In fact, Ibrahim et al. (2010) assumed that a 2.5% increase in national GDP is possible for every 10% increase in construction productivity.

Statistics and history has proven that the Malaysia construction industry is not showing any signs of slowing down. Outputs have been phenomenal with Budget Report (2006) reporting values of RM7.248 Billion, RM7.168 Billion and approximately RM7.35 Billion for years 2004, 2005 and 2006 (Ibrahim et al., 2010) while value of awarded projects were also vast with an increase from RM88.6 Billion in 2010 to RM94.1 Billion in 2011 - the later year recording rather a balanced allocation among residential, non-residential and infrastructure projects although residential projects were slightly less by about 20% to 30% at RM23.5 Billion (CIDB, 2012). Beyond that, the Malaysia initiative have also been stressed via a number of high profile projects such as the Kuala Lumpur International Airport 1 & 2 (KLIA 1 & KLIA 2), PETRONAS Twin Tower, Sepang F1 Track, Putrajaya & Cyberjaya Development, etc. all of which proving just how much the nation is serious to become a developed nation by 2050.

Nevertheless, despite its obvious importance, the Malaysian construction industry has remained synonymous with criticism partly due to the dilemma of its inefficient practices some of which as reported by the CIMP (2007) including duplication of work, lengthy approvals, inefficient time and cost management, and also the lack of transparency. Further saddening news was that even the Director General of the Public Works Department Malaysia did label the industry as lagging way behind, being in the 1960's (Zaini, 2000). Findings in a study by the Standard and Industrial Research Institute of Malaysia (SIRIM) in 2002, also found that the Malaysian building and construction material standards as well as the building and civil engineering standards are yet compatible with those of international ones (Zolkafli et al., 2009). As a result, these inefficiencies have badly hit the economic perspective of the nation with GDP contributions kept slumping from year 1995 to 2007. Reports by Ibrahim et al. (2000) found that the GDP contributions has dropped by almost a third in about 10 years - from 17.3% in 1995 to an average of 5.2% between 1999 to 2004. The following few years also was not any better with records by CIMP (2007) showing that the average input of the sector to GDP was only at an average of 3%. These signify a need for a major shift in the way the nation undertakes and manages the construction industry undertakings.

WHAT IS MALAYSIA PLAN?

Despite national development strategies initiating as early as before independence (i.e. 1956), focus was initially made for the twelve states within the Peninsular Malaysia which excluded Sabah and Sarawak. These were the first two five-yearly economic plans (i.e. 1956 to 1960 and 1961 to 1965 respectively). It was after these two economic plans that the "Malaysia Plan" emerged, covering all fourteen states in Malaysian (including Sabah and Sarawak), with each having different ambition and targets, depending on the need of each period of time, all of which were a well scheduled and planned program, with the ultimately mission of achieving a developed nation status by 2020, although recent target have changed to 2050 as the new target for the nation. These Malaysia Plans were inaugural five-yearly plans, initiated in 1966 with the First Malaysia Plan (1966 to 1970), all of which had pre-specified budget allocated for both nationwide and state-level development respectively. These Malaysia Plans had since taken place consistently every five years up to the recent one which is the Eleventh Malaysia Plan (2016 to 2020).

TENTH (10^{TH}) AND ELEVENTH (11^{TH}) MALAYSIA PLAN

The Tenth Malaysia Plan which took place from 2011 to 2015 carried out the Government Transformation and Economic Program (ETP) which was launched on 25th September 2010 towards steering the nation to a developed nation and a high-income status by 2020. The National Transformation Program (ETP) targets for 2020 were strategized to be achieved via twelve National Key Economic Areas (NKEAs), while six Strategic Reform Initiative (SRIs) were also placed in form of policies to drive the nation's global competitiveness (ETP, 2010).

The Tenth Malaysia Plan holds on five primary approaches to boost the nation's economy and quality standards namely to raise the standard of nation economy, increase knowledge, skill and innovation, promote first-world minded, manage constantly socioeconomic imbalance; enhance level of living quality and stiffen the organisation and nation's execution (Tenth Malaysia Plan, 2010). As for the construction sector in specific, the Tenth Malaysia Plan went all out by targeting "Zero Delay" in public construction project implementation

thus focus was stressed out on the need of an effective project management and supervision which should be carried out by a certified project manager (Abu Mansor, 2010).

On the other hand, the Eleventh Malaysia Plan built upon a major needed aspect of the previous Malaysia Plan which was to dramatically increase labour productivity. Realizing the importance of labour productivity growth on economic progression thus; the plan targeted to propel towards 3.7% productivity growth which is more than double the achievements of 1.8% in the Tenth Malaysia Plan (Malaysia Productivity Corporation, 2016).

LABOUR PRODUCTIVITY

Productivity greatly affects execution plans of organizations of any nature regardless of their size (Kazaz & Ulubeyli, 2007). In laymen term, productivity can be generally defined as the ratio of input to output, whereby the larger the output per unit of input, the better the productivity is. In the context of construction industry, labour productivity measures the output per hour of labour input (Son & Rojas, 2010). The great importance of labour productivity on construction performance has invited a number of researches in the past to have an insight into this topic (Ifedili, 2013; Agwu, 2014) and despite numerous problems surrounding the construction industry, labour productivity issues have remained very critical (Soham & Rajiv, 2013).

Labour productivity is among if not the most important building blocks of a successful project. This is due to the fact that costs of labour makes up to approximately 20% to 50% of the project cost (Rivas et al., 2010) and that it significantly affects the three main objectives / golden triangle of a project which is cost, time and quality (Yi & Chan, 2013) which could cause losses in efficiency up to 50% (Thomas & Napolitan, 1995). Despite advancements in mechanization and contemporary construction methods, the industry still remain labour-intensive (Rivas et al., 2010) and that the productivity of a projects depends on the productivity of labour (Gundecha, 2013) therefore, it remains a critical criteria of a successful project (Gerges et al., 2011). Beyond merely waste in financial resources, low labour productivity could also lead to a variety of other project deficiencies such as delays due to extra time needed to complete tasks, poor workmanship due to incompetence, poor client satisfaction due to inability to meet certain objectives and many more.

LABOUR PRODUCTIVITY ISSUES IN MALAYSIA

Low labour productivity is a global issue. Its significance and the importance to identify the factors affecting low labour productivity has also been highlighted in the past (Rivas et al., 2010) while initiatives has also took place to look deeply into this matter for example Alaghbari et al. (2017) did a study in Yemen, Kaming et al. (1997) interrogated the Indonesia perspective while Jarkas & Bitar (2011) looked into Kuwait. Within Malaysia, studies have been rather scarce even though there have been records of past studies, one of which was by Abdul Kadeer et al. (2005) whom looked into the factors affecting labour productivity in Malaysian residential project and found that the five most important factors were: material shortage at site; non-payment to suppliers causing the stoppage of material delivery to site; change order by consultants; late issuance of construction drawing by consultants; and incapability of contractors' site management to organise site activities. Another study was by Manoharan, (2017) who looked into the principal factors impacting labour productivity in

Malaysian construction industry with particular focus made specifically on non-residential projects around Klang Valley, whereby he concluded that the five factors negatively affecting labour productivity were: equipment and material shortage, poor site management, lack of experience, misunderstanding among labour and superintendent and problems related to drawing and specification.

In term of statistics, the Malaysian construction industry also failed miserably when compared to other main economic sectors in the country in term of labour productivity (refer Figure 1). With reference to Figure 1, despite achieving growth but on the overall, it was still very obvious that in both years 2015 and 2016, the construction sector has failed to surpass or even level with any other the other three main economic sectors of the country namely manufacturing, agriculture and services.

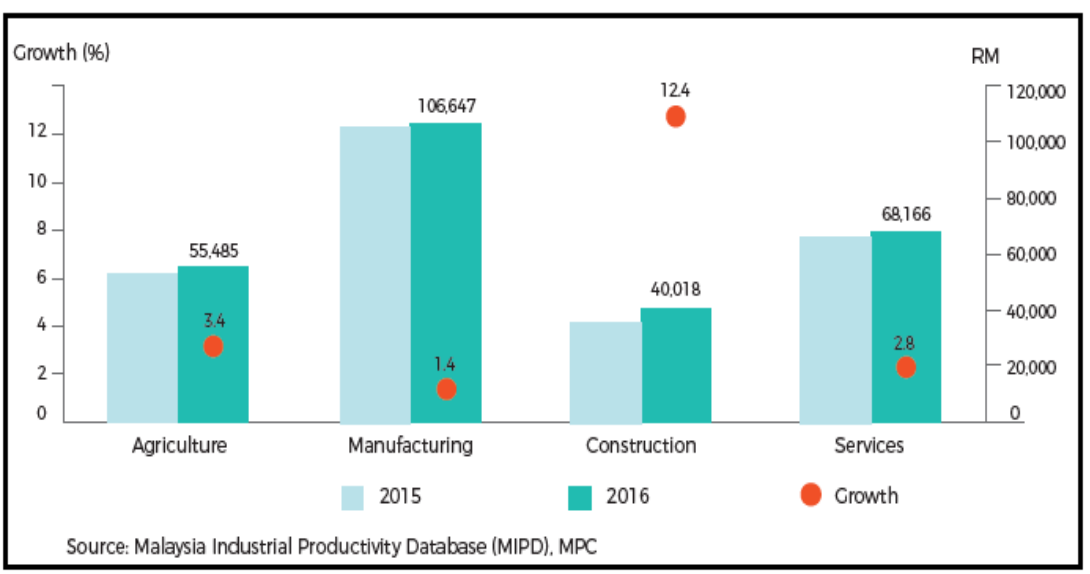

Figure 1. Labour Productivity Performance of the Main Economic Sectors, 2015-2016 (Adapted from: Malaysia Productivity Corporation, 2017)

On the other hand, when compared against selected developed countries, the Malaysian labour productivity ranking also proved to be far from convincing even when compared to their fellow neighbour, Singapore other than being the only one among the rest to show a descending trend (refer Figure 2). These statistics therefore explains why Ibrahim et al. (2010) claimed that the construction industry's contributions have been roughly fifteen times less than other services sectors.

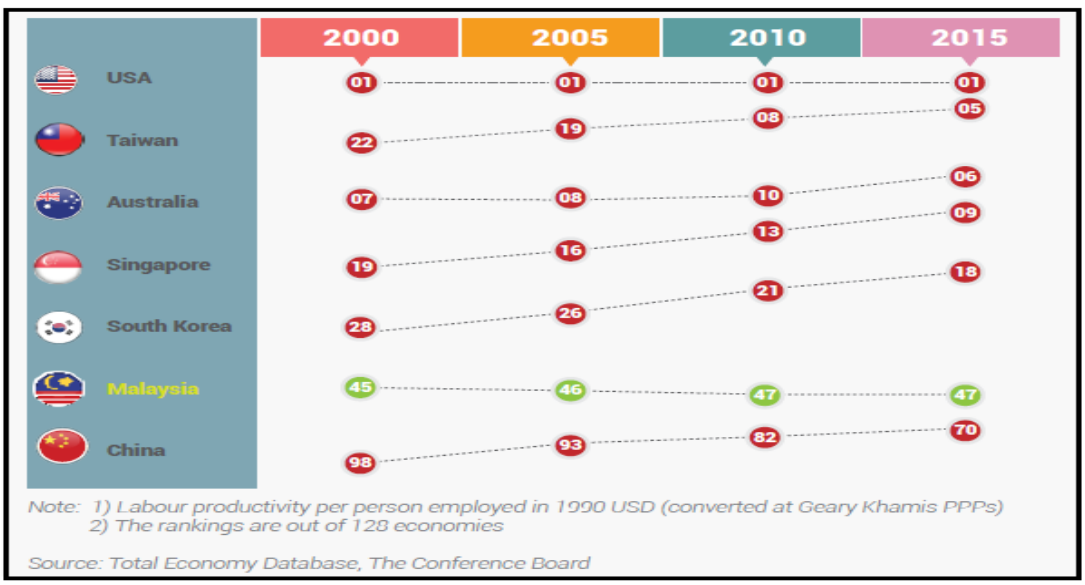

Figure 2. Labour Productivity Ranking of Selected Economies
(Adapted from: Malaysia Productivity Corporation, 2016)

LABOUR PRODUCTIVITY ISSUES DURING THE 10TH MALAYSIA PLAN

Based on past statistics, it has been evident that the inaugural Malaysia Plans have not been performing very well for instance in the Eight Malaysia Plan (2000 to 2005), a presentation by the Director General of Malaysian Public Works Department highlighted that a 78% delay rate was recorded in public sector projects with an average of 171-day time extension per project (Abd. Karim, 2008). Later, towards the end of Ninth Malaysia Plan (2006 to 2010), Joshi (2009) reported an 80% delay rate in public sector project. On the other hand, Abdullah et al. (2010) further reported the accomplishment of a major government agency called Majlis Amanah Rakyat (MARA) which experienced 90% delay rate in projects handled by them.

With past records being seriously unsatisfactory, the Tenth Malaysia Plan (2011 to 2015) had hoped to shift the industry towards performing at a better rate with strategies in placed aimed to steer the industry towards maximum efficiency. This was evident via its "Zero Delay" targets in the public-sector projects (Abu Mansor, 2010). Nevertheless, the plan again failed miserably when 235 and 191 sick projects were discovered in 2011 and 2013 respectively (Jatanora et al., 2016), both of which were within the Tenth Malaysia Plan period.

As have been established in the past, there is a strong connection between labour productivity and project time performance (Yi & Chan, 2013). The fact that labour cost can make up to approximately 20% to 50% of project cost (Rivas et al., 2010), affect project efficacy by up to 50% (Thomas & Napolitan, 1995) combined with the poor labour productivity statistics as shown in Figure 1 and 2, further supports the fact that low productivity level have been the main culprit for delays during the three past Malaysia Plans (8th, 9th and 10th). In fact, the industry has been aware of this fact with reports by the Malaysia Productivity Corporation (2016), highlighting that the recent and still on-going Eleventh Malaysia Plan specifically targeted approximately double growth in labour

productivity, from 1.8% during Tenth Malaysia Plan to 3.7% in the current plan; towards boosting the industry's performance. Therefore, considering that the industry is one of the most important economic contributors', calls for a major shift in the approach taken on Malaysian public-sector project management.

NEED FOR SUPPLY CHAIN MANAGEMENT (SCM) UPTAKE

The construction industry has been heavily criticized for much inefficiency, one of which is poor labour productivity, which has seriously hit the past Malaysia Plans. The urgent need to revolutionize practices have took place worldwide (Pearson, 1999; Vrijhoef & Koskela, 2000) with the Malaysian initiative also taking place via the Construction Industry Master Plan (CIMP) 2000 to 2015 (CIMP, 2007). Nevertheless, the nation's steps to progress have met a halt due to the high influence of traditional practices; even the Malaysian Construction Industry Master Plan (2006 to 2015) also lacked innovative practices (Hamid & Kamar, 2010) thus objectives cannot be properly met.

The benefit of SCM for construction performance have been well recorded (Bahri el al., 2017; Horvath, 2001; Cheng et al., 2010) as well as for effective project management (Love et al., 2004). As a result, many researchers have proposed SCM as the way forward (Egan, 1998; Strategic Forum, 2002; Love et al., 2004). The philosophy which holds onto collaboration as a key driver (Horvath, 2001) has been regarded as a very promising approach to solve construction industry problems (Mehdi Riazi, 2014).

SCM has been studied extensively in the past few decades and numerous definitions have been proposed (Croom et al., 2000). Nevertheless, for the purpose of this research the following definition was selected to describe Construction Supply Chain Management:

"An innovative and revolutionary managerial approach which involves a working culture change and a voluntary initiated agreement for integration and synchronization of two or more inter-dependent members within variety organization level and boundaries as well as range of inter-linked construction life-cycle processes (initiation to handover). It promotes joint effort and strategy on all activities which are underpinned by mutual trust, responsibility, benefit and risk sharing based on a long-term perspective on relationship. Value is achieved through optimization and management of processes, resources, core competencies, talent, information, power and technology within the supply chain towards accomplishment of a set of shared objective and goals, enhance competitive advantage, breaking down any discontinuities and meeting distinctive client needs. Consequently, jointly agreed benchmarks, targets, expectation and values are put in place for continuous improvement efforts and are supported by aligned incentive schemes towards sustaining the endeavour" (Mehdi Riazi & Lamari, 2013).

There is a close connection between improved construction productivity and improved management of supply chains (Vrijhoef & Koskela, 2000) thus, from the context of labour productivity, SCM application has the potential to provide improvements (Mulla et al., 2015) for instance through its potential to among others - improve collaboration and teamwork (Cheung, 2010), improve flow of Information (Eriksson, 2010) and improve efficiency and performance (Egan, 1998). In fact, it has the ability to motivate competitiveness and productivity of all project parties (Jones & Saad, 2003).

