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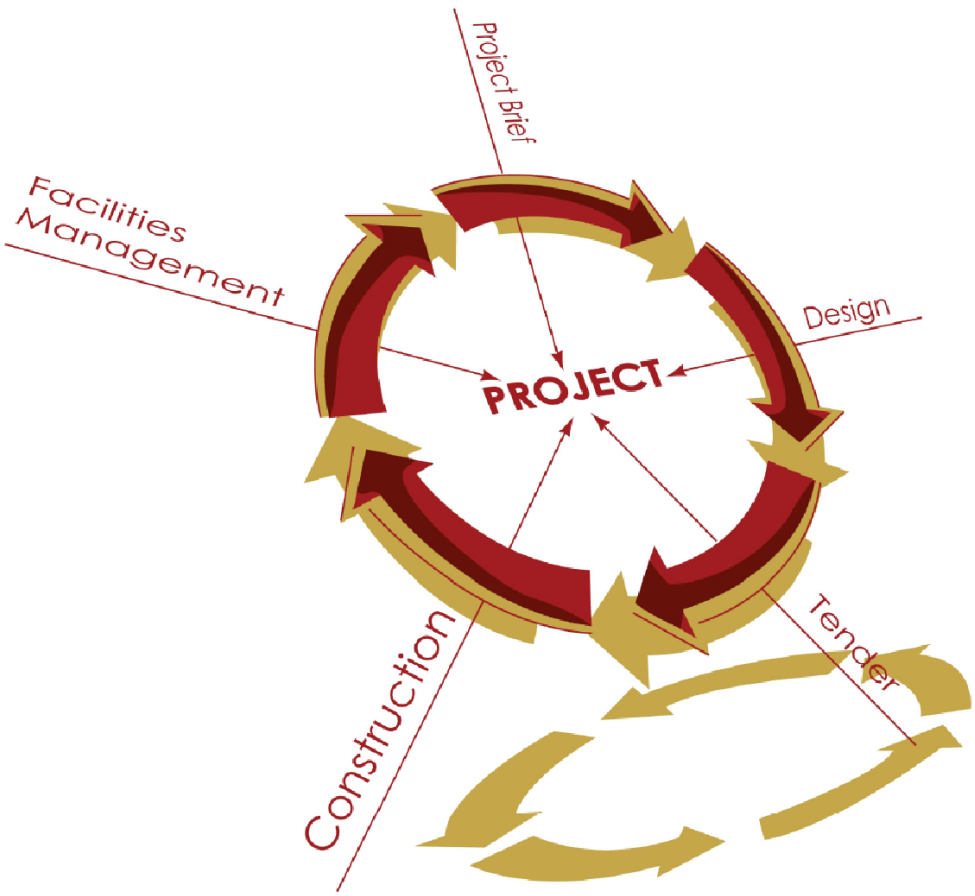

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CIDB MALAYSIA

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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 Engineering Technology, Vocational Education and Social Science (ICETVESS) 2017. This conference were organised by Universiti Pendidikan Sultan Idris (UPSI) and Universitas Negeri Semarang (UNNES) where held on 29-30th August 2017 at Universiti Pendidikan Sultan Idris, Tanjung Malim, Perak.

The aim of the conference is to develop the industry and government sectors (both locally and internationally) to tackle the issue of conference theme on building technology, civil engineering, construction management, engineering education, environmental engineering and green technology. The presenters come from the various disciplines contributed to this conference and more than 150 papers were presented.

The keynote speakers are the world's leading thinkers in the engineering technology, vocational education and social sciences where privileged to have Prof. Dr. h. c. Georg Spöttl, M.A. (Director of the Centre of Technology, Work and TVET (C-TAB) at University Bremen and Director of the Steinbeis Transfercentre InnoVET), Prof. Dr. Fathur Rokhman, M.Hum (Rector, Universitas Negeri Semarang) and Prof. Dr. Ramlee Mustapha (Director of University-Community Transformation Centre, Universiti Pendidikan Sultan Idris.

In many Asia Pacific countries there has been a shift in the last decade from a focus on engineering technology to a focus on product research and innovation. This shift mirrors the realization that engineering technology can drive growth but often fails to be sufficiently in tune with innovators' needs and aspirations. The shift from engineering technology to product personalization also reflects the increasing influence of stakeholders, captured in the oft-repeated mantra 'customer is the king'. Thus, developing a quality human resource is critical to be nurtured. Critical fields such as engineering technology, vocational education and social sciences are pertinent in creating competitiveness and sustainability in most countries. In creating innovative ecosystem, green technology, economy and lifestyles are important.

This Special Issue of Malaysian Construction Research Journal (MCRJ) for International Conference on Engineering Technology, Vocational Education and Social Science are consist of 20 selected papers by the conference committee and expert reviewer from the papers submitted at the ICETVESS2017.

Editorial Advisory Board

Secretariat:

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 ICETVESS that has been held in Universiti Pendidikan Sultan Idris, Tanjung Malim, Perak 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. Twenty (20) papers are discussed in this issue.

Pozin M A A, et al., highlights the barriers of the virtual communication practices in the IBS Malaysian construction industry. The paper employs mixed method research which involve survey questionnaire and interview methods. Results from this study shows that there are five (5) categories to achieve an effective team communication process which are in term of distributed area, open discussion, attitude, communication technologies and reliability of task.

Azizi N S M, et al., investigate the cost elements for liquidated damages in construction contracts in Malaysia. Qualitative approach through case study and literature review was used in this study. The findings from this study showed that there are 18 elements of costs categorized as capital expenditure, loss of profit, human resources and overhead. The results also indicated that the current values of liquidated damages in construction case studies in Malaysia are undervalued with 40% to 50% of the total actual cost damages not recovered.

Jalil A A, et al., shows the payment issued in Industrialised Building System (IBS) housing projects. Mixed method approach through survey questionnaire and interviews session was used in this study involves seven (7) different companies which are developers, building contractors, M&E contractors, IBS manufacturers, architect consultant, Civil and Structural consultant and Quantity Surveyor consultant. The findings show that the current procurement must be modified or changed so that it can cater IBS's requirements and avoid rigidness, which will eventually causing problems to the IBS projects.

Dzulkalnine N, et al., review the payment issue in IBS Malaysian construction industry. In this paper, some recommendation has been made to propose the better financial management for the IBS player. Mixed method research has been applied in this study using survey questionnaire and interview session. The factors of payment issue in this study are categorised into six (6) sections which are initial cost, securing timely and adequate financing, design matters, financial institution, material and contract document. The finding shows that the main factor of payment issue in IBS industry are Design Matters category and Contract Document category. In Design Matters category, the payment issue occurs at the integration design stage and it has been identified the cooperation of every party involved has been the payment issue of IBS project while for the Contract Document category, the payment issue arises because of the current procurement method.

Albahori A S, et al., shows the association between external factors and the implementation of the green building principles among housing developers in Klang Valley. Quantitative

survey is applied in this study through survey questionnaire to the housing developer in Klang Valley. analysis. The result showed that there was significant relationship between social and cultural factors and economic factors with the green building implementation. However, there is no significant relationship between the political factors and the green building implementation among the housing developers in Malaysia.

Togani C U, et al., study on the testing grouting on small dams to solve the seepage problems. This paper determining permeability with the use value of the lugeon test to overcome the seepage by measured the success rate of grouting method on lowering the value of permeability. In this paper, the author used the injection Portland Cement (PC) and water to resolve the seepage of the small dams.

Taleb H, et al., highlight the communication management between architect and clients during design phase. This paper used literature review approach from the previous studies to know about the communication management, communication management plan, standards of communication management, plan communication management and how to control communication. The findings highlight the necessity for essential improvement in communication management among architects as a demanding matter to obtain performance development that eventually achieves successful projects.

Baharuddin M N, et al., shows the key importance factor for IBS formwork system among Malaysian construction stakeholders. A quantitative approach through survey questionnaire is applied in this study among construction personnel. The findings from this study reveals the fifteen (15) factors contributes to the IBS formwork implementation and the main factor is in Government Initiative category.

Azman M N A, et al., shows the essential to establish new spatial criteria, such as attribute maps and preference weights, derived from a survey of local industry decision makers because of the research gap from the previous studies. The study use verification tests on the model to determine the potential precast manufacturing sites in the state of Penang, Malaysia. The findings from this study show that the MCE-GIS model is capable of discovering potential sites on the basis of the specification design of attribute maps.

Kusumawardani R, et al., study on the blockwork plants in Malaysia. This paper intends to identify the blockwork manufacturing process and to identifies the decisive factor to setting up blockwork manufacturing plant. In this paper, the author applied qualitative research method through interview method to three (3) interviewees from three different blockwork plants. The study finds that to manufacture a blockwork, the material that will be use must been chosen and treated wisely so it will not reduce a quality of blockwork and it need a good machinery because the production is heavily relied on the machinery.

Adnan S H, et al., propose the cement replacement material through the application of mechanical and physical properties of concrete containing polystyrene beads as aggregate and palm oil fuel ash. The methodology used in this study is through slump test, compression strength, splitting tensile and water absorption test. The findings from the tests show that the samples with 25% polystyrene beads and 10% palm oil fuel ash obtained the highest compressive strength which is 16.8 MPa, and the splitting tensile strength is 1.57 MPa.

Kaamin M, et al., review the application of micro UAV in construction project. The purpose of this paper is to provide a concise review of Micro UAV technology in monitoring the progress on construction site through visualization approach. This study intends to replace the conventional method of photographing on construction site using Micro UAV which can portray the whole view of the building, especially on high reach point and allows to produce better images, videos and 3D model and also facilitating site engineer to monitor works in progress. The images taken from Micro UAV have been processed generate 3D model and were analysed to visualize the building construction as well as monitoring the construction progress work and provides immediate reliable data for project estimation. The finding shows that by using Micro UAV, a better images and videos can give a better overview of the construction site and monitor any defects on high reach point building structures.

Kadir A A, et al., shows the properties impact from wastewater treatment sludge utilized into fired clay bricks. The methodology used in this study is through X-ray Fluorescence Spectrometer. The findings shows that the characteristics of raw materials obtained by using the X-ray Fluorescence Spectrometer showed that the chemical composition of the raw materials of clay soil and wastewater treatment sludge was high with silicon dioxide and with the same chemical composition Type A and Type B of wastewater treatment sludge are suitable to replace clay soil as raw materials. The author proposed that the percentage of wastewater treatment sludge incorporation was up to 20% with better physical and mechanical properties.

Wee S T, et al., propose the good governance practices implemented by the stakeholders in National Solid Waste Management Policy (NSWMP). The study employs exploratory research approach study through in-depth interviews with several government agencies and concessionaires involved in the NSWMP implementation. The findings of this study show that there are several good governance practices implemented in policy promotion, participation of stakeholders, and capacity enhancement programme for the staff. This study recommends that every stakeholder needs to be proactive to improve their good governance practices in the NSWMP implementation.

Mydin M A O, et al., investigate on the rising damp and salt attack problems of heritage buildings. The case study approach was used in this study through five (5) inheritance buildings that have salt contamination and dampness problem. This study also uses dilapidation survey and it is found that the factors causing the salt contamination and rising damp to occur are the location of building and lack of Damp Proof Course (DPC). From the data analysed, the source of salt mostly is come from the soils and limestone.

Mydin M A O, et al., assess on the waterproofing failures in concrete buildings and structures. Four (4) case studies were carried out to assess the waterproofing failures in concrete buildings and structures. The 4 building was carried out at Cyberjaya, Malacca, Kuala Lumpur and Seremban. Each of them consist of different type of building namely SOHO (small office), Commercial building, Hotel Building and shopping mall. Findings from this study shows that the main factors that contribute to waterproofing failures in concrete buildings and structure are cracks, deteriorated waterproofing system, honeycombs in concrete and construction joint failure.

Hung L E & Ghani A N A experiments the validation on the design of strain gage based sensor for soil compaction. A cylindrical metal sensor block had been designed in two different diameters (50 mm and 100 mm) and with different metal ceiling thickness labeled as Sensor 1 (2.5 mm), Sensor 2 (5.0 mm), and Sensor 3 (7.5 mm). The findings of the study are divided into two sections which are compression test results and calibration results. It shows that the 100mm diameter Sensor 2 of 5.0mm thickness is the best sensor to be used in the actual field soil compaction among all six sensors.