Nevertheless, within the Malaysian construction industry, SCM is still immature (Rashid, 2002; Mehdi Riazi, 2014) as are "lean" practices (Abdullah et al., 2009). Practices are still old fashioned (Abd Shukor et al., 2011) while past Malaysian government plans seemed inept in implementing the concept thus there has been a shortage of contemporary strategies (Mehdi Riazi, 2014). Nonetheless, inspired by past success such as applications by the British Airport Authority (Brady et al., 2006) and the Heathrow T5 project (Potts, 2009), the ability of SCM to overcome labour productivity issues in Malaysian public sector projects looks bright. However, effective implementations in Malaysia should remain in line with the country's current trends (Abd Shukor et al., 2011).

RESEARCH METHODOLOGY AND DESIGN

The objectives of this research are three-folds namely: to rank and establish the main factors affecting low labour productivity in Tenth Malaysian Plan public sector projects, to group the main factors into distinctive root causes / factors and lastly to identify beneficial SCM tools and consequently develop a validated SCM framework to improve labour productivity.

In achieving these research objectives, a number of data collection and analysis methods would be adopted. The first objective would be achieved by identifying the factors affecting low labour productivity from extensive literature reviews. These factors would then be combined with other factors identified from a series of audio-recorded semi-structured preliminary interviews undertaken on six industry experts (at least 20 years' experience in construction industry) towards capturing other factors that may be distinctive to the Malaysian locality and real world scenario. The selection of respondents for the preliminary interview were based on the approach taken by Mehdi Riazi & Lamari, (2013) whereby they claimed that the number of respondents were sufficient to provide a meaningful response on the overview of the industry scenario since their level of experience ensured sufficient exposure to the sector. Those factors from preliminary interviews would then be combined with the ones from literature reviews which then are inserted in questionnaire forms for the survey process; which ultimately aims for a minimum of 30% response rate from the established sample size to ensure validity of outcome.

After establishing the first objective, the main factors will then go through a series of analysis using either Partial List Square (PLS) should they be of formative structure or Structural Equation Modelling (SEM) for reflective structures. Then lastly, relevant SCM tools would be gathered from literature reviews which would then be taken to the industry for a minimum of two audio-recorded semi-structured interview sessions with respondents of at least ten years' experience in construction industry towards developing and validating the final research framework. Each interview sessions will target thirty to sixty respondents as recommended by Issac & Michael, (1995) or it shall be called-off should they reach saturation point.

In term of the scope of research, firstly this research shall focus on projects implemented during the Tenth Malaysia Plan since evidence proof that there were low labour productivity issues during the plan's period and that past research has yet to look into it. Therefore, there is a need to look into this aspect. On the part of respondents, focus shall be placed on only G7 Class contractors which are the highest class eligible to register in Malaysia. Reason being is

that contractors are the main implementer groups and that labours generally work with them. Class G7 also means that they are large contractors with large jobs thus will deal with a great number of labour whereby they are more prone to productivity issues. Other than that, the research will only focus on building projects, taking into consideration the claim by Mehdi Riazi (2014) that SCM in Malaysian construction industry is still at early stage and implementation on complex projects may not be successful therefore, to increase chance for success it is more suitable to start implementation on building project, which is less complex and complicated. Lastly, only projects within the Peninsular Malaysia would be targeted to avoid difference from aspect of culture, locality and public sector project management of Sabah & Sarawak (Mehdi Riazi, 2014).

RESEARCH THEORETICAL FRAMEWORK

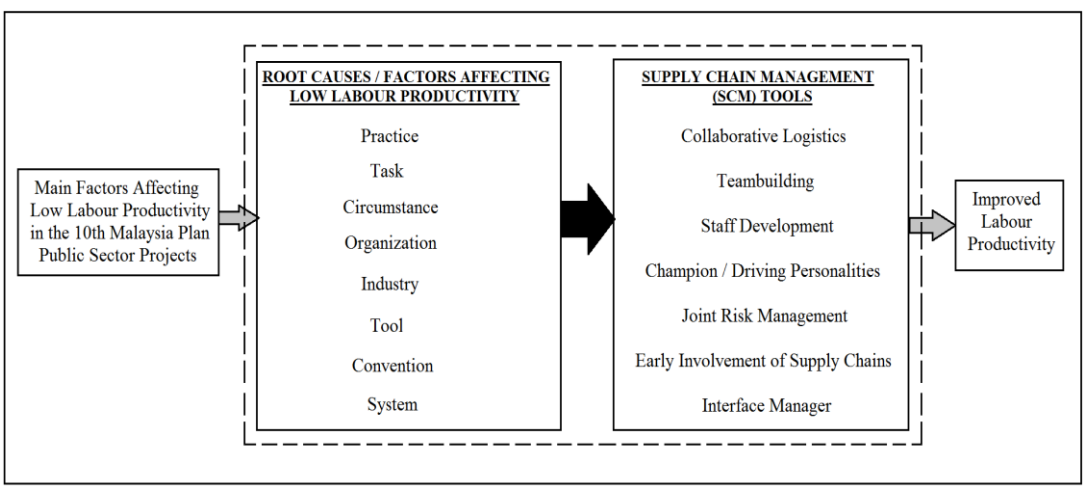

Figure 3. Research Theoretical Framework

With reference to Figure 3, only the areas within the dotted line represent the theoretical framework for this research. Towards developing the research framework, this research would first establish the main factors affecting low labour productivity which will then be taken for further analyses and categorized into distinctive root causes/factors. The root causes / factors will then be matched with beneficial SCM tools that are suitable to cater or mitigate respective root causes; which is hoped to ultimately improve labour productivity in the Tenth Malaysia Plan public sector projects. A framework of similar nature was previously developed by Mehdi Riazi, (2014) which matched beneficial SCM tools to overcome distinctive pathogens of delay; thus, this research aims to achieve the same by focusing on labour productivity issues.

Based on Figure 3, the root causes / factors affecting low labour productivity represents few that was adopted from research work by Busby & Hughes (2004), others may arise as this research progresses. In their study, Busby and Hughes used the term "Pathogen" whereby they defined it by a number of qualities which are: (1) "They are a relatively stable phenomena that have been in existence for a substantial time before the problem occurs"; (2) "Before the problem occurs, they would not have been seen as obvious stages in an identifiable sequence failure"; (3) "They are strongly connected to the problem, and are identifiable as principal causes of the problem once it occurs" (p. 428). They also categorized Pathogens into eight

categories namely “Practice”, “Task”, “Circumstance”, “Organization”, “Industry”, “Tool”, “Convention” and “System” (p. 429). Pathogen in other word describes the root cause of a problem whereby Reason (1990) described it as latent conditions that remains unidentifiable within a system until a problem arises. In fact, Mehdi Riazi (2014) suggested that the term is just a concept that can be adapted to variety of research which is in line with claims by Busby & Hughes (2004) that the concept is suitable for any failure-related research; whereby no doubt low labour productivity is one of them.

On the other hand, the SCM tools used in Figure 3 also represents few examples that have been proposed by different authors – Collaborative Logistics (Huang et al. (2001), Teambuilding (Eriksson, 2008), Staff Development (McCreadie & Rice, 1999), Champion / Driving Personalities (Kumaraswamy et al., 2007), Joint Risk Management (Potts, 2009), Early Involvement of Supply Chains (Pearson, 1999) and Interface Manager (Cigolini et al., 2004). Other SCM tools are expected to surface as this research progresses.

CONTRIBUTIONS TO BODY OF KNOWLEDGE

With past evidence strongly indicating labour productivity is a recurrent dilemma within a number of Malaysia Plan implementation including the latest completed Tenth Malaysia Plan (2011 to 2015) and that SCM has been suggested as a way to go ahead, this research is therefore expected to fill the body of knowledge in a number of perspectives. Firstly, the existence of low labour productivity during the Tenth Malaysia Plan have been evident from past documentation however, despite records proving there are studies on labour productivity issues within Malaysia (Abdul Kadeer et al., 2005; Manoharan, 2017), none of them specifically focused on the Tenth Malaysia Plan projects. This research aims to fill this gap via the establishment of main and root causes / factors affecting low labour productivity during this plan which would certainly add to the body of knowledge in term of labour productivity issues in construction industry.

This research would then go further to identify the beneficial SCM tools to overcome low labour productivity and consequently develop a validated SCM framework to overcome labour productivity issues in public sector projects during the Tenth Malaysia Plan. While SCM has been actively promoted over the past years; research on it is still relatively immature & fresh (O'Brien et al., 2008) and that a holistic approach is still missing (e.g. Barker et al., 2000). Instead, coverage has been only on split issues (Love et al., 2004) while frameworks / models proposed in the past (e.g. Love et al., 2004; Cheng et al., 2010) also lacked comprehensiveness in term of addressing specific industry deficiencies except for a framework by Mehdi Riazi, (2014) which proposed an SCM framework that matched beneficial tools to overcome distinctive root causes of delay. Therefore, the outcome of this research would definitely enhance the richness of literature both in regard to the beneficial SCM tools to overcome low labour productivity but also on the available SCM framework to overcome specific industry deficiencies.

CONCLUSION

The Malaysian public sector projects have been plagued by labour productivity issues whereby the lack in efficiency has led to many severe problems (i.e. delays). Labour productivity is currently at critical point evident from the performance of past Malaysian Plans

including the Tenth Malaysia Plan (2011 to 2015) and the call for a vast improvement of productivity has also been made in the latest and still on-going Eleventh Malaysia Plan (2016 to 2020). These scenarios suggest that there are major inefficiencies taking place within the industry's practices which is in need for a revolution.

The "*leitmotiv*" of literatures is the demand for an increase of the industry's wisdom on synchronizing its practices towards an improvement in communication, integration, collaboration and coordination by up taking the SCM initiative (Mehdi Riazi et al., 2011). Past studies have proven that SCM has been favoured over other practices for example Pearson (1999) claimed SCM has replaced partnering in UK; while others did apply its tools with improved results (Brady et al., 2006; Potts, 2009).

Realizing the urgent need of the nation's industry, the limitation of past research and the proven results through SCM implementations, this research will take a holistic approach to reduce low labour productivity dilemmas by developing a framework that will specifically match distinctive root causes / factors affecting low labour productivity with specific SCM tools that has the potential to improve the deficiencies that exist. Taking the "*root cause / factors*" approach enables solutions to be placed right on the fundamental causes of low labour productivity which is expected to lead to a greater degree of success. With some modification, the proposed framework is also expected to suit other countries worldwide.

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CHALLENGES IN QUALITY ASSESSMENT SYSTEM FROM THE PERSPECTIVE OF CONSTRUCTION PRACTITIONERS

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Abstract
Quality in construction can be defined as meeting the legal and functional requirements of a project with almost zero defects. Therefore, to achieve the high-quality standard in a construction project, it takes an effort and commitment from all the players in the industry. This study aims to identify the construction quality problems from the view of construction practitioners. This research also determines the QLASSIC training barriers and the competency improvement among respondent after attending the QLASSIC training. The severity of the problem and barriers identified was opined by 143 construction practitioners in Malaysia. This study adopted survey design as research design and utilized a questionnaire survey form as an instrument. The data were analysed by descriptive statistics using SPSS software. From this study, the finding shows the main problem in construction quality was lack of experience and competency of labours, the competency improvement was at good and average level after attending quality assessment training. And the most barriers in quality assessment training was training program/courses does not fulfil training needs and inconvenient training environment. Based on the result in this study, the future study will be conducted to identify the training model that can be used to implement the quality assessment training that match the labours needs and as an effort to remove the ambiguities in conceiving how QLASSIC should be implemented.

Keywords: *Construction; Competency; Quality; Quality Assessment System (QLASSIC); Training*

INTRODUCTION

The main function of a building is to protect the occupants and contents from the weather, mainly rain, wind and extremes of temperature. It is most important to provide the basic needs which will achieve all of these functions. Features such as windows, pipe, air conditioning system and finishes are only additional. Obviously, a building must be structurally safe to survive, and the floors must be capable of resisting any normal imposed loads (Ahzahar, 2011). However, there some issues or problem can affect the building quality such as building defects and building failures (Alencasto et al., 2016). A building defect may include a defect such as crack or blemish that reduces the value of a home, condominium, or building (Ahzahar, 2011; Adi Irfan et al., 2014). Building defects can be the result of design error by the architect, a manufacturing flaw, defective materials, improper use or installation of materials, lack of adherence to the design by the contractor, or any combination of them (Afida et al., 2014). Also, common types of building defects was include structural defects resulting in cracks or collapse; defective or faulty electrical wiring and lighting and plumbing; inadequate or faulty drainage system, ventilation, cooling or heating systems; insulation or soundproofing; and fire protection/suppression systems (Mukhtar, 2009).

CONSTRUCTION BUILDING QUALITY

Construction defects are always the key concern of the construction industry (Nur Nabihah Abd Razak et al., 2015). This problem may reduce the quality of a landed housing, strata-titled housing, or public building. Building defects can be resulted from the design error by the architect, a manufacturing flaw, defective materials, improper use or installation of materials, lack of adherence to the design by the contractor, or any combination of them (Ahzahar, 2011). In construction, quality was define as a customer satisfaction (Burati et al., 1991) and conformance to requirements (Corby, 1979). Therefore, the ongoing process that comprises sustaining the relationships by doing assessment anticipate and fulfil stated, and implied needs could achieve the quality. Even though the quality process is implicit process while it involves many relationships and character, the principles ‘’Do the Right Things in Every Time, On Time and First Time ‘’will remain the quality (CIDB, 2014). In Malaysian construction, the actual benefits of having quality are to improve the functionality and achieve a certain level of customer’s satisfaction. Among quality issues involved in the construction, the environment is project management practices, financial management and project success (Din et al., 2011).

The quality challenge in Malaysian construction environment is related by those doing the work, offsite and on-site activities, project management, construction process, training and education, teamwork, supplier partnership, policies and recognition (Sodangi et al., 2010; Wan Mahmood et al., 2006). However, compared to other industry, construction activities always related to discontinuous, dispersed, diverse and distinct. Therefore, the setting of quality is more difficult to implement, and improvement in quality is difficult to achieve (Albert Chan et al., 2003). Thus, in addressing the issues, a quality assessment system in construction has been introduce as an independent method to assess and evaluate the quality of workmanship of a construction work based on approved standard (CIDB, 2006). Furthermore, analysing the quality of the building should be developed by the assessment from time to time from the beginning until the end stages of the construction work.

QUALITY ASSESSMENT IN CONSTRUCTION

The traditional construction quality assessment methods based on periodic site visits by the consultants and validation of the finished product by comparing with the 2D design drawings are often time-consuming, laborious, and prone to human errors (Akinci et al., 2006). Culp et al. (1993) opined that a failing in many quality management efforts had been due to the lack of clearly defined and measurable quality goals. Moreover, one cannot meet the quality goals unless one has established standards to measure them. Measuring standards should be based on facts and data rather than relying on intuition or subjectivity. Thus, an objectively measurable quality performance assessment system is an essential prerequisite for contracting firms wishing to achieve their quality goals, survive and compete in the current changing and competitive market (CII, 1989; Abdel Razek, 1997).

Thus, Construction Industry Development Board of Malaysia (CIDB) introduced a quality assessment system named Quality Assessment System in Construction (QLASSIC). QLASSIC is a system or method to measure and evaluate the quality of workmanship of a construction work based on the relevant approved standard (Yin, 2012). There are four main components to be evaluated in QLASSIC which are structural works, architectural works,

mechanical and electrical works and external works (CIDB, 2014). The QLASSIC assessment on construction projects will be conducted by a competent assessor appointed by CIDB (CIDB, 2014). The quality of the assessment of each building project is important to ensure that each completed project has a high level of quality. Competency assessors are very important in assessing and measuring the quality of a building as it can affect the QLASSIC evaluation process (Sohimi et al., 2016). Therefore, to become a QLASSIC assessor, the construction practitioner have to attend the QLASSIC training course by CIDB (CIDB, 2006). QLASSIC training has been introduced to improve the efficiency of assessors in assessing building quality (CIDB, 2016).

METHODS

This study adopted a survey research design and utilized a questionnaire survey form as an instrument. The survey is usually used to obtain information from participants or samples in crowded quantities (Sabitha, 2006). The instrument that involved, is a set of questionnaire contained the following parts:

- Demographic
- Problem in Construction Quality
- Competency Improvement
- Construction Quality Assessment Training Barriers

The data from this research was analysed using descriptive analysis. The demographic part (Part A) is analysed using percentage, and the other part (Part B, Part C, and Part D) is analysed using mean value. The mean value is the arithmetic average of the score and calculated by adding up all the score and dividing that total by the number of score (Muijs, 2004). Responses for these questionnaires were on a five-point Likert scale format ranging from 1 strongly disagree/poor/none to 5 strongly agree/excellent/very severe. The Likert scale of this study was:

Table 1. Likert Scale

Scale Number	Scale	Mean Scores Scale
1	Strongly disagree/Poor/None	4.20-5.00
2	Disagree/Fair/Slight	3.40-4.19
3	Moderate disagree/Average/Moderate	2.60-3.39
4	Agree/Good/Severe	1.80- 2.59
5	Strongly agree/Excellent/Very Severe	1-1.79

The likert scale is a popular format of questionnaire that is used in education research (Mashwama et al., 2016). The likert scale is chosen in this study because it allows the respondents to express how much they are agree or disagree with certain statements (Mashwama et al., 2017). The scores were further converted to mean scores as follows: 4.20-5.00 for strongly agree/Excellent/Very Severe, 3.40-4.19 for Agree/Good/Severe, 2.60-3.39 for Moderate disagree/Average/Moderate, 1.80- 2.59 for Disagree/Fair/Slight, 1-1.79 for strongly disagree/Poor/None (Mashwama et al., 2017).

A random sampling method has been selected in this survey. The number of respondent in this study was 143. The population of this survey consists of construction practitioners who are contractors, architects, construction project manager, engineer, site supervisor and

any person that in charge of a construction project. By choosing this sampling method, every member of the population has a chance to be selected as a sample. In simple random sampling, every member of the population has an equal probability to be chosen to participate in the research (Tasir et al., 2012).

RESULT AND DISCUSSION

Part A: Demography

Table 2 shows the demographic information of this study. The demographic information was consist of education level, employment position, contractor grade professional skills certification, construction quality assessment involvement, construction quality assessment type and QLASSIC training participation by the respondents. From the survey, it was found that the largest proportion (47%) of the respondents is degree holders, while the rest is 24 percent and 17 percent having Bachelor/Degree and Malaysia Education Certificate (SPM). Only 10 percent of the respondent has certificate, and 1 percent has STPM and Master as their highest level of education. Most of the employment position of the respondents is other (50%) which are project manager, technician, chief executive officer, and etc. Followed by site supervisor (27%), construction site management (16%), civil engineer (5%) and architect (2%). Other employment positions consist of contractor, developers and other construction practitioners. The table 1 also shows, 74% of the respondent is a contractor grade 5 until grade 7. However, 71% of the respondents do not have professional skill certification. The 61% of the respondents have involved in construction quality assessment, and most of the respondents are using QLASSIC (55%) as a main assessment system in the project. The result also indicates that 78 % of the respondent had already attended the QLASSIC training.

Table 2. Analysis Demographic Respondent

Demographic	Percentage (%)
Education Level	
SPM	17
STPM	1
Certificate	10
Diploma	47
Bachelor or Degree	24
Master	1
Employment Position	
Construction Site Manager	16
Civil Engineer	5
Site Supervisor	27
Architect	2
Others	50
Contractor Grade	
G1	4
G2	4
G3	8
G4	10
G5	4
G6	15
G7	55

Demographic	Percentage (%)
Professional Skill Certification	
None	71
SKM 1	3
SKM 2	7
SKM 3	9
SKM 4	1
SKM 5	1
Others	8
Construction Quality Assessment Involvement	
Yes	61
No	39
Construction Quality Assessment Type	
QLASSIC	55
CONQUAS	6
Others	10
None	29
QLASSIC training participation by the respondents	
Yes	78
No	22

Part B: Problem Occurs in Construction Quality

Table 3 shows the problem occurs in construction quality. There are total 14 items that represented the problem in construction quality.

Table 3. Problem in Construction Quality

Num.	Problem in Construction Quality	Mean	Description	Rank
1	Technical Problem	3.74	Agree	9
2	Poor Communication between site management team	3.87	Agree	4
3	Management problem	3.83	Agree	5
4	Shortage of skill and knowledge among site management team	3.56	Agree	12
5	Inadequate construction training	3.83	Agree	5
6	Lack of site supervision/ Less monitoring and inspection by the supervisor	3.76	Agree	8
7	Poor workmanship and incompetence of contractors	3.71	Agree	10
8	Poor construction methods	3.67	Agree	11
9	Lack of experience and competency of labours	4.23	Strongly Agree	1
10	Lack of management commitment	3.78	Agree	7
11	Lack of training to implement quality management	3.91	Agree	2
12	Lack of training to implement quality assessment	3.90	Agree	3
13	Low level of project leadership skills	3.79	Agree	6
14	Poor quality of available equipment and raw materials.	3.78	Agree	7

The result in Table 3 shows most of the respondent strongly agree that lack of experience and competency of the labours is the primary problem in construction quality. Also, the most significant factor contributing to poor workmanship is lack of experience and competency of labours (Ali & Wen, 2011). Furthermore The study by (Mydin et al., 2014) found, lack of skill and experience/issue of labours competency is the second factors leading to poor

workmanship quality. This is because, the most significant in their effects on construction labour productivity are labour experience and skills and competency of construction management and competency of labour supervision (Khalid & Fayek, 2014). Next item which are lack of training to implement quality management (mean=3.91) and lack of training to implement quality assessment (mean=3.90) ranked as second and third most problem in construction quality. The management practice, technology and labour skills and training where the internal factors that affect construction productivity performance (Andrew et al., 2013).

Furthermore, training is important to enhance the knowledge and capabilities of employees (Kaur, 2015) and several factors, such as knowledge, skill, experience, training, etc., build the level of competency in the construction supervisor (Hardison, 2012). The fourth-ranked problem in construction quality was poor communication between site management team (mean=3.87), while the fifth-ranked was management problem (mean=3.83) and inadequate construction training (mean =3.83). Other than these top five (5) problems in construction quality, the respondents also agreed that low level of project leadership skills (mean=3.79). In construction, leadership is even more essential, this has been established in many studies (Odusami, 2002; Long et al., 2004). Next are poor quality of available equipment and raw materials (mean=3.78). The financial situation, equipment ownership, workload, and reputation may directly affect the quality of the project (Arditi & Muhaydin, 1998).

Next are lack of management commitment (mean=3.78) and lack of site supervision/ less monitoring and inspection by the supervisor (mean=3.76). The findings from Arditi and Muhaydin (1998), indicate that management commitment to continuous quality improvement, management leadership in promoting high process quality, quality training of all personnel, efficient teamwork to promote quality issues at the corporate level, and effective cooperation between parties. In addition, the study by Najjar and Jawad (2011), shows one of the main problem in construction is the absence of good quality supervision of the construction industry. The other problem that occurs in construction quality are technical problem (mean= 3.74); poor workmanship and incompetence of contractors (3.71); poor construction methods (mean= 3.67) and that strategy and shortage of skill and knowledge among site management team (mean=3.56). Many prime contractors underlet the specialized work such as insulation, electrical, plumbing and many more on their projects due to their lack of ability to implement these works (Husam & Rosnah, 2016). Also, the study by Husan & Rosmah (2016), found the top five most significant factors that affecting construction quality are unskilled labours, improper material, factors related to owners, lack of timely supervision by site staff, and low experience and competency of supervisor.

Part C: Competency Improvement after Attending QLASSIC Training

Table 4 shows the competency that improves after attending the QLASSIC training.

Table 4. Competency Improvement

Num.	Competency Improvement	Mean	Description
	Structural Works		
1	Reinforced concrete structure works	3.63	Good
2	Structural steel works	3.53	Good
3	Pre-stressed concrete element	3.55	Good

Num.	Competency Improvement	Mean	Description
	Architectural Works		
4	Internal Finishes	3.77	Good
5	Roof	3.82	Good
6	External Wall	3.72	Good
7	Apron & Perimeter Drain	3.74	Good
8	Material & Functionality test	3.74	Good
	Mechanical & Electrical Works		
9	Electrical Works	3.29	Average
10	ACMV Works	3.57	Good
11	Fire Protection Works	3.45	Good
12	Plumbing & Sanitary Works	3.35	Average
13	Basic M&E Fittings	3.70	Good
	External Works		
14	Link-way/ Shelter	3.62	Good
15	External Drain	3.60	Good
16	Roadwork and Car Park	3.59	Good
17	Footpath and Turfing	3.54	Good
18	Playground	3.50	Good
19	Court	3.54	Good
20	Fence and gate	3.63	Good
21	Swimming pool	3.45	Good
22	Electrical Substation	3.47	Good

The result in Table 4 presented most of the respondent have a good improvement about all the work element in QLASSIC assessment after attending the QLASSIC training. Only two items in average improvement which are electrical work and plumbing and sanitary works. The focus on the electrical work quality is important because the scope of work in electrical is regularly the most technical and confusing work on a project and need educated, experienced subcontractor to complete the work (Smith & Hinze, 2011). The result also shows most of the architectural work have a good improvement starting from internal finishes (mean=3.77), roof (mean=3.82), external wall (mean=3.72), apron & perimeter drain (mean=3.74) and material & functionality test (mean=3.74).

Part D: The Barriers of Quality Assessment Training in Construction

The Table 5 shows the result about the barriers of quality assessment training in construction.

Table 5. The barriers of quality assessment training in construction

Num.	Training Barriers	Mean	Description	Rank
1	Lack of funding/financial resources	3.24	Moderate	18
2	Lack of adequate expertise	3.15	Moderate	19
3	Lack of adequate instructors	3.37	Moderate	15
4	Lack of adequate instructional material	3.27	Moderate	17
5	Lack of adequate training facilities	3.31	Moderate	16
6	Unsystematic training approach	3.43	Severe	14
7	Lack of support from the top management in approving staff participating in the training	3.63	Severe	11
8	Training program/courses does not fulfil job description	3.73	Severe	6
9	Lack of new workers interested in skill development program	3.59	Severe	12
10	Adequate completion rates of existing training program	3.27	Moderate	17
11	Training location is not accessible by employees	3.57	Severe	13
12	Training requires too much time to complete	3.66	Severe	9

Num.	Training Barriers	Mean	Description	Rank
13	Instructor has a low ability in conducting training	3.65	Severe	10
14	Inconvenient training environment	3.83	Severe	2
15	Training program/courses does not fulfil training needs	3.86	Severe	1
16	Training schedule conflicts with work schedule	3.68	Severe	8
17	Language barrier	3.77	Severe	3
18	Poor training information retrieval	3.73	Severe	6
19	Lack of self-motivation to participate in training	3.74	Severe	5
20	Lack of opportunity to learn	3.76	Severe	4
21	Unsystematic training assessment and evaluation	3.71	Severe	7

The result in Table 5 shows there are 21 barriers to the quality assessment training in construction training. Mostly, the barriers in quality assessment training is severe and only two barriers is moderate. The first rank of barriers in quality assessment training is training program /courses does not fulfil training needs. In quality assessment system in construction, training is important to enhance the capabilities of assessor in assessing the quality (Sohimi et al., 2016). However, the failure to contend with fragmented nature of construction lead to mismatches between the training offered and the workforces training needs (Fadzil & Ruslan, 2009). Next, the item at second place was the inconvenient training environment. Previous study done by Tabassi et al. (2011) found one of the barriers to the training is dynamic and complex environment of the industry. Also, insufficient time and space available for effective training to take place also important to meet the demand for training (CIC, 2004). Next barriers were found from this study was language barriers. Lack of opportunity to learn rank in fourth place. The study by Campus (2013), found lack of opportunity to learn new skills are the major barriers in the improvement of Quality of Work Life of employees. The fifth rank was lack of self-motivation to participate in training. In a training, motivation can influence the willingness of an employee to attend the training program (Maurer & Tarulli, 1994; Noe & Wilk, 1993). Furthermore, Cheng and Ho (2001), reviewed studies conducted in the past decade and concluded that training motivation influences trainees' training performance and transfer outcomes.

There are two item ranks in the sixth place which are training program/courses does not fulfil job description (mean=3.73) and poor training information retrieval (mean=3.73). Meanwhile, most of the organization face a problem in identify the match or suitable training for their workers (Kontoghiorghes, 2002). Also, the organization face a problem in identify the match or suitable training for their workers because a training must relevant to the job to achieve successful training transfer (Axtell et al., 1997; Kontoghiorghes, 2002; Rouiller & Goldstein, 1993). The item that rank in seven places was unsystematic training assessment and evaluation (mean=3.71). Evaluation and development of training is the most essential aspect of training programme (Topno, 2012). Therefore, poor quality of training provision that resulted in such skills shortages (Andrew et al., 2013). In quality assessment process, it is suggested for the sub-contractors, consultants and Superintending Officer (S.O) participate in the quality assessment training because it can give a positive impact to their performance in quality assessment (Sohimi et al., 2016).

Next item was training schedule conflicts with work schedule (mean=3.68) and training requires too much time to complete (mean=3.66) that rank in eight and nine places. Therefore, training design is important in designing the suitable training that need by the workers. It because, training design plays a very vital role in the employee as well as organizational performance (Ghafor et al., 2011). Moreover, in designing the training, time and cost also

important. The item that rank in ten place are instructor has a low ability in conducting training. Trainer attributes does effect the training process (Gosim, 2016). Thus, some of the barrier in training was an improving the competency are the capability of the trainer, the training process and training delivery style (Ghaffar et al., 2011). Followed by lack of support from the top management in approving staff participating in the training (mean=3.63) at eleven place and twelve place was lack of new workers interested in skill development program (mean=3.59). Among the obstacles to conducting integrated training programs for staff and employees is the lack of incentives amongst employees to undergo the training (Tabassi & Abu Bakar, 2009). Training location is not accessible by employees (mean=3.57) and unsystematic training approach (mean=3.43) was rank in thirteen and fourteen place.

The item that rank from fifth teen until nineteen was at moderate level. The item was lack of adequate instructors (mean=3.37), lack of adequate training facilities (mean=3.31), lack of adequate instructional material and adequate completion rates of existing training program (mean=3.27), lack of funding/financial resources (mean=3.24) and lastly was lack of adequate expertise (mean=3.15). Many researchers agreed that appropriate training and enlarging experience is necessary in producing the quality project (Sohimi et al., 2016). Therefore, labour productivity is significant in construction because of its impact in the process of completing projects (Osama et al., 2010). It was supported that the construction quality can be enhanced by increasing the knowledge of site labours (Chan et al., 2006).

CONCLUSION

Quality in construction project has become one of the important criteria in measure the successful of the project. Thus, a quality assessment system in construction was introduce to address the quality issues in construction. In assessing the quality in construction project, the construction practitioners need to attend a training. From this study, the finding shows the main problem in construction quality was lack of experience and competency of labours. This because, competency of the labours is believed contribute to the quality of building construction. Meanwhile, most of the respondent shows the competency improvement was at good and average level after attending quality assessment training. Again, it shows that the training give an advantage to the respondent to improve their skills. Lastly, the most barriers in quality assessment training was training program/courses does not fulfil training needs and inconvenient training environment. Based on the result in this study, the future study will be conducted to identify the training model that can be used to implement the quality assessment training that match the labours needs and as an effort to remove the ambiguities in conceiving how QLASSIC should be implemented.

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A MODEL OF LOAD-BEARING MASONRY (LBM) TECHNOLOGY ADOPTION: EMPIRICAL STUDY IN THE MALAYSIA COUNTRY

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Abstract
The study aims to develop a model of the Load-bearing Masonry (LBM) Technology adoption by Malaysian housing developer firms. The study also validates the Technology Acceptance Model (TAM) and Innovation Diffusion Theory (IDT) is a basis to explain the adoption of LBM technology using a quantitative method, in which data is collected based on survey approach through questionnaires. Advance statistical tool which is Partial Least Squares Structural Equation Modelling (PLS-SEM) were used to analyse the data collected. The findings indicated that the perceived ease of use and relative advantage are significant factors related to the adoption of LBM technology. Otherwise, factors such as organizational readiness, external supports and facilitating conditions are significant effect on the perceived ease of use and relative advantage. The findings also confirmed that TAM and IDT theory are valid in explaining LBM technology adoption. Finally, the study reinforces numbers of others influencing factors for future study on the LBM technology adoption.

Keywords: *Innovation Diffusion Theory (IDT); Load-Bearing Masonry (LBM) Technology; Technology Acceptance Model (TAM)*

INTRODUCTION

With the availability and advancement of the technology and innovation with a simple technique such as LBM technology, the housing demand could be fulfilled. Compared to the conventional method RC (reinforcement concrete), the LBM technology can provide an alternative solution in reducing the construction cost, accelerating construction works, sustainability and it's durability (Ramli et al., 2015).

The LBM technology has been widely adopted in developed countries. The European countries have used the unreinforced masonry and has been used approximately about 50 percent in new housing constructions in low seismicity zone (Lourence et al., 2008). The use of the interlocking brick system, for example, has gained rapid widespread in many countries as an alternative method to conventional bricks for sustainable housing (Oti et al., 2009).

The adoption of technology in the construction industry has be made a dynamic market for the construction industry and encouraged the growth of the nation's and industry's economics. Construction technology also allows construction companies to enhance their profitability and international standing. Tatum (1986), noted that the adoption of the technology would assist construction firms to be competitive in the global construction demand and compete with foreign firms.