Zakaria M N S, et al., review the level of technology acceptance of foreign worker towards powerpoint (PPT) in Safety and Health Induction Course (SHIC). The methodology used in this study is through Technology Acceptance Model (TAM) to seek the response from the respondents. The factors contained perceive usefulness (PU), perceive ease of use (PEOU), attitudes towards using (A) and behavioural intention to use (BI). The findings in this study show that the foreign workers perceived usefulness and perceived ease of use shows the moderate positive relationship towards the PPT.

Basarudin N A, et al., compare the Malaysian Personal Data Protection Act 2010 and EU General Data Protection Regulation in term of Smart Home user's information in Cloud system. This study adopts doctrinal legal study that analyses the Personal Data Protection Act 2010 on the aspect of protection conferred to the cloud users and with reference to additional point that is well addressed in European Union General Data Protection Regulation. The findings show that there are several significant differences between provisions in which some part of the PDPA 2010 are lacking to provide protection to the cloud users. Some recommendation has been made in this study such as the security system employed by the cloud service provider to trace any hacking or theft matters occurred in the system and the way of solving it.

Mydin M A O, et al., reveals the current indoor environmental quality of the selected offices in Penang Island. A few parameters were determined such as temperature, humidity, air velocity, air flor, noise level and lighting condition. The methodology used in this study is survey tests through case studies. The findings show that the main issue of indoor environment quality measurement are in term of lighting and noise problem.

IMPROVING COMMUNICATION IN MANAGING INDUSTRIALISED BUILDING SYSTEM (IBS) PROJECTS: VIRTUAL ENVIRONMENT

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Abstract

Traditional approaches are still dominant in virtually all construction projects in Malaysia. This was highlighted as the main barrier for further developing the Industrialised Building System (IBS) construction process. Indeed, traditional approaches implemented in IBS have been recognised by several studies as failing to support effective work teams when team processes are disconnected from each other (fragmented), thus failing to produce an effective communication process. Additionally, IBS construction involves large numbers of teams with different expertise and from different organisations, all of which are handled by different numbers of management processes, for instance in planning, manufacturing, transportation, positioning and assembling the structures that involve minimal additional site work. With the increasing demand in building bigger and better buildings and structures, construction projects are becoming more complex to manage by project managers, as they have to manage every single phase by coordinating and monitoring the entire project while at the same time, consider different values and interests from every project team members. Hence, high intensity levels of communication processes involving project team members are importance in order to produce high quality information in decision-making process and conveying instructions to all team members. Regarding the issues of communication practices inside construction projects, this paper explores how communication is applied by the project team management in managing different construction stages inside an IBS construction project with several of stakeholders from diverse locations, and different cultural and organisational backgrounds. Even though a few studies had highlighted communication barriers in the construction field, only a few investigated virtual team practices in the IBS construction industry, especially in Malaysian construction. In this context, preliminary interviews were conducted on several project managers with vast experience in managing IBS construction projects. The content analysis method was used as the technique to ensure the gathered data were comprehensively and accurately analysed. The results showed that most project teams communicated virtually within and among teams for the duration of the project implementation, which the phenomenon is resulting from modern organisational form. There are five categories associated with virtual team work environment, namely distributed area, open discussion, team attitude, communication technology, and reliability of task, all of which are exceptionally pertinent in virtual team, compared to traditional team, work interaction practices.

Keywords: *Virtual team; Communication; Project manager; Industrialised Building System (IBS)*

INTRODUCTION

Pressures from development and modernisation has initiated the effort from the Malaysian government to move into utilising globalisation technology, with a new systematic building development process. As a result, from the initiative in 2014, the construction industry contributed to the Malaysian economy by accounting for over USD32 billion and this sector is expected to grow due to the initiatives planned in the Eleventh Malaysian Plan (RMK 11), which is expected to expand to 10.3 per cent per annum over the next five years.

Therefore, the construction industry is a major contributor toward the Malaysian vision of becoming a high-income nation by 2020.

Thus, through the Construction Industry Master Plan (CIMP), the Construction Industry Transformation Programme (CITP) 2016-2020 was launched by CIDB to improve quality of the standard industry utilising strategic goals to bring the Malaysian construction sector to the next level, with a new vision of transforming the industry by facilitating high technology and modern construction method adoption with the appropriate training quality, to align the supply and demand of workforce, the availability of high-quality information, and to address the low productivity issue.

The CITP is supported by 18 initiatives to enhance the productivity of the construction workforce. One key initiative is to support higher technology adoption, both in terms of advance technology used in the construction method, such as Industrialised Building System (IBS) (Lim et al., 2016), and the advanced materials used in the construction. As a result, the Malaysian construction industry has attempted to implement IBS during the time the nation was reaping the benefits of producing high quality buildings, timely construction completion, and cost savings through standardisation in long-term ownership cost (CIDB Malaysia, 2012). In general, the concept of IBS is the construction involving pre-fabricated components manufactured off-site, where each component is systematically produced by using machine, formwork, and other advance mechanical tools (CIDB, 2009). The construction process begins when each component of specific requirements is manufactured off-site and after completion, each component would then be transferred to the construction site for assembly, where the installation and integration into the structure would entail minimal additional site work. Indeed, this process works systematically, which optimises the use of materials, finishes the project in a timely fashion, and there is less impact from changing weather conditions on construction operations, as well as increasing site neatness and safety. By the end of the introduction of the IBS method, several keys projects were successfully implemented using the IBS method, and some of these latest construction projects include the Mass Rapid Transit (MRT) transport system, 1 Malaysia Financial District, Sungai Buloh and Sungai Besi mixed development projects, and Lightweight Railway Train (LRT) system (CIDB Malaysia, 2012).

However, the initial ambitious goal of incorporating the IBS method into a minimum of 70% of various construction projects in Malaysia is far from reality. One reason for the slow IBS uptake is because of the need by all involved parties to deal with new innovative technology, new construction skill knowledge, and failure to deliver expected return (Akmam Syed Zakaria et al., 2017).

IMPACT FROM FRAGMENTATION

Fragmentation was identified as one of the main barriers in adopting IBS in the Malaysian construction industry (Mohd Nawi et al., 2014). Fragmentation issues commonly represent negative impact on project performance, productivity, knowledge sharing, and innovative solutions. Fragmentation occurs when the entire process of the construction project is broken down into teams in separate parts, in between the design and construction stages. From this scenario, the segregation process would naturally create diversity of discipline specialisation from over the distributed area. Moreover, this would create limited coordination, and integration of an organisation, and thus cohesive teamwork becomes

ineffective. Therefore, this would affect the quality of design process and ultimately, the project outcome. Meanwhile, fragmentation often increases project complexity, rework, increased costs, and longer construction duration. According to Anumba (Evbuomwan & Anumba, 1998), the complexity of the modern organisational structure would force the communication process to become more critical, especially when dealing with many fragmented parties, long life cycles, and multiple organisational structures, all of which would eventually degrade construction performance to become lower than usual (Dainty et al., 2006). As a result, project teams would find it difficult to communicate directly with each other and this will increase unnecessary expenditure and retard the progress and quality of the project (Senaratne & Ruwanpura, 2016). Furthermore as mention by Ruuska, the complexity of the construction project is becoming more critical when handling multiple teams and additional requirement processes (Ruuska, 1996). This phenomenon is infectious in IBS construction projects, since the IBS process involves numerous practitioners in coordinating and planning several construction processes from the design stage to logistics that entails the delivery of IBS components from the factory to the construction site project (transportation), and eventually the positioning and assembly of the manufactured components into a structure with minimal additional site work (Mohd Nasrun Mohd Nawi & Angela Lee, 2012). Thus, the sequential nature of these activities is highly embedded in the construction processes and seems to override itself with new procurement and management methods, e.g., strategic alliances and new methods of teamwork, such as virtual teams (Chen & Messner, 2010; Chinowsky & Rojas, 2003; Abadi, 2005; Affendi et al., 2016). Therefore, some of these challenges in the communication process of IBS construction have been identified from previous studies, as shown in Table 1.

This situation gives a substantially negative impact on the government and industry, especially when attempting to accelerate adoption of the IBS method. The implementation of IBS method needs more support from stakeholders and construction players in the industry, so as to align it with the national agenda.

Table 1. Communication challenges inside IBS construction projects

Challenges of IBS Construction	Description
Fragmentation issues	Separation of expertise within different organisations (e.g., client, consultant) and different design and construction stages
Bureaucracy	Some organisation make it difficult to share knowledge and establish discussions, either during the implementation of a stage or in the planning stages of approval
Poor integration	Project team failure to communicate effectively regarding different values and interests to a project need
Design process	Ineffective design and planning process which needs to be redesigned again to suit the IBS plan
Competency	Incompetence in handling the documentation process and passive use of computer systems
Lack of coordination and planning	Ineffective communication in handling project tasks, especially in coordinating of design, transportation, and installing processes

VIRTUAL TEAM AS AN ORGANISATIONAL FORM

Within the last decade, research on virtual teams were done in many areas, such as manufacturing, human resource, offshore, and small medium enterprise (SME). Current research on virtual teams are at nascent stages and have not been reviewed, especially in and around the Malaysian construction sector, more specifically regarding IBS projects. The rapid

pace of globalisation and fast development of ICT will force organisations into virtual collaborations to enhance their competitiveness. Therefore, virtual, virtualisation, or virtualised are terms that generally represent working groups of people who share their own unique expertise while supported by Information Communication Technology (ICT) to provide effective communication between individuals from different locations and time zones, working together to accomplish project goals. There are multiple definitions by different authors regarding virtual teams. According to Chinowsky, a virtual distributed team is "a group of people with complementary competencies executing simultaneous collaborative work processes through electronic media without regard to geographic location" (Chinowsky & Rojas, 2003). It was also supposed that the term "virtual" covers the wide range of activities and forms of technology-supported systems which support industries, including the construction industry (Hosseini & Chileshe, 2013b).

In others sectors, it has been observed that the implementation or adoption of virtual communication practices within the organisation is like shifting from failure to success (Duarte et al., 2006). The flexibility of infrastructure based on virtual teamwork can produce effective communication among project teams to perform the project tasks more rapidly, unlike those traditional face-to-face teams. This is because the team has the ability to work over spatial and different places (Munkvold & Zigurs, 2007), and they can effectively cooperate across disciplines from distributed teams, which is necessary for engineering projects to succeed (Zhang et al., 2010). Furthermore, supported by ICT, this could reduce relocation times and costs, as well as reducing time-to market cycles, which is one of the significant successful keys in some organisations (Chatfield et al., 2014). Moreover, it was also asserted that this team type evaluates the design in the early stages of the project as relating to different architectural, financial, or even environmental constraints, because the tools used in virtual teams would enable the design team to quickly gain insight of the project. As a result, the following reasons are why it is necessary to implement virtual project teams in IBS construction projects:

- Competency to handle distributed practitioners and site location projects.
- Less collaboration and integration from initial work.
- To support sustainable competition, and contribute agility and innovation in operations.

Moreover, understanding the landscape and key aspects of virtual teams is a necessity for enhancing flexibility and effectiveness of construction projects, due to the popularity of this phenomenon in the industry. Furthermore, in the attempt to understand and develop an effective communication process between construction project teams, some of the advantages of virtual teams over the traditional co-located teams that need to be taken advantage of are shown in Table 2.

Table 2. Virtual team versus traditional co-located team

Criteria	Virtual Team	Traditional Co-Located Team
Location	By different location and time zone	Next to one another in the same area
Task coordination	Tasks must be much more highly structured	Straightforward and performed by the members of the team together
Communication	Rely on electronic communication	Face-to-face interaction (synchronous communication)
Utilisation of resources	Increase the opportunity for allocation and sharing of resources	Variety of practices (cultural and work process diversity) and employee mobility negatively impacts performance in virtual teams

ADVANTAGES OF VIRTUAL TEAM

Since virtual teams have been implemented in many organisations, the advantages and opportunities from virtual teams brings a new dimension in managing projects globally. Opportunities can be taken by virtual teams in enhancing to a higher level of structural and demographic diversity than co-located teams. At the same time, this will increase economic development and productivity processes. For instance, there is some experience from certain organisations in improving project management issues by implementing virtual team practices.