Since construction technology will benefit construction projects and companies, the Malaysian Government has been actively promoting and encouraging the use of the construction technology in construction projects. These efforts are outlined in the Construction Industry Plan 2006-2015 (CIMP 2006-2015) where construction technologies such as interlocking block system as an industrialized building system (IBS) (Sundaraj, 2007) is actively promoted. Therefore, understanding of the factors that contributes to this adoption will offer a platform for the housing industry and the industry players to plan and implement appropriate strategies to improve the effectiveness and performance of the industry. Consequently, this study proposed the model for the adoption of the LBM technology.

Research Questions and Research Objectives

The motivation of this study is to understand the factors effecting on the LBM technology adoption. Meanwhile, the theory in the field of LBM technology adoption is still in infancy stage and there is a need having more studies on this. Therefore, this study attempts to answer two research questions: what are the factors effecting on the LBM technology adoption? What are the validation theory for the LBM technology adoption? The main objective of this study is to: investigate the factors effecting on the adoption of LBM technology. To validate acceptable theory for the LBM technology adoption. Finally, develop a model for LBM technology adoption.

LITERATURE REVIEW AND MODEL DEVELOPMENT

This section discusses on the combination of Technology Acceptance Model (TAM) and Innovation Diffusion Theory (IDT) as a basis on the development of the LBM technology adoption model.

The Application of the TAM and IDT on the LBM technology adoption

TAM was established more than 25 years ago. It was introduced by Davis (1986), in his study to describe the acceptance, usage, and adoption of information technology. From Davis's point of view, technology adoption is affected by use-related beliefs which are perceived ease of use and usefulness. Various researchers have used the TAM model for understanding the 7adoption of technology majorly in information technology (IT). Consequently, TAM becomes one of the most significant models in contributing toward a theoretical understanding of the adoption behaviours in different fields (Alalwan et al., 2016; Rawashdeh, 2015).

Innovation Diffusion Theory (IDT) is a popular theory in the diffusion of new technology, and it appears to be the most widely accepted model by researchers. The concept was introduced by Rogers (1995). In Rogers' IDT (1983), five attributes were found to affect the rate of adoption, namely: relative advantage, compatibility, complexity, observability, and trial ability. A large number of researchers have used the IDT model in their studies (Cheung et al., 2011; Nazari et al., 2013; Ramdani et al., 2009). Meanwhile, the most consistent factor of technology adoption found was relative advantage (Kapoor et al., 2014).

Numerous authors and scholars have extended both TAM and IDT models to enhance the ability of the models to predict new technology use and adoption. The combined TAM and

IDT was found to offer a strong prediction and explanation in technology adoption (Chang, 2008; Wu et al., 2007).

The TAM and IDT models have been widely tested in information technology (IT) and information system (IS) studies, and they were found to be significant in predicting internet use (Chen et al., 2002; Oh et al., 2003), e-commerce adoption (Chen & Tan, 2004; Vijayasarathy, 2004) and enterprise resource planning (Calisir et al., 2009).

Even though TAM and IDT have been employed to explain the adoption in different disciplines, studies in the area of construction technology using the models are limited. Additionally, research regarding other factors within and outside the organization is still lacking (Ramli et al., 2016). Hence, motivated by the approach to combine TAM and IDT and their limited implementation in the field of construction technology, this study used the TAM and IDT models to explain the adoption the LBM technology. In doing so, other factors relevant to the construction technology that may have an influence on TAM and IDT were also incorporated.

Perceived ease of use and LBM technology adoption

In TAM, the actual behaviour of an individual to adopt a technology can be predicted by perceived ease of use, which is defined as the degree to which a person believes that using a particular system would be free of effort (Davis, 1989). Many studies have demonstrated that the level of adoption increases by the ease of use of a particular system (Davis, 1989; Henderson and Devitt, 2003; Nan et al., 2008; Lowry, 2003). The easier a method or technique to be used, the higher the chances that the technology will be adopted. Perceived ease of use has also been widely found to have a positive effect on the adoption of technology in various fields (Bhatiasevi & Krairit, 2013; Li et al., 2012; Rokhman, 2011).

Perceived ease of use in this study is described as the belief of organization to adopt LBM technology at construction site. LBM technology is believed to be the best because it is less complex and easier to assemble on site. Hence, the organization will more likely to adopt LBM technology as a result of being easy to assemble and not complicated to be understood. Therefore, this study proposes the following hypothesis:

H1: perceived ease of use has a significant effect on the adoption of LBM technology.

Relative Advantage and LBM technology adoption

Past research shows that innovation attributes are the major factors accounting for the adoption decision of an organization. Relative advantage is one of the innovation attributes. It is defined as an innovation in the degree to which an innovation is perceived as better than the idea it supersedes (Rogers, 1995). Relative advantage covers factors such as economic profitability or social reputation that determine the degree to which a new idea is perceived better than the solutions previously used for the same purpose. Studies have found that relative advantage is a significant variable and positively related to the adoption of the technology (Al-qirim, 2007; Henderson et al., 2012; Lowry, 2002; Premkumar & Roberts, 1999; Rokhman, 2011; Thong & Yap, 1995).

Relative advantage refers to the degree that determines how the present method is considered better than previous one. In this study, LBM technology is perceived better than the reinforced concrete method. The organization is recommended to adopt LBM technology due to its beneficial outcomes to the organization. The more organization perceived that LBM technology is better than the reinforced concrete method in performing the work, the more likely for them to adopt LBM technology in their construction projects. Hence, the following hypothesis is proposes:

H2: relative advantage has a significant effect on the adoption of LBM technology.

Organization Readiness, Perceived Ease of Use and Relative Advantage

Several studies suggest that organizational readiness is an important component in technology adoption. According to Tsai and Tang (2012), organizational readiness is defined as internal characteristics and properties of a firm and play an important role in the decision to adopt a technology. Iacovou et al., (1995) defined organizational readiness as the availability of the necessary organizational resources for adoption. Internal factors such as organizational readiness were demonstrated to positively affect the adoption of technology through behaviour (Igbaria et al., 1997). Thus, this study proposes that organizational readiness shapes the perceived ease of use and relative advantage. Hence, the following hypotheses were developed:

H3: Organizational readiness has a significant effect on perceived ease of use
H4: Organizational readiness has a significant effect on the relative advantage

External supports, Perceived Ease of Use and Relative Advantage

External support is an important determinant of technology adoption. Studies by Al-qirim (2007), Premkumar & Roberts (1999), and Scupola, (2009) found a positive role external support played in helping organizations to be more competitive. External support refers to the availability of support in implementing and using the technology (Premkumar & Robert, 1999).

In this study, external support refers to the availability of a third party support for implementing and using the LBM system. The third party support such as the government, contractor, and supplier is significant in determining the usage of this system in a construction project (Blayse & Menley, 2004). Industry players are willing to use certain systems if they feel there is adequate external support from the government, contractor, and supplier.

Igbaria et al. (1997), indicated the effect of the external supports on the perceived ease of use. Meanwhile study by El-gohary (2012), showed a non-significant relationship between external factors, perceived ease of use and usefulness (relative advantage). Regarding to the inconsistent results, the relationship between external factors and the adoption of the LBM technology through perceived ease of use and usefulness (relative advantage) should be examined further. The external support may enhance the perceived ease of use and relative advantage of the technology among the organizations that adopt the LBM technology. Hence, the following hypotheses were developed as follows:

H5: External supports have a significant effect on perceived ease of use.
H6: External supports have a significant effect on relative advantage.

Facilitating Conditions, Perceived Ease of Use and Relative Advantage

Facilitating conditions are viewed as external controls related to the environment (Terry, Gallois, & McCamish, 1993). Behaviour could not be occurring if the environment prevents it or if the facilitating conditions make the behaviour difficult (Lu et al., 2008). Facilitating conditions have been identified as more influential factors on innovation adoption (Hung, Ku, & Chang, 2003), and their study on the adoption of WMDS services in China showed that facilitating condition was the critical factors influencing adoption. Policies, regulation, and legal environment are considered the critical aspects of technology adoption (Pudjianto et al., 2011; Zhu, et al., 2006). Policy and regulation are important components in the implementation of a technology and for the future growth of the technological system (Duan et al., 2010).

Several studies found that facilitating conditions affected perceived ease of use and relative advantage (Nan et al., 2007; Taylor & Todd, 1995a; Terzis & Economides, 2011b; Thompson et al., 1994; Venkatesh & Morris, 2000). As facilitating conditions are postulated to play an important role in the adoption of technology, it was hypotheses that:

H7: Facilitating conditions have a significant effect on perceived ease of use.
H8: Facilitating conditions have a significant effect on relative advantage.

A Model of the LBM technology Adoption

Following discussion from the previous section, the model of the LBM technology was presented in Figure 1. The linkages between perceived ease of use, relative advantage, organization readiness, external supports, facilitating conditions, and LBM technology adoption are illustrated in the proposed model.

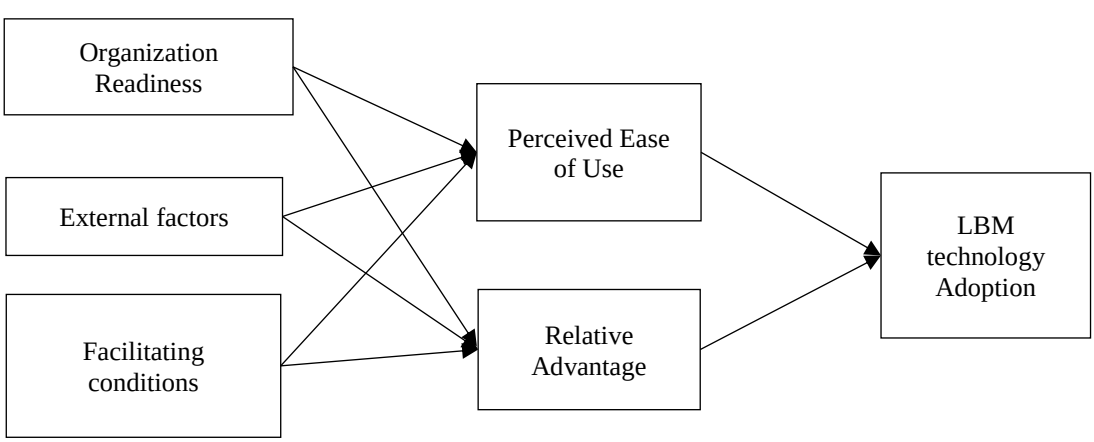

Figure 1. Model of LBM Technology Adoption

RESEARCH METHODOLOGY

This study utilized a quantitative method, in which the data was collected based on survey approach through questionnaires to address on the target respondents.

Sampling

This study focuses in the housing developer firms. Industry players such as housing developers were involved in this study as decision makers in construction projects. According to Ling et al. (2007) a developer or the owner of a project plays a critical role in the construction innovation. Meanwhile, other researchers (Huovila, 1999; Majdalani et al., 2006; Abidin et al., 2013) noted that it is the developer who plays an important role in developing and financing of construction projects.

The sampling list of the developer firms across Malaysia was obtained from the Real Estate and Housing Developer (REHDA) website. The study only focused on developer firms located in Peninsular Malaysia, the population size was is 1,153 registered firms (from REHDA' website 2016).

This study applied proportionate random sampling method in selecting developer firms. The developer firms were stratified according to their geographical location (4 regions). The overall proportion of sample to population was 25 percent and calculated based on formula by Piaw, (2013). Possibility of the low response rate, this study decided to oversample. After decided factoring a 50-percent increase, the number of questionnaires sent out was 426. The breakdown of the questionnaires sent to developer firm by region was 118 for the northern region, 174 for the centre region, 88 for the southern region, and 46 for the eastern region. Then, a random sampling was used to collect the data for every each region.

Respondents

In house of project units, namely as the manager, professional level and executive level were chosen as the respondent's due fact they are involved in the operation of the company. The present study recruited these people as the sources of data to be in line with previous studies conducted on housing developers (Yusof et al., 2011). Secondly, these people are normally involved in the planning and implementation of the company projects. As such, they are considered key employees in the organization's operation and familiar with the projects and their job is critical to the performance of the construction firm.

Constructs Measurements

This study has six constructs. They are perceived ease of use, relative advantage, and organizational readiness, external supports, facilitating conditions and LBM technology adoption. The five items of perceived ease of use adapted from (Davis, 1989; Majid et al., 2008). Six items of relative advantage adapted from (Iqbal & El-Gohary, 2014; Majjid et al., 2008; Moore & Benbasat, 1991). Six items organizational readiness adapted from (Hadaya & Pellerin, 2010; Iacovou et al., 1995; Tsai & Tang, 2012). Seventeen items of external supports adapted from (Premkumar & Roberts, 1999; Saqib et al., 2008; Kog & Loh, 2012). Four items of facilitating conditions adapted from (Lu et al., 2003; Zhu & Kraemer, 2005). Eight items

of LBM technology adoption adapted from (Davis, 1989; Majid et al., 2011; Ramli et al., 2016).

Design of Questionnaires

The questionnaire was structured and divided into two sections:

Section 1-was designed in order to obtain the demographics information of the firms and the respondents.

Section II -consists of 38 items related to the determining factors regarding the adoption of LBM technology.

A five-point Likert scale was applied in this study for the purpose of ranging the statements. A five-Likert scale is considered a balanced scale because there is an equal number of positive and negative options (Galan-Garsia et al., 2014). This particular scale is represented in the form of 1-5 which are strongly disagree to strongly agree.

RESULTS

118 returned questionnaires were useful for the future analysis. Based on the descriptive analysis the majority of the respondents were from private firms (95%) and only 1% of government-linked companies (GLCs). Close to half of the respondents were from small firms with less than 30 employees (46.6%), followed by those from large firms (15.5%) and medium firms (38.2%). Regarding experience in housing projects, 39% of the surveyed firms had more than 20 years of experience, followed by those with experience between 11 and 20 years (35.6%), and less than ten years (25.4%). Many respondents had a senior executive position (49.2%), followed by managerial level and professional level (e.g., engineer and architect) (25.4%). Slightly more than half of the respondents had been in their position less than ten years (55.1%) and only 5.1% had more than 20 years of experience.

It was also found Only 22 firms used the LBM technology in their projects, and 96 firms did not use the LBM technology even though they had knowledge about it.

Analysis and Findings

The partial least square (PLS) approach on the SmartPLS 2.0 software was applied for the purpose to measured relationships in path models. The two-step approach was suggested to be utilized for PLS analysis, namely the measurement model and structure model.

Measurement Model

The measurement model is to establish the construct validity which calculates the convergent and discriminant validity. Table 1 and Table 2 present the convergent and discriminant validity of the construct. Moreover, for the case of convergent validity, the AVE (average variance explain) and composite reliability were measured.

Additionally, the reliability coefficient was measured namely as Cronbach's alpha. In this regard, the composite reliability, AVE, and Cronbach's alpha for each construct were found to exceed the cut-off point as recommended by (Hair et al., 2012). The cut-off point for composite reliability and Cronbach's alpha is 0.7, while the cut-off point for AVE is set to be 0.5. The discriminant validity of each construct was measured (square roof of AVE) and presented in Table 2.

Table 1. Convergent Validity

Constructs	Loading	AVE	Composite Reliability	Cronbach's Alpha
Adoption	0.620 0.760 0.744 0.802 0.623	0.509	0.837	0.756
External Support	0.583 0.573 0.718 0.849 0.786	0.505	0.833	0.749
Facilitating Conditions	0.785 0.918 0.928	0.774	0.910	0.857
Organizational Readiness	0.801 0.824 0.758 0.531 0.667 0.704	0.523	0.864	0.810
Perceived Ease of Use	0.939 0.924 0.831	0.809	0.927	0.880
Relative Advantages	0.799 0.825 0.875 0.843 0.662	0.648	0.901	0.861

Table 2. Discriminant Validity

	Adopt	ES	FC	OR	PEOU	RA
Adopt	**0.714**					
ES	0.525	**0.710**				
FC	-0.064	0.118	**0.880**			
OR	0.214	0.518	0.043	**0.721**		
PEOU	0.017	0.271	0.185	0.834	**0.899**	
RA	0.413	0.678	-0.132	0.750	0.534	**0.804**

Structure Model

The structural model is to measure the relationship of the proposed hypotheses. The results of the hypothesis testing presented in Table 3.

Additionally, the structural model is assessed by examining the squared multiple correlations (R^2). Perceived ease of use and relative advantage had a direct and significant relationship with LBM technology adoption. Both explained 23% of the variance in adoption (R^2= 0.23).

Organizational readiness, external supports, and facilitating condition had a direct and significant effect on perceived ease of use with 76.2% of the variance explained (R^2= 0.76). Meanwhile, organizational readiness, external support, and facilitating conditions explained significantly 71.8% of the total variance in relative advantage (R^2= 0.718).

The predictor power of R^2 for perceived ease of use and relative advantage was substantial. The predictor power of R^2 for LBM system adoption was substantial. These base on cut-off value studied by (Cohen, 1998).

DISCUSSIONS

The result indicated that perceived ease of use had a significant effect on adoption (t value = 1.922, $p < 0.1$). Therefore, H1 was supported. The findings show that perceived ease of use is strongly related to the adoption of LBM technology which is in agreement with the studies performed by Bhatiasevi & Krairit, (2013). The respondents believe the easily of the technology would increase the level of adoption. For this study, the developer's firms demonstrated the LBM technology is easier method and influence the level of the adoption.

Relative advantage had a significant effect on adoption (t value = 6.180, $p < 0.01$). Therefore, H2 was supported. The finding of the study also found that relative advantage is strongly related to LBM adoption. It can be concluded that the firms are willing to adopt LBM technology due to the benefits of the technology. LBM technology is more capable of enhancing the efficiency and performance of the projects in comparison to the reinforced concrete method. This result is consistent with past findings (Al-qirim, 2007; Henderson et al., 2012; Ramayah et al., 2013).

Specifically, organizational readiness had a significant effect on perceived ease of use (t value = 18.160, $p < 0.010$) and H3 was supported. Relative advantages (t value = 10.232, $p < 0.01$). Therefore, H4 was supported. It can be concluded that, the more resources the developer firms have regarding knowledge of staff, finance, and technology, the more favourable their perceptions are about the ease of use and relative advantage of the LBM technology. The result is in tandem with the finding by El-gohary (2012).

External support had a significant effect on perceived ease of use (t value =3.937, $p < 0.01$), H5 was supported. Relative advantages (t value = 7.290, $p < 0.01$). Therefore, H6 was supported. The findings indicated that the availability of external support was an important determinant of technology adoption in organizations. Strong external support such as from the government and contractor can encourage developer firms to form a positive opinion of

the LBM technology. The results consistent with past studies (Al-qirim, 2007; Premkumar & Roberts, 1999; Scupola, 2009).

In particular, facilitating conditions were found to have a significant effect on perceived ease of use (t value = 2.675, $p < 0.01$), H7 was supported. Relative advantage (t value = 3.611, $p < 0.01$). Thus, H8 was supported. The findings show more environment control such as government policies and regulation standard in the construction industry the more likely it will lead the relationship of relative advantage and perceived ease of use. The results is consistent with past findings (Lu et al., 2008; Terzis & Economides, 2011). As a result, all proposed hypotheses were supported in this study.

Otherwise, this study contributes to a theoretical understanding of the factors that influence the adoption of LBM technology adoption among developer firms in Malaysia. The results showed that perceived ease of use from TAM and relative advantage from IDT had a significant effect on the LBM building system adoption. The findings are consistent with other studies (Giovanis et al., 2012; Kou & Lee, 2011; Tung et al., 2008).

Table 3. Relationships of the Hypotheses

Relationships	B value	t value	Results
PEOU – LBM system Adoption	-0.284	1.922	Significant
RA – LBM system Adoption	0.565	6.180	Significant
Organization readiness – PEOU	0.954	18.157	Significant
Organization readiness – RA	0.539	10.232	Significant
External supports – PEOU	0.244	3.937	Significant
External supports – RA	0.422	7.290	Significant
Facilitating conditions – PEOU	0.173	2.675	Significant
Facilitating conditions – RA	-0.205	3.611	significant

CONCLUSION

The most obvious findings emerge from this study is that a model was developed to explain the relationship of the influencing factors on adoption of the LBM system in the Malaysian housing industry. Secondly finding of this study, perceived ease of use and relative advantage are significant factors related to the adoption of LBM technology. Moreover, the others factors such as organizational readiness, external supports and facilitating conditions are significant effect on the perceived ease of use and relative advantage. Additionally findings managed to verify the validity of TAM (perceived ease of use) and IDT (relative advantage) as the basis in determinant of the LBM technology adoption.

The findings also indicated that developer firms will adopt the LBM technology in their projects because the system is easy to use and has relative advantages. Ease of use and relative advantage are driven by factors namely the readiness of the organization, external support, and facilitating conditions. Therefore, the firms need to enhance their resources, external supports and required a policy and regulations when utilization the LBM technology.

Consequently, this model also valuable for the other industry players, policy makers and government agencies who plan and intention to implement the LBM technology in the construction works.

Despite that, this study has a number of limitations and can be useful for future research. The result indicated that relative advantage, perceived ease of use, organizational readiness, external support, and facilitating conditions influencing on the LBM technology adoption. There is need to investigate the other factors such as knowledge of construction stakeholders, quality of the product, organizational culture, and customer demands. Since this research focused on adoption of the LBM technology, future studies could look into organizational performance of firms that implemented this technology in their construction works.

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CHALLENGES IN TECHNOLOGIES AND INNOVATIONS ON MAINTENANCE OPERATION OF BUILDING ENVELOPE FOR HIGH-RISE BUILDING

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Abstract
High-rise building mostly designed in curtain walling confront with troubles during maintenance operation. A high risk in manual and semi-manual operation facing the issue in dealing with technology, expertise, equipment and environment collision is the main agenda of this study. Perhaps, this study will promote a new approach by reviewing the challenges in building envelope's maintenance operation in technologies and innovations for high-rise building. Nevertheless, some of the architects and engineers overlooked on its maintenance operation especially on building façade-cleaning works during design process. Thus, it has stretched an impact to the future maintenance workload and affected to others building maintenance aspects. Therefore, this research purposely to analyse on the difficulties in maintenance operation on building envelope faced by building maintenance management department, contractors, and architects through the closed interviews session. At the end of the research, the best practice of building envelope's maintenance operation on high-rise building is determined and this study may leads to the innovation opportunity and potential in maintenance operation for a better practice.

Keywords: *Building envelope; Challenges; Maintenance operation technologies and innovations*

INTRODUCTION

Building envelope is a skin to a building representing the appearance and image of the landlord. It is functioned as a physical separator between exterior and interior elements to protect the occupants from the external disturbance of the building. Furthermore, this element do protects the building against intruder and provides privacy to the user (Kim et al., 2007). This component also play roles in controlling the environment impact from penetrate into the internal of the building such as moisture diffusion, noise control, fire safety, natural lighting, natural ventilation and thermal transfer (Ramesh Kumar et al., 2017).

Curtain walling are the most popular method to construct building envelope particularly to the high-rise building due to its aesthetic design. Every types of building envelope requires a periodical maintenance to ensure the cleanliness of the building façade and this building component shall be accessed for maintenance operation works (Moon et al., 2015). The building façade design ought to incorporate with the maintenance planning and programme and this works should be done by applying the maintenance friendly element (Herzog, 2008; Andy, 2015; Olusegun et al., 2015).

The current building facade access system for maintenance purpose by using manual system such as rope access, cradle access, boatswain chair, and autonomous robot. However, each of this system has its own advantages and disadvantages.

The building design and maintenance on building envelope issues are staggered due to the miscommunication between design process and operational process that involed with

different parties. There are six major problems for maintenance operation technologies and innovations on building envelope (Elyna Myeda et al., 2011). This problem generally increases the difficulties on maintenance of building façade that cause to the maintenance operation technologies and innovations when it is difficult to reach the specific area on building envelope. The difficulties developed when the building own a stepped or ribbed façade, concave or convex curve elevation, additional elements on building façade such as extended balcony and sun shading panels, slope with inward or outward design, additional attachment such as CCTV or signboard, and recessed windows; that provoke the limitation in maintenance operation technologies and innovations to perform their basic function (Elyna Myeda et al., 2011). Consequently, the challenges of maintenance operation technologies and innovations would be identified within the scope of façade access system faced by design and maintenance teams to provide the best maintenance operation technologies and innovations practice for better building envelope in the future.

LITERATURE PREVIEW

There are four main types of wall construction for a building envelope. They are load bearing wall, infill wall, concrete cladding, and curtain walling (Sanders, 2006). However, this research will be focussed on curtain walling system. Curtain walling is an external non-load bearing wall supported by building frame. Normally, curtain wall is built based on the building form and pattern. The basic building forms are centralise form, linear form, radial form, clustered form, and grid form that are designed by the architect's creativity (Ching, 2014).

Every building has to be maintained due to the high content of dirt, debris, and other harmful mineral deposits in the air. Therefore, the building maintenance is needed to ensure the clealiness of the surface external and internally least once a year (Puķīte, I., & Geipele, 2017). Low rise building can be easily reached to all part of the building envelope by using sky lift crane, ladder, or temporary platform. However, those techniques are not applicable for the high-rise building due to the reasons of high risk, time consume and safety aspect. Thus, building façade access system are introduced to access the building envelope for maintenance operation (Herzog, 2008).

Façade access system can be divided into 4 types that are rope access system (Andy, 2015), boatswain chair (Sala, 2012), cradle access system (Apollo, 2016), and autonomous robot (Moon et al., 2015). Nevertheless, the façade access is designed to fulfil some of the criteria such as safety, climate, operator friendly design, code requirement, architecture and complexity of façade, and equipment storage. These criteria are alligned for façade access design for safety occupation purposes (Herzog, 2008).

Generally, rope access system required track system, eyebolt anchor, or davit arm for hanging purposes (Olusegun et al., 2015). For boatswain chair, it will need two anchor points and fall arrest system and working line (Sala, 2012). Furthermore, cradle access system will need monorail system, or davit arms as supportive system. Whereas rope restraint system, and mullion rails are generally used to stabilise and guide the cradle to move vertically on the building envelope (Olusegun et al., 2015). Autonomous robots are invented to increase the efficiency and effectiveness maintenance on building facade. They can be divided into QMST robotic cleaning, building façade maintenance robot system (BFMR), and kinematics model

of the climbing robot, pure water window cleaning system / Sky Thruster, and sky cleaner (Moon et al., 2015). Every types of autonomous robot will need different types of supportive hanging system depending on the autonomous robot design (Moon et al., 2015; QMST, 2015; Zhang et al., 2006).

Although there are many types of façade access system to maintain the building envelope, however the difficulties are confronted by different parties. The architect has to face the issues arised into his idea and the principles of building envelope design in order to fulfil the needs of comfortable working environment in the building (Ted, 2016), besides of dealing with the creativity and client's needs. However, some of the design caused to the complications in maintenance operation technologies and innovations such as lack of skill and experienced operators, bad weather, complicated equipment, building shape and pattern.

The major problems for façade maintenance are the weather, building shape and pattern. Failure of weather prediction may lead to crash again the building envelope, drop of tools, tangled ropes and increase difficulty of movement (Thorin, 2011). While the building with stepped façade or ribbed façade, concave or convex curve elevation, additional design on building façade such as extended balcony and sun shading system, slope with inward or outward design, additional attachment such as CCTV or signboard, and recessed windows are increasing the difficulties and limitation access (Elyna et al., 2011) in the maintenance operation technologies and innovations. As a result, external high-rise building become the world most challenging task in maintenance with a high risk (BBC, 2014).

The persons involve in this area and expertise ought to follow the requirement in Department of Occupational Safety and Health Malaysia (DOSH). Generally, it states that there are eleven workplace safety requirements for the workers as it can assist on minimising the accident to occur. It is to provide a guideline on ensuring public safety during the work commissioning. Moreover, DOSH also provides a checklist on maintenance work for the architect, engineer, contractors, and maintenance management department. It has clearly written on the safety requirement in a higher workplace (Department of Occupational Safety and Health, 2007).

METHODOLOGY

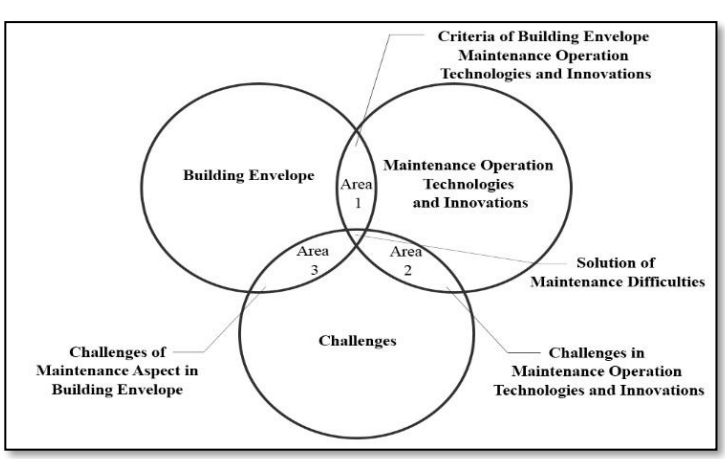

Figure 1. Theoretical research framework

The three circle represent the main focus of this research. They are building envelope, maintenance operation technologies and innovations, and challenges. This conceptual framework connected with three main focus and form a relationship between the basic components. The interconnected part of the three circle are the core of this research finding. It emphasises on the research and indicate the pathway for complete the research finding (Clinical-Community Relationships Evaluation Roadmap, 2013).

Research Process

There are three main focus in this research. The information are collected through literature review and guided interview session. The three components of main focus for this research are shown below:

Building envelope: There are many types of building envelope such as curtain wall, concrete cladding, infill walls, and load bearing wall. However, curtain wall are the main focus for this research and becoming more popular in the country. It is purposely to define the characteristic of the building envelope designed by the architect.

Maintenance operation technologies and innovations: The maintenance operation aspects in the building and methods of maintenance used to clean building envelope. It is identified through the interview session with high-rise building maintenance contractors and expert.

Challenges: Challenges are the difficulties face during the periodical maintenance. This is collected from the maintenance department though the interview session.

However, the area of intersection of two major circles show the relationship between two major focus. This area is to identify the relationship between two main focus as a gap of the study. The interview has to be carried out to obtain the data for each following (Clinical-Community Relationships Evaluation Roadmap, 2013):

Area 1	Creteria of Building Envelope Maintenance Operation Technology and Innovation.
Area 2	Challenges in Maintenance Operation Technology and Innovation.
Area 3	Challenges of Maintenance Aspect in Building Envelope.

Figure 1 shows the intersection of three circles that produce the criteria of each interrelated area between three main focus that produce the substance criteria in Area 1, Area 2 and Area 3. The center intersection represent the key elements of solution in maintenance between the focus criterias and substances criterias. This will contribute to the finding of the research (Clinical-Community Relationships Evaluation Roadmap, 2013).

There are two vital approaches that being used in this research to collect the relevant and reliable data. These approaches are literature review that leads to the guidance interviews (The Guidance Interview - Techniques). Based on the Figure 1, it clarifies on every main focus in the circle that shows the responsibility in their commitment and decision making. Normally, the architect will be responsible on decision making in design stage, familiar with building envelope design criteria and characteristic. However, the maintenance is carried out by the

contractors. They acting to use and operate the maintenance operation technologies and innovations. Subsequently, they are qualified to respond on high-rise maintenance operation technologies and innovations due to the eligible experience. In cooperate to perform the maintenance on building facade, the maintenance department play a vital role on selection and monitoring the contractors. The supervision by maintenance department who in charge in the high-rise building envelope maintenance is also be nominated to answer the interview questions to react on challenges in managing maintenance operation works by the contractors.

RESULTS AND FINDING

Building Envelope

These experts mastering on design and usually their creativity is a scale of its achievement. Table 1 shows that the architects creativity and tendency in designing buildings through their experience. However, the decision is cooperated with their clients along the design process.

Common Building Form for High-Rise Building

Table 1. Shows the architect decision in designing building.

Building form		
Respondent	**Codes**	**Descriptions**
Respondent 1	(Linear form)	This type of design are stable and easy to design.
Respondent 2	(Clustered form)	Mix development with podium
Respondent 5	(Clustered form)	KLCC twin tower
Respondent 6	(Linear form)	TNB Dua Sentral

On the other hand, the architects are aware on the importance of the high-rise building façade access system to entertain the maintenance operation utilities. Its implementation on building design to allow the maintenance operation technologies and innovations on the building envelope is challenging them whereby some of the design characteristic against the maintenance competencies. Consequently, the architects are mostly will concentrate their creativity on building design and this difficulties will be delivered to the engineer to solve the problem on maintenance issues. Therefore, there is the lack of communication between building design and practical operation. However, the architect habitually authorised and dominated the decision, however the expert of façade system options should collaborates and reflects to the design determination (refer to Table 2).

Maintenance Practice in Building Envelope in Design Stage

Table 2. The awareness in maintenance operation during design stage

Respondent	Codes	Descriptions
Respondent 1	Yes	
Respondent 2	Yes	All solutions will be well thought out by Façade engineer to provide every possible solution to maintain the façade as design onset.

Generally, the architects are aware on maintenance operation difficulties caused by their creativity. This complexities will be faced by the maintenance departments and contractors without bothering the building form, design and shape of the building. The concentration on high-rise building with convex or concave elevation, and the building with cornices are the

most difficult elements maintenance operation that confronted by them. There are two ways to solve the unreachable external building façade. Most of the contractors will try on the extended telescopic davit arms for the fragile building aesthetic components such as glass, ceramic, louvers and so on. The telescopic davit arm can extend further to avoid contact of the fragile materials on building façade. Nevertheless, this telescopic davit arm only can be used for gondola system which only allow for vertical top to down with repetitive maintenance operation.