1) Reduced time travel and cost: IBM was estimated to reduce USD50 million in travelling costs and downtime through virtual team approach. The expenditure of travelling time and costs on daily allowance can be reduced and even eliminated as virtual teams communicate via technology. In addition, face-to-face meeting time is reduced and it also minimises the level of disruption to the daily office routines (Baskerville & Nandhakumar, 2007).
2) Tampa Bay Arena, Florida. The project was conducted through a web-based construction partnering project. The potential of a project collaboration through the web was demonstrated, with the requirements and information being freely accessible with a member's security code. The result revealed that project managers found all participants to be very satisfied with the cooperation, and team-work, as well as the reduction in communication problems and response time (Guss, 1996).
3) Supported by great technology in virtual environment has seen positive relationship between project teams on a construction project in Dubai. Team members indicated that virtual teams are valuable in coordinating and producing effective communication, as long as it is achieved with decrease in costs, improvement in quality, and reduced time to market (Kaur *et al.,* 2016).
4) The use of global virtual engineering team (GVET) has been applied in the engineering, procurement, and construction (EPC) industry. These strategies are an open system to capture more experience and feedback to produce higher productivity, speed-to-market, higher labour productivity, and lower wages (Chen & Messner, 2010).
5) MedicDec, as a manufacturer and marketer of medical devices, developed appropriate structure of virtual teamwork model in improve organisational strategy to support optimal management of virtual teams in a systematic manner.

Moreover, the following advantages of virtual teams for project management process are listed in Table 3.

Table 3. The advantages associated with virtual teams

Advantages	References
Reducing relocation travel time and cost, and organisational affiliation that traditional teams face	(Fuller, 2008)
Greater productivity, shorter development times	(Sushil *et al.,* 2010)
Better team outcomes (quality, productivity, and satisfaction)	(Gabriele *et al.,* 2004)
Effective in decision making, knowledge sharing, and communication planning	(Lipnack & Stamps, 1997)
Integrating talent in newly industrialised organisations; facilitating transnational innovation processes	(Affendi *et al.,* 2016)

PROJECT TEAMS COMMUNICATION

The construction industry is commonly known as an information-dependent industry. Thus, every single phase requires good quality communication to share a knowledge (idea, fact, and interpretation, and social emotional concept) in developing good quality project outcome. Therefore, effective communication plays a key role for success in delivering data and inter-operability between contractors, sub-contractors, and other parties related to the construction project. According to Otter (den Otter & Emmitt, 2007), the different values and interests from diverse project teams and organisations, and the success of projects depend on effectiveness of communication practices between project teams employed at the project level. For instance, since the activity of processing data in construction sites involves the use of laptop in keying-in the details of materials, the activity between employee and laptop is manually passive. The employee would spend more time dealing with co-located information when the laptop is waiting for data input. This condition decreases work productivity, and delays on-site activities. Thus, project managers should employ alternative ways for implementing project communication plans, by identifying what are ideal and appropriate tools and techniques for communication team management practices.

In particular, looking at previous study, some literature focused on the social perspective dimension on how communication process and connection between team works. As suggested by Dainty (Dainty et al., 2006) “team development, team role theories, and other teamwork factors as techniques to improve team communication”. For instance, in the delivery process of IBS components, unloading to the site project, huge size of components, redesign issues, and transportation process need careful and cohesive planning from different project teams, which is important in maintaining close relationships and understanding their specific roles in the overall task so as to provide better solutions. Moreover, organisations need to look into how to manage communication work flow by adopting ICT, for example in virtual communication among construction project teams in a distributed project area. As suggested by Wikforss and Lofgren (Wikforss & Löfgren, 2007) “to solve the practical communication problems in the construction industry, the perspective must be widened from ICT to organisational and management viewpoints”. There are multiple view-points to focus on in the management of communication process on stakeholders, and communication technology in managing communication team processes, such as team role theories and team development processes. As illustrated by previous studies, changing the mind-set to further transform ICT implementation into IBS component management process is the main factor from the developer’s side. As such, team players would not understand the benefits from new technology development, even though ICT uptake increases productivity and profit in

improving IBS project management. In fact, there are various information technology (IT) tools suitable for overcoming communication barriers in facilitating the IBS construction process, such as building information system (BIM), cloud computing, mobile computing, and global virtual engineering teams (GVETs) (Tsai, 2009; Hosseini & Chileshe, 2013a).

- Building Information System (BIM)
  BIM is employed to increase AEC practitioners to ensure the construction process flow more effectively. BIM technology is generated by computer modelling, starting from planning, design, construction, and operation of facility. This model consists of 3D models of the project components and links with all the requirement information. BIM was developed to reduce errors and to improve productivity, cost, safety, scheduling, and quality of construction project. Thus, BIM is capable of enhancing project performance along with overcoming the problems stemming from the fragmented structure dominating the industry.

- Cloud Computing
  The expanding complexity on IBS construction necessitates the exchanging of increasing amounts of data and information. Based on the issues of fragmented process, cloud computing can provide significant impact on effective information system utilisation for improving the effectiveness and enhancing the appropriate information flow, along with access to data, information, and services. Cloud computing is a valuable technology which sends and retrieves data and various applications by utilising the Internet and central remote servers, including application servers and database servers. This system integrates cloud computing and mobile clients (such as smart mobile devices including smartphones and tablets), servers and data centres, and logistics management, and could be applied for the pre-cast concrete supply chain management.

- Mobile Computing
  Mobile computing enhances project management by providing activity workers with different kinds of information relating to building standards, materials, activities, and reprocesses in working periods. All kinds of activity workers frequently use verbal report via smartphone and also visual reports using pictures taken using digital cameras of smartphones. Thus, the communication process is revolutionised with the integration of mobile application processes in the AEC industry. Hence, the construction management process could be more flexible in processing data at the construction site.

- Global Virtual Engineering Teams (GVETs)
  The construction industry has started to harness this new paradigm. In the non-construction industry sector, it was recommended that virtual teams have many advantages for the organisation. Thus, the construction industry is witnessing the emergence of GVETs regarding the capabilities of crossing over geographical and temporal borders. Thus, many teams in the construction industry are actively becoming virtual. The advantages of GVET have been confirmed to imbue high productivity, higher qualities of products and services, timeliness of completion of tasks, cost savings, and the ability to deal with current complexity in construction projects.

In particular, when looking at project characteristics, a normal project team is temporary nature. More specifically, since this group is temporary, their relationships and interactions continually change, thus reflecting the efficiency of the working place. Meanwhile, there is a different skill required to implement IBS project phase, since it requires expertise originating from a different location. In fact, practitioners may belong to different places with different languages and cultures, thus contributing to communication failure.

Another problem of the communication process arises from the structure of the organisation in distributing information flow. As suggested by Lunenburg (Karlsen, 2002), the organisation should be distributing information into three directions, which are downward, upward, and horizontal directions.

- Upward – information from subordinate to supervisor as a report for the management. This includes progress report, request for information, suggestion, and decision.
- Downward – information based on advice, instruction, and staff regulation from superiors to subordinate.
- Horizontal – shared information with same hierarchical level among teams, normally at a project-level communication in construction.

Furthermore, in overcoming the barriers from the complexities inside construction projects, project managers and teams need to communicate effectively both up and down within the supply chain, to produce information flow toward other team practitioners (Dainty *et al.,* 2006). Moreover, with the advantages of ICT, which can resolve practical communication problems in the construction industry, this perspective must be widened from ICT to organisational and management viewpoints. Coinciding with the construction teams which are widely geographically dispersed, project managers can plan the communication process by breaking it down into manageable, predictable, and orderly steps. Therefore, this research aimed to explore how project managers handle the communication process between virtual team members in coordination of design, transportation, tracking, and installation to ensure a successful implementation process during the project level.

METHODOLOGY

To examine the barriers of communication in construction projects, multiple approaches were employed in order to guarantee the data were gathered comprehensively. The approaches included a literature review and survey of industry practitioners. Additionally, the data and information for literature review were collected and gathered from libraries, articles, books, web sites, and other printed/published material sources, such as proceedings, bulletins, and international and national journals. The aim of this study was to obtain data from multi-stakeholders involved in the IBS industry. Five project managers were selected from different project teams that have experience in managing IBS construction projects for more than 10 years.

For this study, the survey technique was selected because this technique was deemed the most appropriate technique for gathering data for achieving the objectives of this study. This is because the survey technique has an effective way of obtaining information, insight, knowledge, and experience from a large group of industry players in the shortest period of

time. Furthermore, this technique is suitable to draw upon the experience of the respondent as well as the possibility of getting a reaction, for example through observation, questionnaire survey, and one-to-one interviewing.

Due to issues of confidentiality, it was decided that the name of respondents in this study would not be disclosed. Instead code names (e.g., R1, R2) were used to identify these respondents. The list of the respondents, as well as some demographic details, is shown in Table 4.

Semi-structured interview was selected as the data collection strategy from a qualitative approach, as the aim was to gain in-depth knowledge of the concepts or variables being studied, but the scope covered is restricted to the knowledge and experience of those involved only.

For the purpose of this study, the interview was conducted approximately 45-60 minutes in a quite comfortable and interruption-free setting. All interviews were audio recorded and transcribed verbatim for analysis. Then the data were analysed by using content analysis and representation via tables, documents, and expression.

Table 4. Respondent's profile

Name	Position	Experience (in years)	Company/Discipline	Location	Gender
R1	Director	10	Manufacturer/Installer	Southern	Male
R2	Project Manager	16	Contactor	Northern	Male
R3	Project Manager	10	Contractor	Northern	Male
R4	Managing Director	15	Contractor	Northern	Male
R5	Project manager	20	Contractor	Northern	Male

FINDINGS & DISCUSSION

Based on the findings from the interviews, it was confirmed that the entire elements obtained from the findings are necessary for application in IBS projects in order to achieve an effective team communication process. The findings in Table 5 shows all the recommendations discussed during the interview process.

Table 5. Summary of efficiency of virtual communication practices in IBS projects

Categories	Statement
Distributed area	The big challenge is to organise people in multiple locations, which is how project managers control the communication process according to limitation of physical and social interaction, as well as limited face-to-face communication. *"Usually this type of communication between project manager and other team for certain project. Before this we communicate by using phone and e-mail to connect our team on different location. Now we use WhatsApp application as a new medium to interact with others member in real time situation. But still created monthly and weekly meeting at the project site. This is how we practices".-R2*
Open discussion	Respect each team's idea according to frequency of communication among teams in a construction project. This environment creates good work relationships and collaboration without confrontation among team members. *"Communication through ICT has provided a good service in motion the process of everyday work, but we need to hold a weekly meeting to solve problems, especially those involving technical matters. So through this medium all participants will declare the problems that arise to get a consensus. Meeting can avoid confrontation or miscommunication among teams at the project site".-R5*
Attitude	Personnel attitude becomes a potential motivator for group and individual performance, including commitment, continuity, and positive self-improvement. *"The approach I took was to implement a policy of "open door" that anyone can come and discuss openly any time soon. A situation like this to reduce communication gap between me and our team. This way I can find out something with real problems and they are not awkward to share the problem. With existing technology, all the discussion by the employees I can see even though they realized I was there in the group. In addition, I also act as a mediator in decision-making in the event of a problem among the other team. What I do is to be a good listener to discuss with both sides openly".-R1*
Communication technologies	ICT is used to support information effectively and obtain accurate data without any delay. *"Nowadays facilities such as ICT communication tool commonly used for example WhatsApp, Line and Telegram make it easily for any business. For example the application tools are multifunction either to share a picture, make a call or video call, sharing location. In the same time the conversation can be make one-to-one or grouping".-R1*
Reliability of task	Effectiveness of information feedback is needed for teams from distributed area to avoid project delay. Lack of communication will cause and affect the path of the project activity to change or divert. *"All of information is normally shared through Dropbox and Google Drive. All project teams involved can access data in real time through a smart phone. Through this application, all types of data and information such as pictures, drawing plan is easily referred".-R4*

CONCLUSION

The aim of this research was to explore how project managers manage their communication between project teams in the construction process. It begins with the identification of construction manager experience in handling IBS projects, followed by communication challenges in handling distributed teams in construction projects. Here, project managers are selected as the keys party with the responsibility to initiate, plan, execute, monitor, and close a complete construction project. Communication issues in the

construction sector had been highlighted by numerous researchers as a critical factor in the delivery of effective team communication practices. Unfortunately, the efficiency of communication practices of virtual teams in construction projects lacked investigation, especially in relation to IBS construction project team communications. Based on data collection from several project managers, this study found that most project teams communicate virtually with one another along the duration of the project implementation. These phenomena are a result of the modern organisational form. There are five categories associated with virtual team work environment, namely distributed areas, open discussions, team attitudes, communication technology, and reliability of task, as presented in Figure 2 previously. These categories are exceptionally pertinent in virtual team, as compared to traditional team, work interaction practices. In contrast there is a need for similar studies in order to support project managers in managing an effective controlled environment. This is because virtual teams are demonstrating a steady decrease in social interaction, communication, and emotional expression levels. Thus, emotional intelligence needs to be identified in order to support effective communication and manage emotions in the virtual environment, especially in Malaysian IBS projects.

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COST ELEMENTS FOR LIQUIDATED DAMAGES IN CONSTRUCTION CONTRACTS: A CASE STUDY IN MALAYSIA

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Abstract

A charge on liquidated damages upon delay of completion of projects are found to be common in Malaysia. Previous scholars showed that there are various methods in ascertaining the liquidated damages. The diversity of these methods raises disputes in determining the reasonable amount that should be charged as compensation for the damages. This has resulted in disputes between contractors and employers and inconsequently led to major cost implications to the project as it involves the process of arbitration, mediation, and litigation. Therefore, the research objective of this study is to identify the costs elements to provide a basis for ascertaining a genuine pre-estimate value of liquidated damages and to examine the current value of liquidated damages in construction case studies in Malaysia. Findings from this study showed that there are 18 elements of costs categorized as capital expenditure, loss of profit, human resources and overhead. The results from this study also showed that the liquidated damages in construction case studies in Malaysia are undervalued with 40% to 50% of the total actual cost damages not recovered.

Keywords: *Component; Formatting; Style; Styling; Insert*

INTRODUCTION

Breach of contracts in a construction project is a critical issue, and the liquidated damage is among the remedies available in the contract to compensate the loss suffered by the client (DTM, 2012; Long et al., 2016). A breach of contract may be a partial or complete failure to perform, delayed performance, faulty or inadequate performance (Long et al., 2016; Oon, 2005). In the Malaysian construction industry scenario, delay in completion of construction projects leading to impose of liquidated ascertained damages to the contractor are reported to be very common (Doraisamy et al., 2016; Ali et al., 2012; Jatarona et al., 2016; Azman et al., 2014). The loss suffered by the clients when there is a delay in completing the projects are such as loss of income or profit, loss of rental or usable value of the property, increased financing costs, including interest on a construction loan, extended maintenance and operation expenses and additional consultant fees (Azman et al., 2014; Gonzales & Stovall, 2011; Kassim & Loong, 2002).

There are various measures used to estimate the value of liquidated damages. Study by McDonald (1984) recommended four generic principals in measuring liquidated damages. Firstly, the losses claimed by the client must be at a reasonable accuracy. Secondly, the contractors estimate was realistic. Thirdly, the contractors actual cost was reasonable. Fourthly, the contractor was not responsible for the increased expense. These four principles

are generic and further supported by Thomas et al. (1995), where the principals provided are difficult to estimate.

Another method of estimating the value of the liquated damages in international practice is by multiplying 15% of the pretender estimate of contract (Eggleston, 2009). Malaysia adopts a different method where the percentage that is multiplied with the contract sum is not a fixed percentage. According to the Malaysia Standard Form of Contracts such as PWD Form 203 (A) (Eggleston, 2009) specifically for government projects, the value of liquidated damage is determined by multiplying the base lending rate with the contract sum. The base lending rate is debateable since there are no studies that examines whether or not this is a sufficient amount to determine a genuine pre-estimate value of liquidated damages.

There are also cases where the practice in the industry is to estimate the liquidated ascertain damage by taking a percentage allocation from the selling price of the property being constructed (National House Buyers Association of Malaysia, 2002). The percentage taken varies from 10% to 30% of the property selling price (National House Buyers Association of Malaysia, 2002). Anecdotal evidence showed that the current practice in measuring liquidated damages in the Malaysia construction industry varies significantly and is at the discretion of the employers' decision. The various methods of measuring liquidated ascertained damages show that there are no certainties in measuring a genuine liquidated ascertained damage. Inconsequentially, it leads the contractual parties to be exposed to a higher risk of being in dispute. It is important that the matter is addressed early to ensure that the interests of all parties in the contract are protected.

The numerous cases of contractors in Malaysia to be imposed liquidated ascertained damages (Doraisamy et al., 2016; Ali et al., 2012; Jatarona et al., 2016) reinforces the need for an in-depth understanding as to what constitutes as a basis for ascertaining a genuine pre-estimate value of liquidated damages. Therefore, the research objective of this study is to identify the costs elements to provide a basis for ascertaining a genuine pre-estimate value of liquidated damages and to examine the current value of liquidated damages in construction case studies in Malaysia.

METHODOLOGY

This study adopts a qualitative research methodology. A literature review was done to build a conceptual framework in providing a basis for ascertaining liquidated ascertained damages. The databases used are such as Emeralds, Springer Link, Engineering Village and Lexis Nexis. The second stage of the study executed a content analysis in which relevant documents were collected such as the contract documents of the projects. Content analysis is adopted since it is a systematic procedure for reviewing or evaluating documents, both printed and electronic materials (Bowen, 2009).

A total of 5 case studies was used in this study. A letter of invitation to participate in this research was sent via fax and e-mail. A follow up call was conducted to make an appointment to gain the relevant information. Table 1 shows the information for the case studies used in this study. The names of the projects are kept private and confidential.

Table 1. Case studies

Project	Project Owner	Contract Sum (MYR)	LAD charge per day (MYR)	Contract period (day)
1	Government	RM70,593,513.44	RM13,000.00	630
2	Government	RM98,000,000.00	RM17,721.00	910
3	Government	RM155,230,103.77	RM24,420.00	936
4	Private	RM304,193,010.00	RM100,000.00	1288
5	Private	RM327,326,778.50	RM29,866.00	2432

RESULTS AND DISCUSSION

Figure 1 depicts the cost elements that will be affected when there is a delay in a construction project. A total of 18 cost elements are identified from the literature review. These cost elements are further categorized into four themes which are capital expenditure, loss of profit, human resource, and overhead. The review of the literature showed that financing interests and loss of profit are the most commonly cited cost implications upon a delay in a project (Gonzales & Stovall, 2011; Bello, 2010; Eggleston, 2009; Singh, 2007; Lim, 1993; McDonald, 1984). Financing interest are the costs implied when the owner of the project outsource the funding for the project (Gonzales & Stovall, 2011; McDonald, 1984; Eggleston, 2009; Lim, 1993; Singh, 2007; Bello, 2010; Abdul-Rahman et al., 2009). In Malaysia, it is unlikely that government projects are outsourced funding, however it is common for private projects. Losses of profit are such as the loss for return of investment predicted when the building is occupied, the social costs involved, the rental rates of the space or facilities, loss of productivity due to inability of operation in the building, business disruption and etc. (Sambasivan & Soon, 2007).

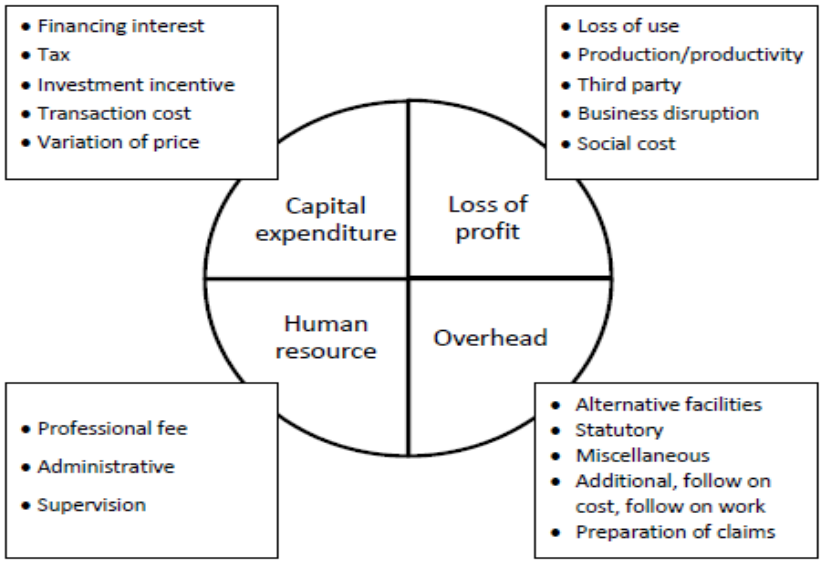

Figure 1. Cost elements for ascertaining liquidated ascertained damages

Under human resource, there are professional fee, administrative costs, and supervision costs (Shehu et al., 2014). Professional fees are charged proportionately to the project costs. Typically, the costs for the professional fees are an agreed percentage between 2% to 5% from

the contract cost sum (Azman et al., 2012; Pertubuhan Akitek Malaysia, 1986; Board of Quantity Surveyor Malaysia, 1983). Hence, when delay occurs the contract cost will increase and in evidently increase the cost for the professional fees since costs are calculated based on a fraction of the percentage total construction costs. Administrative and supervision costs are vulnerable to the length of the contract period. Scholars identified these items as 'wholly time dependent items' (McDonald, (1984). As for items under the theme of overhead consists of alternative facilities, statutory, additional follow on work, preparation of claims and etc.(Bello, 2010; Bakhary et al., 2015). Alternative facilities are such as the need to provide temporary offices, storage, or space to accommodate the loss suffered due to a delay (Bello, 2010).

Table 2 depicts the calculation of the liquidated ascertained damages for each construction project. The results from table 2 show that each construction project covered only 6 to 8 costs elements out from the 18 cost elements identified. This constitutes a percentage of only 30% to 40%. The results imply that the clients of the construction projects are at a high risk of loss since 60% to 70% of the costs elements are not accounted for in the event of a delay.

Table 2. Calculation of LAD for each case studies

	Cost incurred per day (RM/day)				
Element of cost	**Project 1**	**Project 2**	**Project 3**	**Project 4**	**Project 5**
Financing interest	-	-	-	-	1,416.70
Inflationary/ Fluctuation/ variation of price	5,523.44	4,326.92	1,551.34	11,449.53	-
Tax	-	-	-	-	-
Investment incentive	-	-	-	-	-
Transaction cost	-	-	-	-	-
Professional fee	8,184.13	12,043.13	13,593.72	-	-
Administrative	-	-	-	2,124.47	25,596.13
Supervision	79.37		1,245.40	5,904.37	10,689.44
Loss of profit	-	-	-	-	-
Loss of use	-	-	-	-	-
Production/ Productivity	-	-	-	-	-
Third Party	-	-	-	-	-
Business disruption	-	-	-	23,617.47	-
Social costs	-	-	-	-	-
Alternative facilities	-	-	-	-	-
Overhead	-	-	37,596.54	3,186.70	906.37
Preparation of claims	-	-	11.22	-	-
Additional/ Follow on cost/ Follow on work	192.36	2,280.94	-	-	-
Miscellaneous	12,321.11	1,681.32	-	637.34	593.38
Statutory	793.65	461.54	18.13	7,278.38	-
Total	27,094.06	21,153.85	54,016.35	54,198.26	39,202.02

Figure 2 shows the calculated value of the liquidated ascertained damages and the value stipulated in the contract document for all five construction projects. The analysis from figure 2 shows that only one out of the five construction projects (project 4) is ensured that the cost for damages upon delay are sufficiently compensated.