As a result, the second solution to be used on special building shape and form design such as convex, concave elevation or cornices design. The desire solution involves with the combination of both method that is gondola and abseiling systems. This technic requires a high level of trained workers with special skill as they need to swing themselves to get to the nearest surface on the building envelope. Table 3 shows the solutions is taken consideration and attention during design stage.

Table 3. Challenges and solution for building envelope design

Respondent	Codes	Descriptions
Respondent 1	(Consider about maintenance)	Rotating BMU arm is difficult to estimate and it needs some special design. Solution; Change the design for many times due to the issue keep on appearing.
Respondent 2	(Consider about maintenance)	Every effort will try to enable building maintenance system to be used for future maintenance. Solution; Building form to suit the building maintenance system so that every possible solution is able to cater for future mechanical maintenance. Usually, all solutions will be well thought out by Façade engineer to provide every possible solution to maintain the façade as design onset. In case of area of difficulties to use the mechanical mean, human abseiling team to be used from the top of building.

Due to the critical difficulties involve in façade maintenance operation, the cost to ensure the cleanliness of this building envelope is considered high. This will lead the maintenance department to plan the maintenance programme and effected the financial management in performing maintenance operation to clean the building envelope from twice a year to once a year.

Table 4. Kind of building design that can increase the difficulties of Maintenance operation.

Respondent	Codes	Descriptions
Respondent 3	(concave or convex curve elevation)	The high linear building design with curvy shape. Solution; For curve building, swing and attach to the wall to reduce the gravity. The workers need to expert in using the technique of rope access.
Respondent 4	(concave or convex curve elevation)	Building designed with curve or cornices
	(additional design on building façade)	Building designed with curve or cornices
Respondent 5	(concave or convex curve elevation)	The building designed with curve. For example, the UEM tower which has curve on top of the building or YTL HQ.
	(additional design on building façade)	The building which has cornices at unexpected area. For example, the UEM tower which has curve on top of the building or YTL HQ.
Respondent 6	(concave or convex curve elevation)	The skyscraper especially those in curve and unique design.
	(additional design on building façade)	Cornices are also one of the design that difficult for maintenance operation.

In Table 4, it indicates the character of building design that can increase the difficulties of maintenance operation. The respondents that is contractors and maintenance department agree that the building designed with concave, convex curve elevation and cornices will increase the difficulties of the maintenance operation.

Table 5. Performed the precautions to overcome the obstacle in maintenance operation during design stage.

Respondent	Codes	Descriptions
Respondent 3	(Change technic)	Combined both system (gondola and rope access) to achieve maximum usage of techniques.
Respondent 4	(Change technic)	Combine both system
	(Other solution for obstacle)	Use extended davit arm.
Respondent 5	(Change technic)	Combination of both gondola and abseiling will help to solve the problems. Most of the issues is solved with this method
Respondent 6	(Other solution for obstacle)	All can be done by using gondola system as the building design is not too complicated.

Table 5 shows the options in maintenance operation to overcome the complexities during design stage. Most of the respondents choose to overcome the hitches through the extended of davit arm as it can be extended to the building envelope. While the telescopic davit arms is not practical to solve the difficulties to reach the complicated area. The best methods for maintenance operation from all respondents is the combination techniques between abseiling and gondola system.

Maintenance Operation Technologies and Innovations

The most popular in maintenance operation technologies and innovations in Malaysia are rope access system, abseiling, cradle access and gondola system. This data can be represented as the whole for Malaysia due to the data collected are from the largest city of Kuala Lumpur. Kuala Lumpur is the most progressive city with the latest technology revival compared to other cities in Malaysia (Soriya Yin, 2016). Therefore, Figure 2 shows that the most applicable techniques in maintenance operation technologies and innovation apply in Kuala Lumpur and representing Malaysia as a whole results. From this graph, abseiling is a manual methods used to reach to the building façade that cannot be attained by mechanical systems. This methods as the second preferable after gondola systems. However, the gondola system is suitable for the building that need a repetitive cleaning from top to bottom of the façade which is mostly used in many high-rise building in Kuala Lumpur. This is because most of the high-rise building in Malaysia designed in linear form with repetition designed.

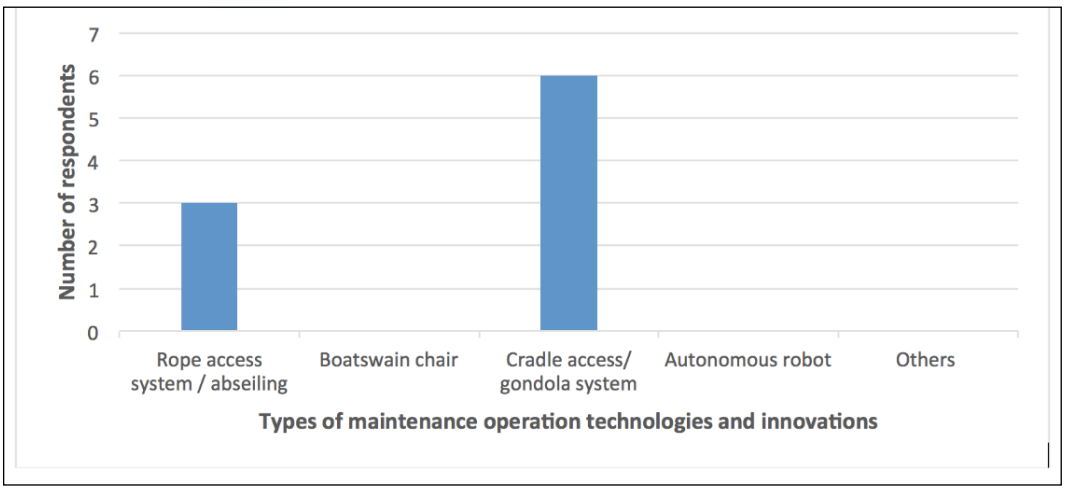

Figure 2. The application on maintenance operation technologies and Innovations

The height of the building should be considered in maintenance; to plan and calculate for the gravity and force which may apply on the system itself. It affect the length of the rope that will be used during the façade maintenance operation. The maintenance design aspect on the building roof top and façade is the highest consideration before using the façade access system. Every maintenance aspects such as anchorage points, fixed base davit arm, windows anchors, double rails, and the maintenance access must be identified by the contractors. These are the main criteria's that should be respected in decision making before determining the planned for effective maintenance operation, technic and equipment, time consume, skill workers, safety requirement, manpower and cost consume before taking responsible in maintenance procurement.

The challenges in maintenance operation technologies and innovations are still keep on going until today and some of the problem stay unsolved. The abseiling methods confronted with the problem of the fixing point design which are only suitable for the designated façade area on the roof top. It requires a special platform for safety purpose for each area.

The gondola system faced six major issues which is required for attention that is the machine, the clearance of the davit arm, size of gondola system, storage design, building aesthetic purposes and the clearance of the davit arm which has to be carefully designed. It is significance to allow the gondola to function for each part of the building façade. The other challenges is the number of davit arms needed to hang and support for the gondola system. Numbers of davit arms are important to allow the façade maintenance operation run in parallel whereas it will affect the time consumes in maintenance operation.

Furthermore, building design and shape supposedly communicate throughout the building operating period. The gondola system can only allow for vertical movement and it is not flexible for convex or concave elevation. In addition, the davit arm is needed to move from fixed base to another in each time during cleaning.

Weather is the greatest challenge in both abseiling and gondola system during the maintenance operation work. It will affect the maintenance by increasing the risks and difficulties in maintenance. The safety requirement provided by DOSH has strictly written

that the maintenance work should be halt to ensure that every individual are safe in workplace. Therefore, this system is facing with a high risk operation in unpredictable weather.

As a conclusion to the building maintenance aspect for building envelope, the elements of maintenance access, anchors, window anchors, davit arms, and double horizontal rails are needed for a high-rise building. Figure 3 shows the element in building maintenance aspect should be applied in high-rise building towards building envelope. The davit arms is the most applicable for every building envelope design for high-rise building. The maintenance access must be easy access to the building façade by providing a safety access such as door and ladder. The anchors and windows anchors are used in abseiling system and it is flexible to the tie back for the gondola system, while windows anchors is used to stabilize for gondola system. Davit arms and double horizontal rails are used for gondola system. Davit arms is used to hang and support the gondola when it has to extend out of the building form. While the double horizontal rail is applicable for the horizontal movement of gondola system.

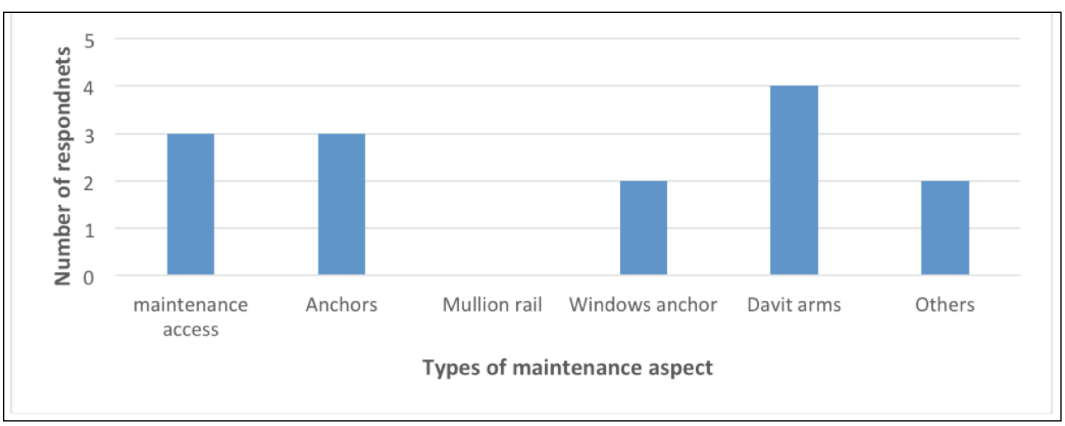

Figure 3. Building envelope maintenance aspect used

The architects have faced these complicated issues to conceal the maintenance elements from the stakeholder's perspectives due to the reason of personal interest. The awareness on maintenance operation in design aspect should be cleared as it may affect the stakeholders' decision to suit the maintenance operation technologies and innovations application.

The challenges

There are few difficulties that frequently faced by the workers during the maintenance operation. The problems are handling maintenance through the building shape, weather, lack of experience and training of the labours, and time consume to obtain the permit. The unpredictable weather is the most challenging during deciding the maintenance planning and operation. This factor may lead to the suspended operation due to the safety factors.

The lack of training or experience among the worker will cause to the most high risk work in maintenance operation. Therefore, the workers should be trained and exercised to overcome the fears on height and healthy assurance beside of controlling the system, handling tools and safety aspect. The communication in two ways system sometime will reach their limitation of loss functioning or out of connection. It is a bad situation during emergency cases and may lead to an injury and accident.

Moreover, the permit to work prepared by the maintenance department are consuming some time as they need to ensure that all the equipment are safe and follow the procedure before the contractor in charge signing the permit. The crucial issues such as building shape, the convex, concave design or cornices requires a special skill to handle the operation.

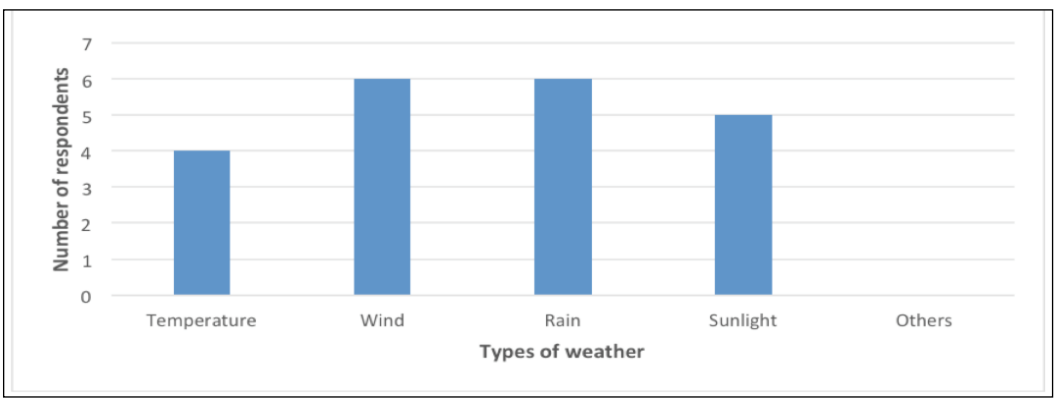

Figure 4. Weather consideration for high-rise external maintenance work

According to Figure 4, most of the respondents mentioned four types of weather that contributes to difficulties in maintenance operation; they are selected which is temperature, wind, rain, and sunlight. The high temperature caused to the heat abortion and reflection on the surface of the building façade materials that may produce a high temperature on building envelope. It also affect the workers mental and physical as the body metabolism will increase than normal temperature.

Wind is another serious problem for the façade maintenance. The wind speed factor may swing the gondola and rope access system. The wind that exceed 15km/h speed will force the operation to stop. However, DOSH has clearly stated that a safe condition of the wind speed for operation is not exceeding 32km/h. besides, the heavily rain or thunderstorm also will cause the work to stop.

In addition, the common materials that is glass and aluminium for high-rise building envelope will result to the sunlight reflection. This will cause to glare on eyes of the workers during the maintenance operation. Therefore, this operation will be performed by concerning the sun direction to avoid the sunlight reflection onto the eyes of the workers.

DISCUSSIONS

The three main focus of this research which are building envelope, maintenance operation technologies and innovations, and challenges found that most of the high-rise office buildings are constructed in curtain walling system due to its aesthetical design. The main materials of curtain wall commonly used for these buildings are glass and aluminium. The common design for high-rise office building is in linear or clustered form due to the reasons of stabilities and easy to maintain. This research found that there are two main maintenance operation technologies and innovations used in Malaysia. They are rope access system/abseiling and cradle access system/gondola system. These maintenance operations technologies are widely used in the country especially cradle access system/ gondola system for façade maintenance. Gondola system are commonly used to a linear form building design. Rope access system are

used to reach the area that is unreachable by the gondola system. However, this system will require a high experience and trained workers to perform this skills. The contractors state that the most common difficulties are; to find the experience and skills-workers, training program, fail to predict the weather, to fulfil the safety requirement, problem in communication system, building shape, building materials, building envelope inspection, replacement material or element on building facade and lack of maintenance design elements on the building envelope. Each of this challenges can lead to another major issues that may cause to a high cost of maintenance operation, special maintenance systems design, custom made on special designated material and specialist contractors. Figure 5.1 indicates the conceptual theoretical research framework of this study. It has totally shown the whole finding of this research.

Challenges in Technologies and Innovations on Maintenance Operation of Building Envelope for High-Rise Building

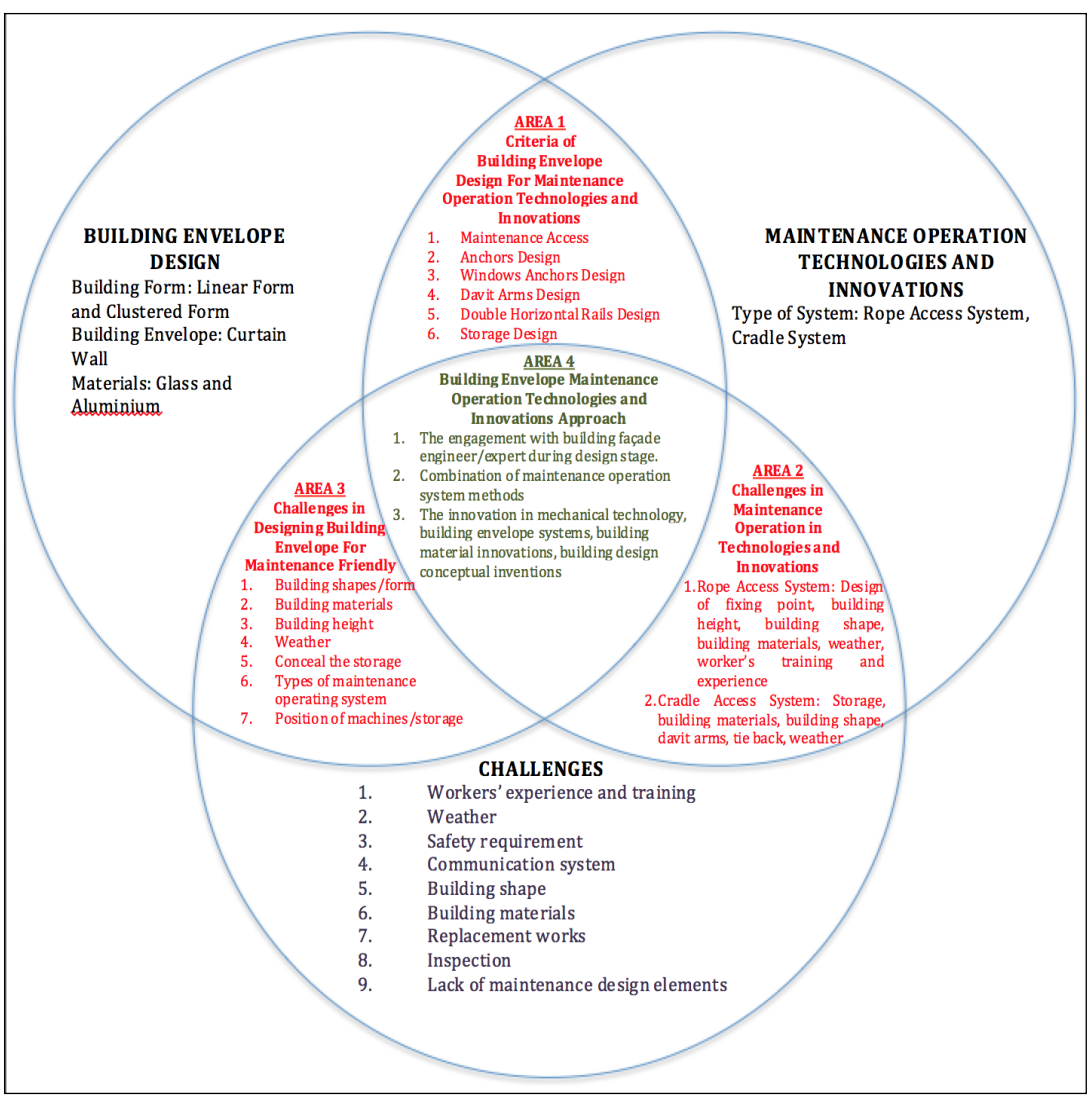

Figure 5. Conceptual theoretical research framework

Area 1 show that the criteria of building envelope maintenance operation technologies and innovations. This research found that the building envelope should perform this six maintenance criteria's which are maintenance access, anchors, window anchors, davit arms, double horizontal rails, and storage. Each of them are vital for the cradle access system and rope access system. This criteria's communicate between building envelope design and system that used in maintenance operation technologies and innovations. Therefore, a minimal difficulties and issues could be solved by allowing this element into the building enveloped design.