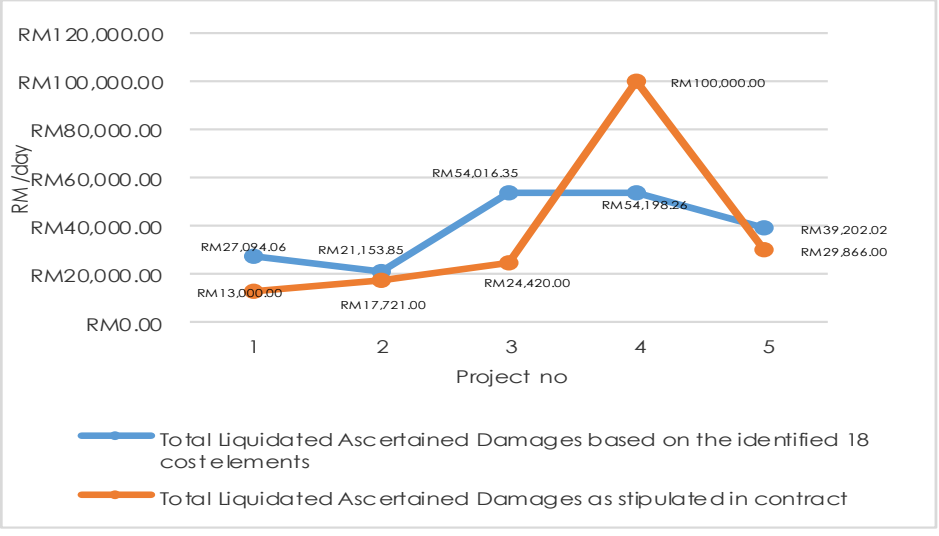

Figure 2. Value of liquidated ascertained damages (calculated vs as per agreed in contract)

The value of liquidated damages agreed in contract for project 4 is RM100, 000.00 whereas the calculated liquidated damages is RM54, 198.26. Therefore, the value of liquidated ascertained damages stipulated in the contract document in project 4 has covered an additional of RM45, 801.64 which constitutes a percentage of 85% more than what it should have covered. This position the contract at risk of being determined via court as void since the ascertained value can be considered as a penalty for the contractor. When an amount of compensation is more than the actual cost of the damages, it can be considered as a penalty. Hence, the contractor in project 4 can challenge the value of the liquidated ascertained damages in arbitration or court. The main principle in liquidated damages amount under the common law is to ensure that the amount provided in the contract is a reasonable compensation to the innocent party and not made to penalize the party at fault (Lim, 1993; Singh, 2011; Furmston, 2000). Penalty clause is illegitimate and void (Lim, 1993; Chetwin, 2011; Barnes, 2005). Therefore, it is vital to have a reasonable amount of liquidated damages in order to ensure the liquidated damages provision in the contract enforceable. There has been several court cases where the provision of the liquidated ascertained damages in the contract was determined to be void since the value was not a reasonable amount. For better understanding, refer the leading cases of Dunlop Pneumatic Tyre Company Ltd v New Garage Motor & Co. Ltd [1915] AC 79 87 (UKHL 1, 1914) and BFI Group of Companies Ltd v DCB Integration System Ltd [1987] CILL 348 (BFI Group of Companies Ltd v DCB Integration System Ltd (1987). Nevertheless, to determine whether the value of liquidated damages is penalty is still subjective since the assessment of the cost implications upon delay for the construction projects used in this study was not thoroughly reviewed. There are still many other cost elements that was not taken into account for in Project 4 as shown in Table 2 such as financing interests, professional fees, loss of productivity, additional follow on work and etc.

Figure 2 also shows that the value of the liquidated ascertained damages as stipulated in the contract documents for the remaining projects are all undervalued which implies that projects 1, 2, 3 and 5 are at a higher risk for the employer due to not being able to compensate the total cost damages incur upon delay in a project. Project 1 & 3 has the least amount of costs damaged compensated from 40% to 50%. Whereas the costs damages for Project 2 & 5 are covered more than 70% to 80%. Although the liquidated damages are undervalued, the provision for liquidated damages in the contract remains enforceable. This is a different scenario in the case of where the liquidated damage value is determined as a penalty, which inconsequently leads the provision for liquidated damages to be void.

CONCLUSION

The result from this study concludes that there are eighteen cost elements to be considered in ascertaining the amount of liquidated damages. The eighteen costs elements are further categorized into four themes which are loss of profit, overhead, human resource, and capital expenditure. The results also indicated that the current values of liquidated damages in construction case studies in Malaysia are undervalued with 40% to 50% of the total actual cost damages not recovered. There are many other cost elements not taken into account in the liquidated damages calculation. The cost elements in ascertaining liquidated damages can also inform contractors whether the liquidated damages are an extravagant amount causing the provision of liquidated damages to be void. Nevertheless, the case studies used in this study are limited to five. Hence, more case studies of construction projects in Malaysia are required to obtain an accurate representation. The findings from this study contributed to the body of knowledge by providing a holistic approach in determining the value of liquidated damages which are currently ambiguous and uncertain.

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HOW INDUSTRY PLAYERS PERCEIVED PAYMENT ISSUES IN INDUSTRIALISED BUILDING SYSTEM (IBS) HOUSING PROJECTS?

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Abstract
Housing projects have become one of the significant contributors to our national gross domestic product. However, since 1990s housing sector was known for its poor performance, heavily depending on foreign labors, increasing cost and cannot cater to the demand. Malaysian National Housing Policy 2012 has focused on the implementation of industrialised building system (IBS) to transform the housing industry by improving its quality, more economical, speed to construct and less dependency on foreign labors. Despite of these advantages and great efforts from the government, recent studies show that the IBS adoption is still far behind the target. Among the identified and significant challenges that discourage housing projects from adopting IBS is the payment system which is closely associated with procurement adopted. Adopting traditional procurement system which is suited for conventional construction method has been create problems to the industry players. Due to this, many developers either neglect to adopt IBS or if they adopt it, the related parties have to face payment difficulties. This paper explores payment challenges in IBS housing projects, and ways to overcome them. The findings can be used for the industry to justify on the need for a better procurement system for IBS project.

Keywords: *Industrialised Building System, payment, construction industry, procurement*

INTRODUCTION

The adoption of IBS or prefabrication concept has been widely practiced around the world especially in developed countries. In the United Kingdom, the government has given a serious attention for prefabrication implementation by encouraging innovations and modern methods that can produce better construction product, cost effective and environment friendly (Nadim & Goulding, 2010). The practice also been applied in other countries like Singapore, Hong Kong, Sweden, Germany and Denmark (Oostra, & Claeson, 2007; Lessing et al., 2005). In Australia, the government has committed to the industry transformation since 1970s and prefabrication has been proven to bring numerous benefits to their construction industry (Blismas & Wakefield, 2009). For Malaysia, the term used to represent the prefabrication construction is Industrialised Building System (IBS). The innovative approach of prefabrication concept has been introduced by the Malaysian government to increase the performance of the local construction industry (Rahman & Omar, 2006). IBS gives many advantages compared to conventional construction methods such as quicken and simplify the construction process, reducing the hazards and risks, minimization of construction wastages and improving the environment quality for sustainable development (Hassim et al., 2009; CIDB 2003; Kamar et al., 2009; Nawi et al., 2011; Thanoon et al., 2003). Besides that, Kamar et al. (2009) and Thanoon et al. (2003) proved that IBS adoption can enhance the construction performance in terms of quality, cost saving and safety compared to conventional methods (CIDB, 2010). IBS components which are fabricated in the factory where it involved automated manufacturing process with repetitive procedures, constant quality surveillance and strict control under trained and skilled workers can produce a high quality of IBS components are much better compared to conventional building materials (Nawi et al., 2011).

Since many years, the Malaysian housing projects are associated with negative issues such as low quality, delay, heavily dependent on manual labors, lack of skilled workers, and slow adaption to modern construction method (Agus, 1997). To improve the performance, the National Housing Policy (2012) has formulated six strategic thrusts. Thrust 3 is focusing on the adoption of effective strategy to meet housing demands while thrust 5 is focusing on intensifying research and development towards implementing modern construction method and green technology. According to Abd Jalil et al. (2015), to reach both thrusts, the implementation of IBS is seen as the best mechanism and its adoption should therefore be increased. The success of IBS adoption in housing projects can be seen in developed countries, which some have been proven since 1960s such as the Living Solution (United Kingdom), Sekisui Home (Japan), Wenswonen (Netherlands) and Open House (Sweden) (Oostra and Claeson, 2007). However, for Malaysian context, the adoption of IBS was far from government target. Many reports showed that most housing developers and contractors are reluctant to implement IBS and they prefer to continue using the conventional construction method (Din et al., 2007).

Research has been conducted to identify the barriers of IBS adoption and one of the causes is due to the current payment system which some said is not fair to the relevant parties and expose to dispute (Shukor et al., 2011). Besides that, according to the IBS Roadmap Review 2007 (IBS Roadmap, 2007), CIDB has also identified several factors that discourage the usage of IBS, and they also stressed on the current payment mechanism which they said need to be re-look to suit with IBS environment. In addition to that, many researchers argue that the current payment practiced is only suitable for conventional projects, not for IBS projects (Abd Jalil et al., 2015. As a result, many IBS projects have find difficulties especially when comes to payment for IBS manufacturers. The consequences of payment issues or disputes are very significant as the delivery and installation of IBS components are expose to delay (Nawi et al., 2015). Research development on IBS has received significant attention in Malaysia. There has been many studies on IBS product and are mostly focusing on IBS product and process and supply chain from the perspective from contractors and IBS manufacturers. Among the studies are IBS advantages (Azman et al., 2011; Din et al., 2007; Thanoon et al., 2003), IBS history (Blismas & Wakefield, 2009; Nawi et al., 2007), supply chain management (Shukor et al., 2011; Faizul, 2006; Kamar & Hamid, 2011), barriers on IBS implementation (Nawi et al., 2011; Rahman & Omar, 2006; Kamar et al., 2009), awareness and acceptance level of contractors (Jaafar & Mahamad, 2012; Hassim et al., 2009; Mohamad et al., 2009; Idrus and Hui, 2008), and critical success factors (Kamar & Anuar, 2011). However, research specifically focusing on payment challenges, issues and disputes for IBS project are still lacking (Nawi et al., 2015). Therefore, this paper will cover 2 objectives: 1. to discuss the issues under current payment practices in IBS housing projects and 2. To identify ways to overcome the issues.

PAYMENT ISSUES

Dzulkalnine (2014) defined payment in construction as transaction sum of money or monetary consideration to the contractors or suppliers for their work done or their sold goods. Judi and Rashid (2010) stressed that the payment mechanism is so crucial and its flow must be well arranged to protect the rights and interest of the parties involved, and it has been one of the major factor that contribute to project success. In modern construction where changes

in construction process and roles of parties have evolved, payment cannot be too rigid as this can prevent the relevant parties from getting their fundamental rights on well paid.

For IBS housing projects, research has identified some payment issues that the industry need to deal with. For example, Nawi et al., (2015) highlighted that most construction parties agreed that the current payment system used only suit to conventional project and not for IBS projects. Mohamad et al., (2012) study showed that more than half of IBS manufacturers and main contractors are very concerned on payment issues and they have experienced payment disputes in terms of procuring IBS components. Due to high initial and set up costs, payments especially to IBS manufacturers is extremely crucial as this would generate their productivity and deliver the product on time (Dzulkalnine, 2014). The payment issues have affected the efficiency of the IBS delivery as the payment system is not secure and effective. Idrus and Hui (2008) findings emphasized that payments for IBS components to manufacturer supposedly be made when the order is confirm, not after the components are manufactured. However, under current payment system, the developer or client will only pay the cost for IBS components to contractors based on progress payment, and the components need to have reached the site that is payment on delivery. Thus, based on Nawi et al., (2015), the main contractor need to use their own money, and they need to wait for quite a long period to get the claim from client. The current system only allowed client to pay the cost for IBS components after those components have reached the site. Most main contractor stressed that the current payment system is not fair and disrupt their cash flow (Shukor et al., 2011). To further worsen matters, only 75% of the total delivered IBS components will be paid to the main contractor in each progress payment.

Nawi et al., (2014) highlighted important practice scenario where most of main contractors do not have strong financial funding to pay the whole cost for IBS components. However, they need to ensure the components arrive on-time to avoid delay in installation. So, they pay some portion of the cost and they request for the IBS components to be delivered first, and they will pay the remaining cost when they have received payment from developers. Some IBS manufacturers agree with this system as they also have to consider storage problems where they cannot store the components in their factory for a long time and the components are purposely made for certain project cannot be used for other projects (Shukor et al., 2011). However, the current system placed a great risk to IBS manufacturers, as they have already spent 100% of the cost, but they can only receive the full payment after the main contractor get claim from clients. Nawi et al., (2014) argued that most IBS project client prefer to maintain the traditional method of payment method due to their familiarity with that system. The traditional payment system is already understood by all and they are already used to it. However, Jaafar and Mohd Radzi (2013) argued that when the nature or process of construction project has changed, the procurement method and the payment system should also be revised to suit with the changes. This to ensure the service or goods that they have given, will be paid accordingly and most importantly will avoid dispute that eventually might jeopardize the project success. It showed that payment issues pose a huge conundrum for IBS projects especially to the IBS manufacturers and main contractors. The current payment system has exposed certain players to high commercial risks. Abd Jalil et al., (2015) revealed that many IBS manufacturers and main contractors agree that the payment system is not fair to them, thus a new payment system which more equitable should be developed.

DATA COLLECTION

Payment issues are related to procurement system that the industry adopted. Rashid et al., (2006) revealed that to gain data or information on procurement matters that related to building project, researcher must include views from various relevant parties. The same concept was applied in previous research on procurement by Rashid and Morledge (1998), Love (2002), Davis et al., (2009), Jaafar and Radzi, (2013). Therefore, in order to ensure the data for this research is comprehensive, the selection of the sample or the population was based on the involvement of respondents in IBS housing project within the research areas which are in the state of Kuala Lumpur, Selangor and Penang. The personal details of the interviewees including their names, age, and gender are not disclosed to remain confidentiality. The respondents consist of 7 different companies which divided according to their nature of business. They are developers, building contractors, M&E contractors, IBS manufacturers, architect consultant, Civil and Structural consultant and Quantity Surveyor consultant. In overall, they are divided into 4 major groups which are developers (18.7%), contractors (30.5%), IBS manufacturers (27.1%) and consultants (23.7%). The data collection is gained through mixed method which combines the quantitative data (questionnaires) and qualitative data (interviews).

Both methods are conducted sequentially which first through questionnaires, then followed with face to face semi-structured interviews. This step was also applied in previous research by Mbachu and Nkado (2006), Adnan et al. (2008), Tabish and Jha, (2011), Jaafar and Radzi, (2013). The questions are designed to know the respondents views on payment challenges in IBS housing projects and ways to solve the challenges. Their answers are based on their experienced and knowledge from their current or previous involvement in IBS housing projects.

Questionnaire

The questions are divided into two sections which first, to identify the payment challenges, and second to gain respondents feedback towards recommendations to overcome the challenges. For questions on procurement challenges, respondents must answer through a five-point Likert-scale with options from “never” to “very often” while for questions on recommendations to overcome the challenges, they must answer through a five-point Likert-scale ranging from “strongly disagree” to “strongly agree”. Among the research that use the same scale are Kong et al., (2006), Ling and Poh (2008), Adnan et al. (2008), Jaafar and Radzi, (2013).

Each of the respondent’s company must have registered with their respective professional institutions. The respondents were consist of developers (registered with REHDA), G7 building contractors (CIDB), M&E contractors (CIDB), IBS manufacturers (CIDB), architect consultant (PAM), C&S consultant (IEM) and QS consultant (BQSM). Overall, from the total 199 questionnaires sent, only 118 or 59.3% were replied. The highest reply was received from the IBS manufacturers where 74.4% from total questionnaire sent to them were returned, followed with 62.9% (developers), 57.7% (building contractors), 53.3% (architect consultant), 52.0% (QS consultant), 46.7% (C&S consultants) and 42.9% (M&E contractor). Table 1 shows the questionnaires percentage of response.

Table 1. Questionnaires percentage of response

Nature of Business	Develop-er	Building Contractor	M&E Contractor	IBS Manufacturer	Architect Consultant	C&S Consultant	QS Consul-tant	Total
No. of companies involved in IBS housing projects within the research areas	49	70	16	61	17	16	31	260
No. of questionnaires sent	35	52	14	43	15	15	25	199
No. of response sample	22	30	6	32	8	7	13	118
Percentage of response	62.9%	57.7%	42.9%	74.4%	53.3%	46.7%	52.0%	59.3%

Background of Respondents

The majority or 63% from total respondents have bachelor degree as their highest academic qualification, 19% possess master degrees and 18% with diploma. From total respondents, 23% of them have registered and become member with their respective professional institution. In terms of work expertise, 32.2% are specialized in quantity surveying, followed with architect 11.1%, civil engineers 9.3%, IBS designers 11.0%, IBS installer / IBS site engineers 8.5%, operation manager 7.6%, construction manager 5.9%, mechanical and electrical engineers 5.1%, site supervisor 5.1% and lastly project manager 4.2%. Table 2 shows the respondents expertise. In term of working experience, 40% of the respondent have between 11–19 years, 37% between 1-10 years and 23% have more than 20 years. For interviewees, most of the respondents or 83% have between 8-15 years while 17% have between 16-25 years of experience.

Table 2. Respondents' expertise

Expertise	Frequency	Percentage
1. Developer	11	9.3%
QS	5	4.2%
Project Manager	4	3.4%
Civil Engineer	2	1.8%
Architect		
Total respondents from developer	22	18.7%
2. Contractor	14	11.9%
QS	7	5.9%
Construction Manager	6	5.1%
Site Supervisor	3	2.5%
Architect	6	5.1%
M&E Engineer		
Total respondents from Main Contractor	36	30.5%
3. IBS Manufacturer	13	11.0%
IBS Designer	9	7.6%
Operation Manager	10	8.5%
IBS Installer / IBS Site Engineer		
Total respondents from IBS Manufacturer	32	27.1%
4. Consultant	8	6.8%
Architectural Consultant	7	5.9%
C&S Consultant	13	11.0%
QS Consultant		
Total respondents from all Consultants	28	23.7%

Interviews

Interviewees were selected from the respondents who joined the questionnaires survey. After screening, 12 respondents were chosen based on their wide experience in the research areas. The purpose of the semi-structured interviews among others is to cross verify the questionnaire result, to investigate more on the related matters and to find new findings that might left behind in the questionnaires. To ensure the information gained through interviews are not missed, the interviews sessions were recorded and transcribed. From all the interviewees, 4 are from IBS manufacturers (M), 3 from contractors (C), 2 from developers (D) and 3 from consultants (CO).

Procurement Challenges on Payment

To identify the payment challenges, respondents are required to rate the questionnaire and the result is tabulated as below. Table 3 shows the questionnaire's results on payment challenges in IBS housing projects.

Table 3. Questionnaire's results on payment challenges in IBS housing projects.

	1. Payment								
	Challenges under current procurement	**Scale / Frequency**					**SD.**	**Avg. Index**	**Cat. of Rating**
	Question	**Never (1)**	**Rarely (2)**	**Sometimes (3)**	**Often (4)**	**Very Often (5)**			
1	To procure IBS components, contractors need to advance their own money for upfront payment.	1	5	23	52	37	0.8721	4.01	Often
2	Upfront payment must be paid to IBS Manufacturers upon confirmation of orders (before the start of production IBS components).	0	5	24	45	44	0.8631	4.08	Often
3	Contractors have difficulties to pay upfront payment when the orders are in large quantities.	0	8	46	41	23	0.8678	3.67	Often
4	Manufacturers will only deliver the components upon receiving the agreed payment.	1	4	24	61	28	0.8091	3.94	Often
5	Contractors claim the cost of IBS components under "material on site" in progress payment.	1	7	15	53	42	0.8923	4.08	Often
6	Contractors' payments to IBS manufacturers have been delayed due to late payment from Clients.	2	5	38	36	37	0.9721	3.86	Often
7	To ensure full payment from Contractor to IBS Manufacturer, both parties make additional agreement such as "Director Guarantee".	3	16	43	34	22	1.0271	3.47	Sometimes
8	IBS Manufacturers will claim extra cost for additional work such as changing design, variation orders, supervision on site, consultation fee etc.	1	5	23	58	31	0.8412	3.96	Often

There are 8 questions and they are grouped into 3 major problems which are upfront payment, claim process and extra cost for additional works.

Upfront Payment

The first problem that received the highest average index is upfront payment where 3 questions are posed related to this problem. Respondents said that the main contractors must pay the upfront to the IBS manufacturers before they start components fabrication. However, most main contractors have no financial source to pay the upfront except using their own money and this has cause difficulties to them especially when the orders are in large quantities. The first 2 questions received the first and third highest average index at 4.08 and 4.01 while the third question received the average index of 3.67. According to M1, the upfront payment must be paid before the start of components fabrication because the IBS manufacturer will use this money to buy the required materials to fabricate the components. The materials include cement concrete, steel, sand, precast mould and also to pay the manufacturer's operation cost on labor, machines, cranes operator etc. Normally, the amount of upfront is ranging between 30% - 50% from total cost, depending on the shape and size of the components. This was agreed by M2, M3 and M4. M2 added the reason why IBS manufacturers request such amount is because they have no other source of capital to start the fabrication process except from requesting upfront payment from the main contractors.

However, many contractors argued on the amount of the upfront payment. Among them are C1, D1, I1, CO1, CO2, CO3, and C2. C1 stressed that the IBS manufacturers should consider to lower the upfront amount because 30% - 50% is too high. He explained that the main contractors do not entitle to any financial help to pay the upfront. For them, besides of paying the upfront, the main contractors also need to pay their own operation and construction cost like the preliminary works, machines and cranes, materials suppliers and subcontractors. C2 agreed and he explained that without financial help, most main contractors had difficulties to pay the upfront. So, to ease the burden, some main contractors use a strategy where instead of using a single order that include the whole components, now they split the orders into several orders. By doing this, they do not need to pay the upfront base on the whole components, but they only pay the upfront base on each of the split orders. So, the amount for upfront in each split orders will be less compared to the amount for upfront in single orders that cover the whole components. However, this strategy was disagreed by most IBS manufacturers. M1, M2, M3 and M4 argued that the split orders will cause problems to them.

Claim process

The second problem under payment is the claim process where 3 questions are posed relating to this problem. Respondents said that the claim for IBS components is made under 'material on site' in progress claim and the IBS manufacturers will only deliver the components after full payment is settled. However, the payments to the IBS manufacturers were often delayed by the main contractors because the payments to the main contractors were also delayed by the developers. The first question received the second highest average index at 4.08 while the second question, 3.94 and the third question, 3.86. C1 revealed that at present, there is no specific clause to claim for IBS components. So, the main contractors will claim the IBS components under 'material on site' clause in progress claim. Under this clause, it is stated that the developers will only pay the cost for the construction materials after those materials have reached the site. He argued that this clause is only suitable for conventional projects, not for IBS projects. This because, the conventional projects involve raw construction materials which build on-site, while IBS projects involve components that are

ready made products which build in the factory. This argument was agreed by D1, M1, I1, M2, M3, C2, D2 and M4. M1 added that most main contractors have no large cash in hand, so they face financial problems because to claim the IBS components from developers, they need to wait for a long time start from the confirmation of orders until the components have delivered to site. He said: "Under 'material on site' clause, the main contractor can only claim the cost of the IBS components after the components have reached the site. So, they need to wait long time since components orders until delivery to the site. Due to this long process, it is unjust for main contractors to only be paid after the IBS components reached the site." However, M3 added that some IBS manufacturers take lenient measures by allowing the main contractors to pay the remaining payment after the developers have paid the main contractors. That means the IBS manufacturers will still send the IBS components despite they do not receive full payment from the main contractors, and the full payment will be made after the developers have paid the main contractors. C2 and M4 agreed with the practice, and they said that despite of not paying the full amount, many main contractors pleaded to the IBS manufacturers to deliver the components on time, while at the mean time they will work out to settle the full payment.

Cost for additional work

The last problem under payment is extra cost for additional works. There are 2 questions posed relate to this problem. Respondents rated that they often been extra charged on other IBS related works such as design changes, variation orders, supervision to install IBS components and consultation fee as these works are considered additional. The average index for this question is 3.96. However, for the question on 'Director Guarantee' which considered as additional agreement, respondents rated that they apply it only for sometimes and it receives the least average index at 3.47. According to M3, as an IBS manufacturer, his company will charge extra cost for any additional works because the works will incur cost to them. For example, if design changes happen where certain columns or beams need to be removed, this will definitely increase the load and strength to the other columns and beams, thus a new design must be made. However, C1 argued that some IBS manufacturers do not clearly stated what works that they considered as additional and will be extra charged. Due to this, some main contractors were shocked after they noticed that works such as design changes, supervision for installation and IBS consultation will be charged extra cost. Regarding the 'Director Guarantee', D1 explained that the aim of this additional agreement is to ensure the full payment will be paid by the agreeing parties. If any breach of payment happens, the victim of the non-payment can present the 'Director Guarantee' agreement before the court. If the respondent is found guilty, his personal asset such as property can be seized by the court to be used to settle the breach of payment. D1 added that this agreement is aim mostly to ensure the full payment for IBS manufacturers. However, the 'Director Guarantee' only suitable for large and high cost housing projects. Therefore, only few of high cost IBS housing projects had applied this additional agreement. To conclude, the upfront payment still becomes a major issue in IBS housing projects. Many respondents agreed that the main contractors have difficulties to pay the upfront and the amount of upfront is too high. Besides that, the respondents also emphasized on the issue of claim process where they said the claim under 'material on site' clause is not suitable to be used to claim for IBS components. Many respondents admitted that the delay on IBS components occur because of payment problems that happens to IBS manufacturers.