The challenges in maintenance operation technologies and innovations is stated in Area 2 result to two different systems are commonly used for façade maintenance operations. There are two options which leads to a different challenges in maintenance operation technology and innovation.

Rope Access System

The result shows that fixing point, building height, building shape, building material, weather and workers' training and experience are the challenges in using this system.

Cradle Access System

The challenges are storage, building materials, building shapes, clearance of davit arms, and number of davit arms, tie back and weather in handling this system.

Another challenges faced by the architects in designing building envelope for a maintenance friendly is specified in Area 3. The architects ought to entertain the maintenance aspects that are conceal from view (for a huge maintenance machines), the maintenance system consideration for building envelope, and position of machines related in maintenance work. The three challenges are coordinated with the building shape, building materials, and building height to achieve a maintenance friendly design. In addition, consideration on the building orientation to reduce the wind preasure during maintenance operation is highly recommended.

This research defined that there are three approach for building envelope maintenance operation technologies and innovations approach based on the difficulties defined in each section. The first solution is through delegating or concerning the façade access system and solution in building design by inviting the façade engineer and expert to perform in maintenance engineering design during design stage. This can minimise the complexities on the building envelope in maintenance access system.

The combination methods such as rope access system and cradle access system are considered as the perfect match to suit their strength and weakness in maintenance operation system. The application on these systems however may affect to the maintenance operating cost as it is required the skilled operators to handling the work.

Furthermore, variety on maintenance innovation in mechanical technology, innovation in building envelope systems, building materials innovation and the invention on building design conceptual towards free maintenance could solve the challenges between three major issues

in maintenance operation technology and innovation. These approaches are defined by capturing the problems and challenges in Area 1, 2 and 3. It is believe to reduce the cost of the maintenance, operation, risk and safety issues. However, it has not yet been reviewed on its effectiveness.

Although the building envelope maintenance access system is essential to a building, the architects are eager to perform their creativity without placing the maintenance aspects as priority. Therefore, the building maintenance unit should serve their creativity by creating solution or leaving the unsolved problems. This will burden to the stakeholders which that own the image on the property and management in the future.

CONCLUSION

Building form is not a vital structured design and yet the building shape and pattern are the most concern in the maintenance technologies and innovations. Building design such as convex or concave elevation and cornices design are the most difficult to access during maintenance operational works. In addition, the materials used on the building envelope also causes to its difficulties. The brittle materials for aesthetic purposes are suggest to minimise the maintenance risks in designing building façade access system.

There are many types of maintenance operation technologies and innovations on building envelope for high-rise building. It is now faced a lot of challenges in maintenance aspects such as maintenance elements provided on the building, distance between the maintenance elements, building shape and design, availability of storage, safety requirement, the workers' personalities and skills, and weather. Most of the problems can be solved through the building design at earlier design stage. However, this approach may not limit the creativity of the architects to perform their art work. Nevertheless, the importance of maintenance aspects are crucial to ensure that the building can be operated appropriately.

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PROCEDURES AND IMPLEMENTATION OF DEFECT MANAGEMENT IN MALAYSIAN PUBLIC PRIVATE PARTNERSHIP (PPP) UNIVERSITY PROJECTS

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Abstract

Building condition assessment is essentially required to evaluate building defects that affect payment mechanism as prescribed in the performance based output specification. Disputably, empirical studies that investigate defect management in Public Private Partnership (PPP) projects are still scant. Therefore, the study reported in this paper intends to identify the key factors of defect management procedures and their implementation in Public Private Partnership (PPP) university projects that lead significantly to project performance and thus, develop a conceptual framework. Employing a case study method, this study drew on data gathered from 70 practitioners and academicians who participated in a brainstorming workshop conducted at a local university. Data were analysed using a software for thematic analysis, Atlas.ti. The findings disclosed several key variables of defect management procedures comprising coordination, compliance, resources and training, work process, benchmarking, commitment of management, skill and competency as well as monitoring. The findings of this study provide useful guidelines for policy makers, from public and private sectors, to improve on effective implementation of defect management for PPP university projects in Malaysia.

Keywords: *Defect management; Procedures; Public Private Partnership (PPP); Success factors*

INTRODUCTION

The 10th Malaysia Plan marks a progressive development of 28 Public Private Partnership (PPP) projects as reported by Public Private Partnership Unit (PPPU). Amongst these projects, the educational sector achieved the highest number of active projects with approximately 19 projects conducted by the PPPU. Most of these educational projects encompass construction of facilities at public universities including new campuses, hostels and training institutes. In principle, the nature of each PPP project is mainly guided by pre-determined performance based output (Javed et al., 2013). As such, many researches were conducted to scrutinize the issues concerning performance measurement mechanism, affordability and cost saving, effectiveness, efficiency, quality of service delivery, value for money and risk management (Ismail, 2011). However, there has been little study so far that focuses on defect management, particularly in regards to procedures and implementation.

Previous researchers have reported on issues related to defect management in PPP projects in Malaysia involving poor performance of defect occurrence, user's dissatisfaction on complaints procedure, inadequate facilities and service provided, quality of concessionaire work and lack of performance measurement (Oyedele, 2013; Lop et al., 2017). In addition, most of the public projects have reported on delayed completion and quality issues that impacted the government (Jayaseelan & Tan, 2006). A parallel example was highlighted by the City of Edinburgh Council (2017) on recent major incident at Oxgangs Primary School Edinburgh, on 29th January 2016, where a part of an external wall was collapsed. Subsequent

inspection of defects in the construction of external wall for another 16 schools in Edinburgh were carried out immediately. This has resulted an enforced closure of all 17 schools for up to five months for inspections and remedies, causing massive disruption to 8,400 people comprising students, teachers and parents. All these school buildings were built under the Public Private Partnership (PPP) scheme. In conjunction with this incident, the Royal Incorporation of Architects in Scotland (RIAS) has seriously advocated the importance of complying to building regulations, technical standards and inspection procedures which are in place to protect the public from fatal safety defects. This concurs with Javed et al. (2013) who acknowledges that PPP projects should procure performance based output specification to achieve value for money in which any defect occurrences would reflect payment mechanism.

Given the above-mentioned situations, this study will identify the key factors of defect management procedures and their implementation in Public Private Partnership (PPP) projects that are significantly related to project performance. The study will also reflect on the practices and implementation of Malaysian educational sector, specifically the university. Finally, the research findings will propose a basic conceptual framework.

DEFECT MANAGEMENT IN PPP PROJECTS

The term ‘defect’ is generally defined as a failure or deficiencies in regards to building functionality, performance, statutory or user expectation that occurs throughout the project implementation process (Pheng & Wee, 2001). It also refers to the shortcomings in design and construction practices including normal depreciation from wear and tear which causes reduction in value of buildings or services. According to Olanrewaju and Mohd Faris (2010), design and construction defects usually occur due to wrong construction methods, poor materials selection and quality of workmanship. They further explain that other causes entail building age and natural weather conditions. In addition, Mohd Isa et al. (2011) explicate that most commonly reported defects are the results of inadequate specification, wrong materials selection, quality of workmanship and supervision factors, while wrong design selection could also contribute to building defects. Gahlot and Sharma (2006), however highlight that defects are also caused by lack of good maintenance practices and usage. Failure to manage defects would affect the cost of repairs and smooth buiding operation, reduce service life and cause serious disasters in certain situations (Kian, 2001).

Building defects are usually classified as 'patent' and 'latent' defects (Rhodes & Smallwood, 2002). ‘Patent defects’ can be clearly identified through inspection during construction and Defect Liability Period (DLP) while ‘latent defects’ occur after the building is occupied. However, Atkinson (2002) delineates defects as ‘physical defects’ and ‘process defects’. ‘Physical defects’ are caused by project documentation, incompliance with industry practice, failure to fulfil user’s requirements and mismatch between material or structures and contract; while ‘processing defects’ occur during construction stage. After the construction stage, there is a period called Defect Liability Period (DLP) in which a contractor should improve any defects identified by a superintending officer after a work is practically completed. All defective repair expenses at this point should be borned by the contractor and no additional cost should be imposed on the government (Government Procurement Division, 2018).

The Total Asset Management Manual underlines the need for inspections to ensure that periodic assessment is conducted throughout the asset life cycle (Government of Malaysia, 2009). During the inspection, the use of matrix calculation is essential to provide precise explanation on the defects found that lead to time saving. By using the Condition Survey Protocol (CSP) 1 Matrix, scores for overall rating of a building can be determined either by good, fair or dilapidated (Che-Ani et al., 2011). The inspection indicates that architectural defect is the most common defect found as compared to electrical, mechanical and civil (Hassan et al., 2011). Such defect can manifest itself within the structure, fabric, services and other facilities of the defective building (Watt, 1999). Ahzahar et al. (2011) reported that blemishes (scaling, honeycomb), corrosion, damage of exterior surface, dampness, peeling paint, roof defects, cracking, spalling or chipping were among the features of defects found in their study.

To remedy these defects, it is important to be well-versed with the nature of project and contract document. The PWD203A (Clause 48), as stated in Malaysian Form of Contract, describes defect management procedures constituting after completion of a project until a certificate of making good defects is obtained (Government of Malaysia, 2010). Building Condition Survey Report (BCSR) is a mechanism that is deployed as a comprehensive report to inform developers of rectification works. If the developers fail to resolve the complaints, the same report will be forwarded to Tribunal of Housing Claim (Radzuan et al., 2011). However, in PPP projects the practices are slightly different. Hashim et al. (2017) revealed that the real practices of PPP projects were absence and there was no specific reference to defect liability due to the nature of project extended under performance based contracts. Table 1 shows various forms of PPP that are implemented globally indicating the roles of stakeholders in managing defects.

Table 1. Defect management current practices in PPP projects

PPP options	Ownership	Defect Management during Operation & Maintenance	Financial Responsibility
Build – Own – Operate – Transfer (BOOT)	Public	Private by concession	Private
Build – Own – Operate (BOO)	Private	Private by fee contract	Private
Design – Build – Finance – Operate / Maintain (DBFO/DBFM or DBFOM)	Private	Private by fee contract	Private
Build – Transfer (BT)	Public	No operation required	Public
Build – Operate – Transfer (BOT)	Public	Private by concession	Private
Build – Lease – Transfer (BLT)	Public	Private by fee contract	Private

Adopted from (Gambo & Gomez, 2014)

In order to improve PPP practices, Koru & Tian (2004), suggest the importance of defect management strategy in managing a project which can assist the project team to utilise data to understand the defect character for quality improvement. In general, defect management is essential for quality of construction and operation. This process incorporates site/building inspection, defect diagnosis, defect recording, keying the information into computerized system and communicating the information to respective people for corrective measures (Dong et al., 2009).

RESEARCH METHODOLOGY

A qualitative approach was applied in this study through a brainstorming workshop as the primary means of data collection. Creswell (2009), defines qualitative research as an exploration to understand the meanings from individuals or groups prescribing human or social problems. It encompasses emerging questions and procedures. In this research, case study was conducted as a strategy of in-depth inquiry in which the researchers explore participants' practices, procedures, process, programmes or activities. However, as suggested by Stake (1995), the cases are bounded by time and activity that enable the researchers to collect detailed information using a variety of data collection procedures. Figure 1 summarises the flow of qualitative research method applied by this study.

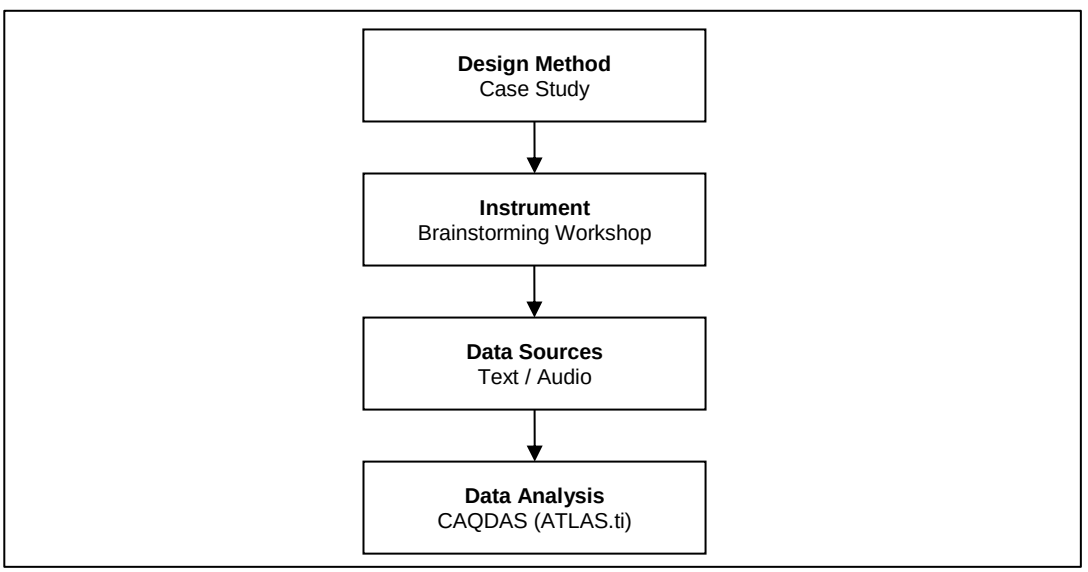

Figure 1. Qualitative research methods

An organised workshop was conducted on the 18th and 19th May 2017 at University X. The workshop was carried out to gain input, knowledge and ideas pertaining to issues, challenges, current practices and strategies during project implementation at University X. The workshop participants comprised of (i) experienced practitioners who are directly involved in PFI projects and (ii) academicians from the built environment discipline at the university.

A total number of 70 (77.78%) invited participants representing the practitioners (technical staff) and academicians attended the two-days workshop to discuss the three focus area (themes) namely: (i) sustainability; (ii) defect management; and (iii) key performance indicator (KPI). This study was only confined to internal discussion to seek the participants' perspectives without including the concession companies. The sampling selections were based on the participants' designation, involvement in PFI project, work experience, professional background, research and publication in PFI area. It can be justified that most of the participants have sound knowledge of PPP/PFI projects in Malaysia. Table 2 presents the profile of participants.

Table 2. Profile of Workshop Partcipants

Type of Participants	Expected participants (n=90)	Participants attended (n=70)	% of attendance
Practitioners (Technical Staff) Engineer / Assistant Engineer / Surveyor / Lawyer	48	35	72.92%
Academicians Associate Professor / Senior Lecturer / Lecturer	42	35	83.33%
Total	**90**	**70**	**77.78%**

The participants were divided into three groups. Each group comprised of 8 participants who were guided by 1 facilitator and 1 rapporteur. A set of questions on specific variables was provided to each group to allow in-depth discussion. Given a similar theme of defect management, the first group discussed on its procedures and implementation, the second group talked about documentation and stakeholders while the third group exchanged views on building defects. However, this paper presents solely on the report of defect management focusing on the procedures and implementation as illustrated in Figure 2. Two experts, one from a legal department and another one is a policy maker of PFI Unit, were appointed as panellists to evaluate on the output during the presentation session.

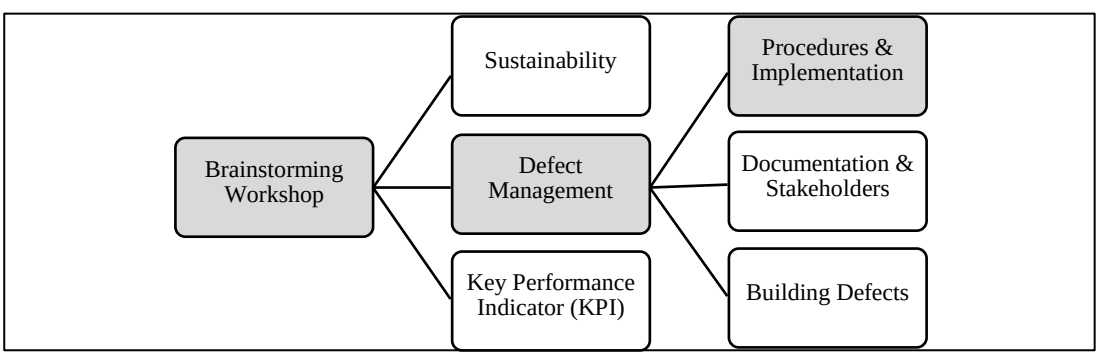

Figure 2. Scope of paper discussion (coloured in grey)

The outcomes of the workshop were processed through thematic analysis technique using Computer-Aided Qualitative Data Analysis Software (CAQDAS) known as ATLAS.ti. Thematic analysis, as defined by Braun & Clarke (2006), is a qualitative descriptive technique in organizing and describing data set in a comprehensive manner through a process of identifying, analysing and reporting the patterns (themes) within structured data. Hence, the analysis of this study was conducted using the process of familiarisation with data, generating initial codes, searching for themes, reviewing themes, defining / naming themes and producing a report. In this study, three codes were generated to group the inputs from the participants consisting issues, challenges and strategies. These inputs, which were based on the participants' current practice and experience, were grouped according to the relevant codes as explained in the findings.

FINDINGS AND DISCUSSION

Figure 3 illustrates the findings of the workshop. The outcomes are presented using a cognitive mapping (network diagram) as a technique to arrange complex data, structure ideas, explore relationships, ease understanding and illustrate visual presentation (Mohd Tobi, 2016).

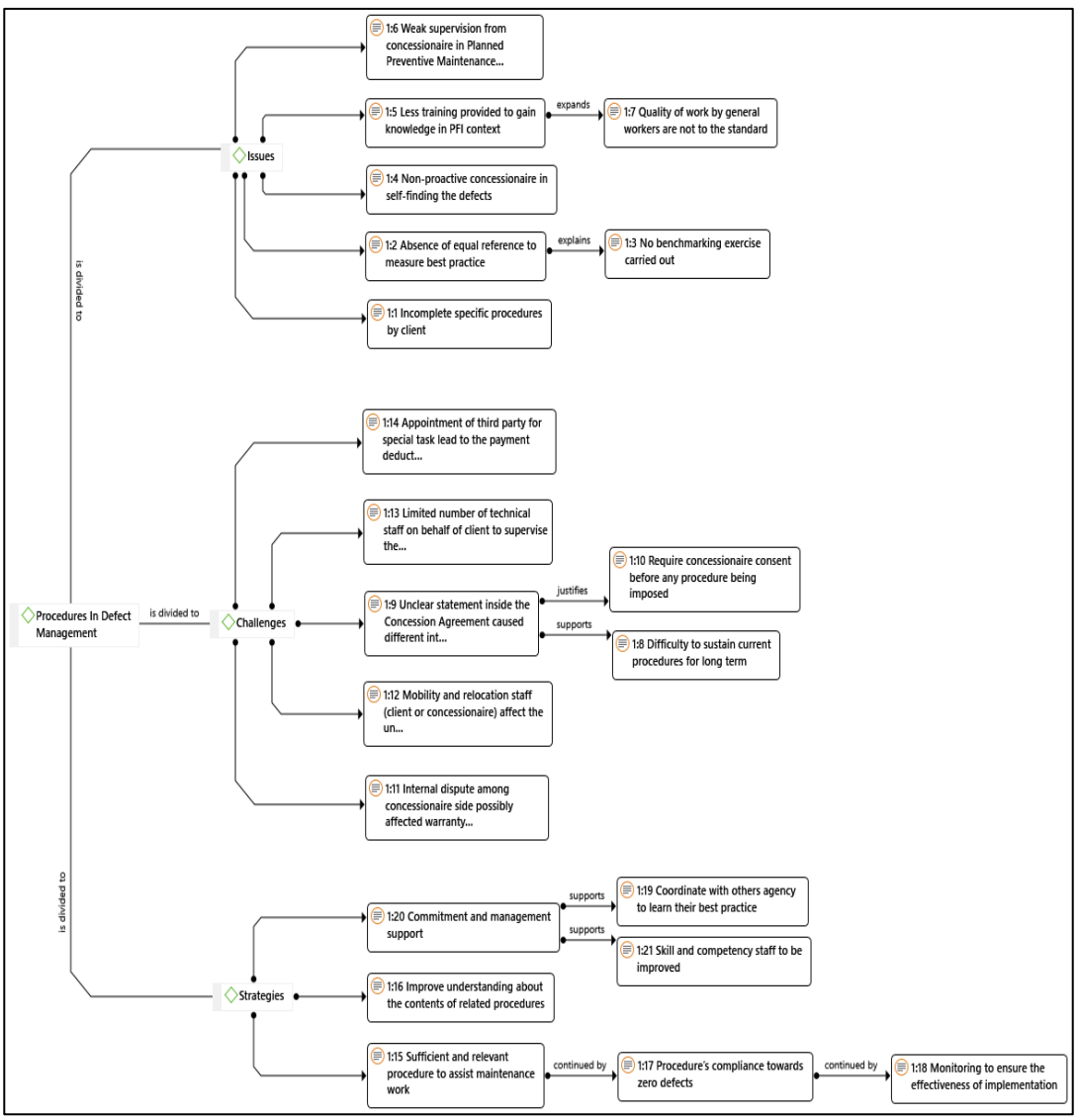

Figure 3. Network diagram shows the input from respondents

The network diagram above presents the input gathered from the participants on procedures of defect management which are divided into three codes namely issues, challenges and strategies. The numbers inside the nodes represent a group of participants who contributed their answers: number of quotations. In this case, number 1 is used for all nodes to show the answers given by one group of respondents. All together 21 quotations on the procedures and implementation aspects were recorded throughout the brainstorming workshop.

Table 3. Relations, tabulation and frequencies

Code-Code Relations				
Relation Types	**Usage**	**Comment**	**Formal Property**	**Symbolic Name**
is divided to	3	Establish a meta relation between a concept and its attributes.	Asymmetric	*}
Hyperlink Relations				
Relation Types	**Usage**	**Comment**	**Formal Property**	**Symbolic Name**
continued by	2	1:15 is continued by 1:17; 1:17 is continued by 1:18	Asymmetric	>>>>
expands	1	1:5 expands 1:7	Transitive	?
explains	1	1:2 explains 1:3	Transitive	?>
justifies	1	1:9 justifies 1:10	Transitive	!>
supports	3	1:9 supports 1:8; 1:20 supports 1:19; 1:20 supports 1:21	Transitive	*>
Cross Tabulation and Frequencies				
Codes			**Frequencies (n)**	
			Grounded (G:)	**Density (D:)**
Procedures in Defect Management			0	3
Issues			5	1
Challenges			5	1
Strategies			3	1
Groundedness refers to the number of linked quotations; Density counts the number of linked codes.				

Table 3 (ii) above shows the usage of hyperlink according to several types of relation. It is apparent that hyperlink uses the 'supports' relation to describe one node to another. Table 3 (iii) shows the grounded (G:) and density (D:) frequencies which are calculated inside each node. 'Issues' and 'challenges' get the highest G-count for a node which point to a more grounded data. On the contrary, 'procedures in defect management' marks the highest in the D-count for a node indicating a denser surrounding network.

Code No.1: Issues

The Public Private Partnership Unit (PPPU) is lacking on central procedure for defect management at the national level to cater for PFI projects in Malaysia. However, University X (case study) has taken an initiative to set up multiple sub-procedures related to defect management although it has not been fully completed (1:1). Currently, any unresolved issues caused by absence or unclear references will be brought forward to the Project Monitoring Committee (PMC) which will then determine its own procedures. Practically, all those procedures will be compiled under Work Procedure Manual (WPM). This manual is proposed by clients and it should obtain mutual consent of agreement from concessionaire to ensure the effectiveness of work process. For example, at University X, a few Standard Operation Procedure (SOP) such as "Maintenance Reserve Fund (MRF)", "Dilapidation/Obsolescence", "Unscheduled Failure" and "Beyond Economic Repair" procedures have not yet received any confirmation from concessionaire to proceed (1:10). Indirectly, this will take a longer time to

be implemented. Generally, no benchmarking process has been conducted for the SOP development except for reference to the Concessionaire Agreement (CA) (1:3). This is because of the uncertainty of finding a similar project to be compared to (1:2). In addition, the participants also recounted on limited training provided for current staff (1:5) which caused the low quality of workmanship (1:7). The concessionaire also reported lacking in self-findings of building defects (1:4) and weak supervision in planned preventive maintenance (1:6). They also delay the updating work order and remedial works which would reflect payment deduction.

Figure 3 summarises the significant issues related to defect management procedures and their relationship as reported by the participants. It is obvious that lack of areas are found stringently on the participants' contents readiness, source of references, supervision, pro-activeness, training and quality of service delivery. The findings coincide with previous study conducted by Pieters et al (2014) which discovered that first time participants in PPP projects encountered difficulties in identifying necessary documentation and procedures in a reasonable time. This was caused by the lack of successful standard measurement of PPP projects (National Union of Teachers, 2003) where there was no acceptable operational framework and standard agreement to be referred to (Kusljik & Marenjak, 2013). As consequences, the delayed / overlooked necessary documentation have caused a weak public institution in PPP projects (Solomon & Srinath, 2017) that could hinder constant compliance and good quality of service delivery by the private operators (Robinson & Scott, 2009).

Code No.2: Challenges

The participants also revealed several challenges that they encountered when dealing with defect management procedure and implementation. In daily operation, they work with Computerised Facility Management System (CFMS). However, several elements inside the CFMS such as infrastructure, information communication technology and landscape are malfunctioned which then caused difficulties in analysing the work order and preparing performance report. In terms of manpower, staff mobility is perceived as one of the key challenges as the relocation of staff and new recruitment (both staff from client and concessionaire) lead to lack of understanding of concession agreement (CA), appendices and other documentations (1:12). Furthermore, the uncertainties of certain clause (grey area) in concession agreement (CA) for example on general duties, maintenance works, maintenance service level, additional works and default by concession company allow misinterpretation of compliance among stakeholders (1:9). Other challenges include insufficient staff or client to monitor maintenance work (1:13), internal issues from the concession side such as dispute issues that could jeopardise clients' warranty claim (1:11) and appointment of third party for special task lead to payment deduction as well (1:14). Since the contract has been prolonged for about 20 years, it has difficulties in maintaining reasonable procedure to sustain in the long term (1:8).

In line with the findings above, Solomon & Srinath (2017) state that the challenges faced in managing operational PPP projects are usually influenced by several factors such as managerial capabilities of the concessionaires, poor technical aspect, weak public institutions, weak legal framework and unstable policy respectively. Abd Karim (2011), has classified all possible challenges according to risk attribute into 10 groups namely political, economic, legal, construction, operation, project selection, project finance, market, relationship and

natural factor. In order to overcome the above challenges, it is important to respond immediately to users' concerns on operational defects and rectify reported operational problems (HM Treasury, 2006) as well as establish a clear resolution method to address disputes between stakeholders (Hwang et al., 2013).

Code No.3: Strategies

To improve current procedures of defect management, the participants were concerned on these following aspects; procedures should be revised regularly to suit with the current changes due to long term contractual agreement, improve understanding about the contents of related procedures (1:16), Computerized Facilities Management System (CFMS) must be fully functioned and utilized, skill and competency of staff to be improved (1:21), commitment and management support (1:20), revision of the Concessionaire Agreement (CA) at the national level for standardization of those who are involved with the Ministry of Higher Education (MOHE) and Public Private Partnership Unit (PPPU) (1:15), moving towards defect minimization (1:17), collaboration with external agency for benchmarking (1:19) and monitoring aspect to ensure the effectiveness of implementation (1:18).

The input from the participants mirror the findings reported in previous researchers in this area. Robert Osei-Kyei et al., (2017) indicate that in managing operational PPP project, suitable stakeholder management mechanism and consistent project monitoring are among the factors of successful projects. Li et al. (2005) adds that social support, good governance, committed public agency and sharing of power between the public and private sectors (coordination) are among the success factors. Furthermore, Almarri & Boussabaine (2017) highlight the importance of understanding the multi-benefit objectives of stakeholders and recommend the stakeholders to make informed decisions according to most significant success factors. HM Treasury (2006), also suggests periodic evaluation and assessment of service delivery, employing qualified and skilled expertise in service operation, focus on resources and training in a contract life and developing specific guidance for public sector for benchmarking.

Figure 4 shows eight factors that has a significant relationship between defect management procedures and project performance. This conceptual framework concurs with the input from the participants and the literature. The framework support Goran Mladenovic et al. (2013) who believes that the ultimate goal is to sustain project performance of PPP projects that could be influenced by a number of factors and their interactions during project life cycle.

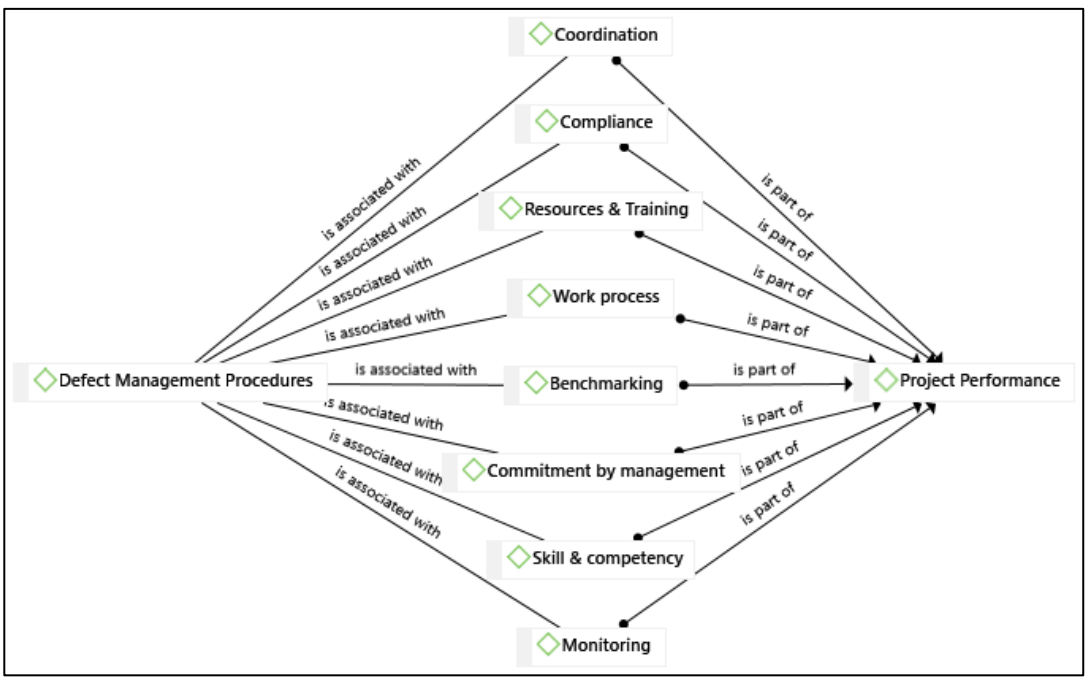

Figure 4. Conceptual framework of defect management procedures and implementation for PPP project

CONCLUSIONS

The findings of this study provide evidence on the procedures of defect management in PPP university projects that encounter several issues and challenges in the aspects of implementation because of the absence of appropriate guidelines and references. The liability goes to the clients (public sector) in preparing their own procedures to protect their rights while the concessionaire (private sector) will be affected through the payment deductions if they cannot comply with the agreed standard. The eight factors were identified as contributing factors to project performance comprising coordination, compliance, resources and training, work process, benchmarking, commitment of management, skill and competency as well as monitoring. It is recommended that policy makers at national level will be able to justify the needs of performance requirement on service delivery in terms of defect evaluation and monitoring by developing a realistic guideline or procedures to be referred by stakeholders who are involved in PPP university projects. In terms of the direction of future research, it is targeted to investigate other aspects of defect management in PPP university projects such as documentation, stakeholders, condition assessment, key performance indicators and dispute resolution. It will further continue to develop a defect management framework for PPP university projects specifically in Malaysia.

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