RECOMMENDATIONS TO OVERCOME THE CHALLENGES

This part will discuss on respondents' feedback towards the recommendations to solve the payment challenges. Below are the results on recommendation for payment. Table 4 shows the questionnaire's results on recommendations to overcome payment challenges in IBS housing projects.

Table 5. Questionnaire's results on recommendations to overcome payment challenges in IBS housing projects

	1. Payment								
	Recommendations for new procurement model	Scale / Frequency					SD.	Avg. Index	Cat. of Rating
	Question	Strongly Disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly Agree (5)			
1	Upfront payment should be agreed between Clients / Consultants and IBS Manufacturers, not involving Main Contractors.	7	18	26	28	39	1.2527	3.63	Agree
2	Payments to IBS Manufacturers must be paid by Clients before the production of IBS components.	5	15	31	40	27	1.1042	3.58	Agree
3	Contractors should not be burdened on payment to IBS Manufacturers, as this will disrupt contractor's cash flow.	4	12	33	40	29	1.0639	3.66	Agree
4	Payments to IBS Manufacturers should be paid directly by Clients, not through Main Contractors.	8	19	32	21	38	1.2791	3.53	Agree
5	Extra cost such as cost for supervision, changing design and consultation fee should be clearly stated / addressed before the confirmation of orders.	1	1	11	57	48	0.7357	4.27	Agree

There are 5 recommendations to solve procurement challenges on payment in IBS housing projects. They are grouped into 3 which are upfront payment should be paid by developers, direct payment to IBS manufacturers and cost for additional work.

Upfront payment should be paid by developers

The first recommendation is the upfront payment should be paid by the developers. There are 2 questions that relate to this recommendation. The respondents agree that the upfront payment should be agreed between developers and IBS manufacturers, and the payment for the IBS components must be made by the developers before the components start to be fabricated. Both recommendations received the third and fourth highest average index at 3.63 and 3.58. According to C1, when the projects start, most main contractors have already spent a lot of money to pay their subcontractors and suppliers. So, they have difficulties to pay the upfront because the upfront amount is too high and they have no financial support, except depending on progress claim from the developers. Therefore, he stressed that the upfront payment should be shifted from main contractors to the developers. This will definitely reduce the main contractors' burden. Besides, they can also focus to manage the project without need to find any financial help or cut any budget just to pay the upfront. Besides, if the developers

pay the upfront, they can make single order for the whole IBS components that the project required, and the main contractors will no longer need to do the split orders due to their financial constraint.

This was agreed by M1, I1, M2, CO2, C2, D2 and M4. According to D2, if the main contractors have lack of money and need to find other sources just to pay the upfront, this can jeopardize their focus and can expose them to financial problems. M4 agreed with the justification and added that if the payment is made before the components start to be fabricated, the IBS manufacturers will ensure the IBS process from design until installation will not be disrupted. This because most of disruption on the IBS work is due to payment issue.

Direct payment to IBS manufacturers

The second recommendation is on direct payment to IBS manufacturers. There are 2 questions that relate to this recommendation. The respondents agree that the payment to IBS manufacturers should not be paid by main contractors because this can disrupt their cash flow and instead, the payment should be made directly by the developers. Both recommendations receive the average index of 3.66 and 3.53. According to C1, to pay the IBS components the main contractors need to use their own money and they can only claim the cost when the components reached the site. This will certainly affect their cash flow. So, if the payment for the IBS components is shifted from main contractors to the developers, this will help the main contractors' to better control their financial flow. This idea was supported by M1, I1, M2, CO2, CO3, M3, C2, D2 and M4. They agreed that if payments for IBS manufacturers are paid directly by the developers, this can solve many problems including the issue on 'material on site' claim. Besides, the IBS manufacturers will no longer need to make additional agreement such as the 'Director Guarantee' or 'Deeds of Assignment', just too secure full payment or direct payment from the developers.

D2 added the IBS components are purpose made for the developer's particular project and the components cannot be sold to other projects. Besides, the IBS components will eventually become the developers' buildings. So, it is better for the developers to pay direct to the IBS manufacturer, not through main contractors. Furthermore, the direct payment will avoid the main contractors and the IBS manufacturers from payment disputes. He gave an example where his company also had the experience of make direct payment to the IBS manufacturer, and the project was smoothly run without delay. He commented:

"The payment problems to the IBS manufacturers may expose the project to delay in components delivery and affect the completion time. So, we had the experience where we paid our IBS manufacturer directly as we want to avoid payment disputes which usually happen between IBS manufacturers and the main contractors."

Cost for additional work

There is only one question that relate to this recommendation. Respondents said they agree that cost for additional works such as changing design, consultation fee, supervision etc. must be clearly stated before the confirmation of orders. This question received highest average index at 4.27. According to M1, most quotations from IBS manufacturers do not

clearly state the additional works that are necessary in completing IBS work from design until final installations. As a consequence, many main contractors do not realize that changing design, supervision at site, consultation fee and variation orders will be extra charged by the IBS manufacturers. However, on the IBS manufacturers' side, they considered those works as additional and will charge extra cost because the changes may cause their engineers to re-design, the fabrication process need to be rearranged, the delivery need to be rescheduled and the size, load and strength of IBS components need to re-look to suit with the changes. Therefore, CO1 stressed that the IBS manufacturers must clearly state the type of works that are included in the quotation and the other additional works that are not included in the quotation, but they are necessary to complete the IBS works. He explained:

"Some main contractors thought that the cost to complete the IBS works only involve the price of the IBS components, the delivery process and their installation. However, they do not realize that they also need to pay additional cost which are necessary to complete the IBS works, such as the cost for supervision at site, changing design, consultation fee, training the labours etc."

CONCLUSION

Payment is embedded in procurement system. The adoption of payment mechanism is very much related to procurement applied. Previous literature has raise the issues and the importance of providing suitable procurement to ensure project success. For Malaysian context, the current procurement being practiced in IBS projects are not much different compared to conventional projects? This means that the procurement for IBS and conventional projects are having no different despite both projects have different natures, characteristics and needs. As a result, many IBS projects face great problems because the procurement they use are not suit with IBS needs. Due to that problems, many agrees that in order to ensure successful IBS projects, the current procurement must be modified or changed so that it can cater IBS's requirements and avoid rigidness, which will eventually causing problems to the IBS projects. Due to this issue, contractors can make split orders so that they will only pay the upfront base on that particular order. However, this strategy is not welcome by the IBS Manufacturers as they need to fabricate the components based on the split orders. This disallows them to make detail production planning that cater the fabrication for the whole components.

The findings also highlighted on payment disputes happen between IBS Manufacturer and Main Contractor. The agreement between both parties are often breached. So, to secure full payment for IBS Manufacturer, many projects apply Deeds of Assignment where the Developer will pay direct to IBS Manufacturer, but it must have the consent from Main Contractor.

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PAYMENT ISSUE OF INDUSTRIALISED BUILDING SYSTEM (IBS) IN MALAYSIAN CONSTRUCTION INDUSTRY

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Abstract
The construction industry makes up an important part of the Malaysian economy. Due to unpleasant working condition and the availability of cheap foreign worker, government has implemented the Industrialised Building System (IBS) for government project. This study aims to identify the payment issue of Industrialised Building System (IBS) in Malaysian construction industry and propose the recommendation to the IBS industry to make a better financial management for IBS project. This study employs quantitative and qualitative approach to collect information on the payment issue of Industrialised Building System (IBS) which involved contractor, manufacturer, developer and academician. This study is expected to help the contractor to maintain their business with especially at the early stage of construction which involved huge capital investment for the IBS project. The outcome of this study will encourage construction industry especially IBS contractor to have better understanding on financial management.

Keywords: *payment, procurement, financial, Industrialised Building System, management, construction, conventional, comparison*

INTRODUCTION

The growth of construction industry will give multiplier effect to the material production sector, equipment and other services sector. According to Mohammed & Ahmad (2002), the growth of construction industry can be seen in this aspect:

i. Job opportunities
ii. Physical growth
iii. Construction Technology
iv. Increment of Land Value

Due to unpleasant working condition and the availability of cheap foreign worker, majority of construction companies preferred to hire them. Therefore, in 2008, to reduce the dependency on foreign worker, government has initiated the implementation of Industrialised Building System (IBS) to the construction industry. Every government project shall achieve at least 70% of IBS component (CIDB, 2010). As mentioned by Ministry of Works, IBS will be mandated to the private sector with value of project RM 50 Million and IBS score of 50% (CIDB, 2017).

IBS is defined as a construction technique in which components are manufactured in a controlled environment (on or off site), transported, positioned and assembled into a structure with minimal additional site work (CIDB, MPC, REHDA, & CREAM, 2014). According to Hung, Hamid, Din, & Norman (2015), IBS assure valuable advantages such as reduction on

unskilled workers, less wastage, less volume of building materials, increased environmental and construction site cleanliness and better quality control.

Table 1 show the statistics of foreign workers in all industry in Malaysia. Construction sector shows the increasing number from year to year. In 2015, the number is foreign worker is quite surprising which it increased almost about double from year 2014. This situation is expected as many ongoing mega projects such as MRT. As years increase, the number of foreign worker is also increase. This statistic alarming that the construction industry was flooded by the foreign worker which does not compatible with the government initiative to reduce the foreign worker in construction industry. The main problem of foreign worker in the construction is most of the workers is not a skilled worker which will affect the quality of the building in Malaysian construction industry.

Table 1. Numbers of Foreign Workers in Malaysian Industry

Year	Sector					Total
	Maid	Manufacturing	Construction	Services	Agriculture	
2000	177,546	307,167	68,226	53,683	200,474	807,096
2001	194,710	3 12,528	63,342	56,363	222,886	849,829
2002	232,282	323,299	149,342	64,281	298,325	1,067,529
2003	263,465	385,478	252,516	85,170	350,351	1,336,980
2004	285,441	475,942	231,184	93,050	384,473	1,470,090
2005	320,171	581,379	281,780	159,662	472,246	1,815,238
2006	310,662	646,412	267,809	166,829	477,497	1,869,209
2007	314,295	733,372	293,509	200,428	503,201	2,044,805
2008	293,359	728,867	306,873	212,630	520,867	2,062,596
2009	251,355	663,667	299,575	203,639	499,910	1,918,146
2010	247,069	672,823	235,010	165,258	497,711	1,817,871
2011	184,092	580,820	223,688	132,919	4 51,542	1,573,061
2012	142,936	605,926	226,554	138,823	457,350	1,571,589
2013	169,936	751,772	434,200	269,321	625,093	2,250,322
2014	155,591	747,866	411,819	270,048	488,090	2,073,414
2015	148,627	450,364	745,131	293,433	497,480	2,135,035

Source: Ministry of Home Affairs

Construction Industry Transformation Programme (CITP) 2016 – 2020 mentioned that IBS assures valuable advantages such as the reduction of unskilled workers, less wastage, less volume of building materials, increased environmental and construction site cleanliness, and better-quality control. Besides, it offers benefit to adopters concerning cost and time certainty, attaining better construction quality and productivity, reducing risk related to occupational safety and health, alleviating issues on skilled workers and dependency on manual foreign labour, and achieving the goal of reducing the overall cost of construction. Figure 1 show the evolution of IBS industry in Malaysia. In 1964, the first building using IBS in Malaysia is Pekeliling Flat which using Danish System of large panel of pre-fabricated (Hamid, Kamar, Zain, & Rahim, 2011).

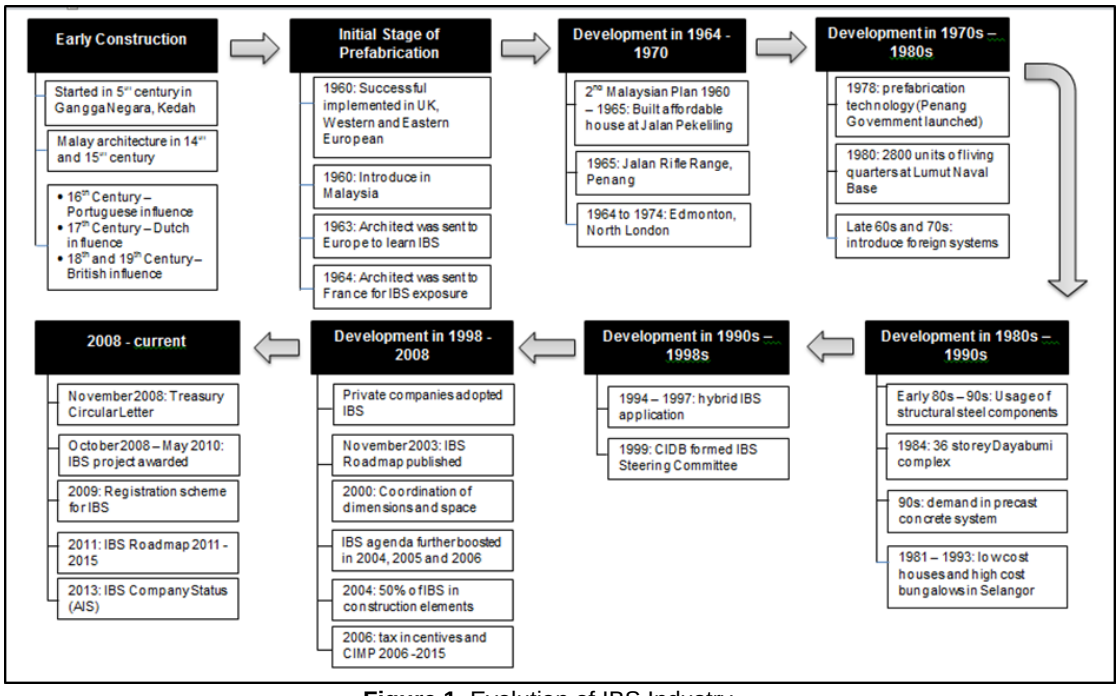

Figure 1. Evolution of IBS Industry

Government Circular on IBS

Starting year 1960, there are many initiatives from the government to implement the IBS. The IBS issue is highlighted in each government circular which the objective is to increase the usage of IBS for government and private sector. Figure 2 shows the government circular related to implementation of IBS in Malaysia.

IBS was mentioned in Malaysian annual budget starting year 2004. The current budget for year 2016, government also mentioned that there was allocation of RM 500 million to promote IBS in Malaysia.

Released on 31st October 2008, the Treasury Circular Letter was issued to all Secretary Generals, Heads of Federal Department, State Secretaries, Heads of Federal Statutory Bodies as well as to all local authorities. The essence of the instruction is the usage of Open Building, MC design and 70% IBS Score for all projects. Agencies are required to submit periodical reports of IBS project implementation to ICU which acts as the central monitoring agency. Exemptions are offered for certain classes of projects and the IBS Centre will function as the main technical reference centre.

The new government circular is Construction Industry Transformation Plan (CITP) which was launched on 10th September 2015 and was initiated in 2014 by Ministry of Works through the Construction Industry Development Board (CIDB) Malaysia. It is a 5 years programme covering the period from 2016 until 2020. Under CITP, there are 4 strategic thrust which are Quality, Safety and Professionalism, Environment Sustainability, Productivity and Internationalisation. IBS falls into Productivity thrust which mentioned that Malaysia still has

a low take-up rate Industrialised Building System (IBS) in construction(CIDB, 2015). Only 24% of public projects worth RM10 million and above achieved IBS score of 70, a far reach from the intended 100% take up rate, despite a Ministry of Finance circular mandating it.

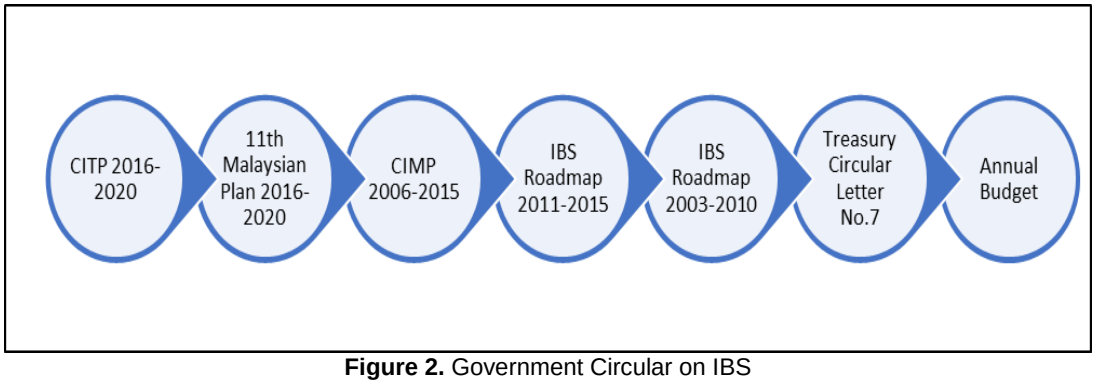

Figure 2. Government Circular on IBS

Apart from the advantage of using IBS, the construction player especially contractor is suffered in term of financial management to implement IBS. One of the main challenges faced by the Malaysian construction industry is difficulty in securing timely and adequate financing at the various stages of construction and difficulty in repatriating profits and dividends. Lack of integration at the design stage leads the additional cost by IBS contractor. IBS component manufacturer is currently involved only after the design stage which has resulted in the need for plan redesign and additional cost is incurred.

Table 2 shows the show the data from Bank Negara Malaysia (BNM) as of 2017 on amount of loans applied by construction sector, loans approved for construction sector and percentage of loans approved for construction sector (Bank Negara Malaysia (BNM), 2017).The financial institutions which provide the loans are commercial banks, Islamic banks and merchant or investment banks. From the table, it is revealed that only 45.9% of loans for construction sector is approved as June 2017. The percentage is quite alarming that the payment issue will arise especially for those who want to venture in IBS industry.

Table 2. Loans Approved for Construction Sector

Year	Loans Applied by Construction Sector (RM million)	Loans Approved for Construction Sector (RM million)	Percentage Approved for Construction Sector (%)
2006	26,620.4	13,496.1	50.7
2007	39,532.8	20,892.2	52.8
2008	35,849.0	20,541.8	57.3
2009	34,353.8	16,612.6	48.4
2010	58,778.9	25,524.1	43.4
2011	66,863.3	32,168.0	48.1
2012	59,067.6	26,306.7	44.5
2013	61,674.9	23,532.0	38.2
2014 (as September 2014)	50,681.5	16,977.3	33.5
2015 (October until December 2015)	15,071.3	6248.9	41.5
2016	65,997.9	25,760.6	39.0
2017 (as June 2017)	33,366.7	15,313.8	45.9

Source: Bank Negara Malaysia, 2017

IBS contractor face difficulties to get loans from banks due to different method of payment to conventional construction. Conventional construction applied progress-based mechanism method of payment which are the payment will be made based on physical progress at site. It will also be a challenge in the financial management of the projects in view of the increasing cost of diesel and raw materials, especially cement. This will affect in the production of precast concrete panels, floor slabs and the transportation of material and modules (CIDB, 2007).

As for now, there is no documented evidence for the solution of payment issue for IBS contractor. Many of the past research did mentioned about the payment issue for the IBS contractor, but there are no details about the payment issue related to procurement system and contract document. Therefore, to resolve the payment issue of IBS contractor, this research is expected to investigate the payment issue of IBS industry and provide the recommendation to resolve the payment issue.

This study is expected to help the construction player especially who are involved in the IBS project to maintain their business with especially at the early stage of construction which involved huge capital investment for the IBS project. Besides that, this study might educate the client or policy maker to mention about IBS project in the construction contract. The findings will contribute to knowledge which suited to financial management and construction industry management. The framework generated from this study will provide better solutions in terms of financial management for IBS player especially contractor towards the development of Malaysian construction industry.

Current Payment Procurement Method

To date, there is no detailed IBS building guidelines or standard regulations for procurements systems or contract documents in terms of tendering, design, construction and operations have been produced. Previous researchers had concluded that the current traditional and modern procurement methods were not suitable for IBS projects especially in terms of project coordination and payment.

Hung, Hamid, Din, & Norman (2015) mentioned that IBS requires a different strategy on supply chain, planning, scheduling, handling as well as purchasing of materials. With this regard, a new business approach, investment and financial planning including the effective combination of cost control and selection of projects that give enough volume to justify the investment is a must in IBS construction. The limited take up of IBS in private project is also affected by the different payment system required when using IBS.

Current payment method is based on work progress, that doesn't apply when comes to IBS method. The conventional method practices the S-curve payment method which the payment will be made on progress. The payment method for IBS construction cannot be treated same as conventional because there is difference in terms of preparation of material on site, set up the factory and supply of skilled worker for installation purposes.

Mohammad, Mahbub, Musa, & Yusof (2017) mentioned that the payment and procurement mechanism need to be reviewed for a project that adopt IBS. The established form of contract is no longer suitable for IBS project. A new mechanism of payment and

procurement needs to be introduced for IBS. The IBS adopters require reliable and safer payment and procurement for parties involved.

LITERATURE REVIEW

Factors of Payment Issue in IBS Industry

A survey has been done to the IBS player in Malaysian construction industry involving manufacturer, contractor, developer, policy maker and academician. Most of the respondents have experience in IBS industry in local and oversea and involved in private and government project. According to (Kamar, Hamid, & Mustapha Alshawi, 2009), the challenges of IBS implementation can be categorised into ten (10) issues and one of the main challenges is in term of finance and costing.

i. High Initial Cost

The payment issue for the IBS project is always been arise by the construction player especially the contractor. The high initial cost has burden the player of IBS project as they need to have high investment for IBS project. Before ever getting the first draw, the contractor will have spent a large amount of money. The contractor is required to put out cash not only on the construction itself, but also on such things as the estimate, which is time consuming and expensive, and on setting up the job in the office and in the field, purchasing materials, renting equipment and hiring labor. It is reasonable, therefore, for the contractor to attempt to recapture this cash outlay as rapidly as possible. It is also reasonable to conclude that a contractor needs only a small profit margin on cost items that are fixed and definite, such as subcontractor's bids and the purchase of materials, whereas a larger profit is required on risk items, such as labor performed by the contractor's forces, which might have a cost overrun (Wiley, 1984).

The initial cost involved the cost to set up the factory, machinery, skilled workers and others related cost. According to the respondent, the high price in terms of production cost is the main challenge to the IBS contractor.

ii. Variation of Price (VOP) of Material

Before the Treasury Circular No 2 of 2008 dated 6th August 2008 was issued, the reimbursement for fluctuation of steel prices through Variation of Price (VOP) provision was based on the ceiling price and not actual transaction price, as steel was a controlled price item.

As such, contractors had to bear the extra cost from the difference between steel bar ceiling prices and their actual transaction costs. Besides, the continuous increase in steel bar prices had caused much burden to contractors. This issue had been raised by contractors in many platforms including the dialogue session with the Minister of Works held on the 16th of July 2008 and also through various memoranda forwarded to the various Government Ministries. The plight and

grievances of the contractors were well received by the government, whereby through Treasury Circular No 2 of 2008, the Government had made some improvements to the VOP provisions (CIDB, 2009). Hamid, Kamar, Zain, Ghani, & Rahim (2008) also mentioned in their research that the main barriers in IBS implementation is because of high cost of IBS component.

iii. Drawing and Design Matters

The differences of the construction method include purchasing of materials in advance before the actual site progresses. In addition, the design of IBS construction project might require designers to consider the ease to fabricate and to install the components but the common practice shows that contractors and manufacturer of IBS components is involved only after the tender stage of the value chain. This lack of integration among relevant players in the design stage has resulted in a need for redesign and additional cost to be incurred in IBS project.

iv. Contract Document

Gibb & Isack (2003) and Blismas (2007) suggested that IBS should not be used as an afterthought, or as a late solution to shorten construction time, but rather as an integral part of the design from the earliest possible stage of the project. To reap the maximum benefit from IBS, it is often essential that IBS is selected as a method of construction at the early stage of the project Abdullah, Kamar, Nawi, Haron, & Arif (2009). Therefore, IBS requires the type of contract route that allows adopters to be involved at the beginning such as in Design and Build, direct negotiation and turnkey contract route.

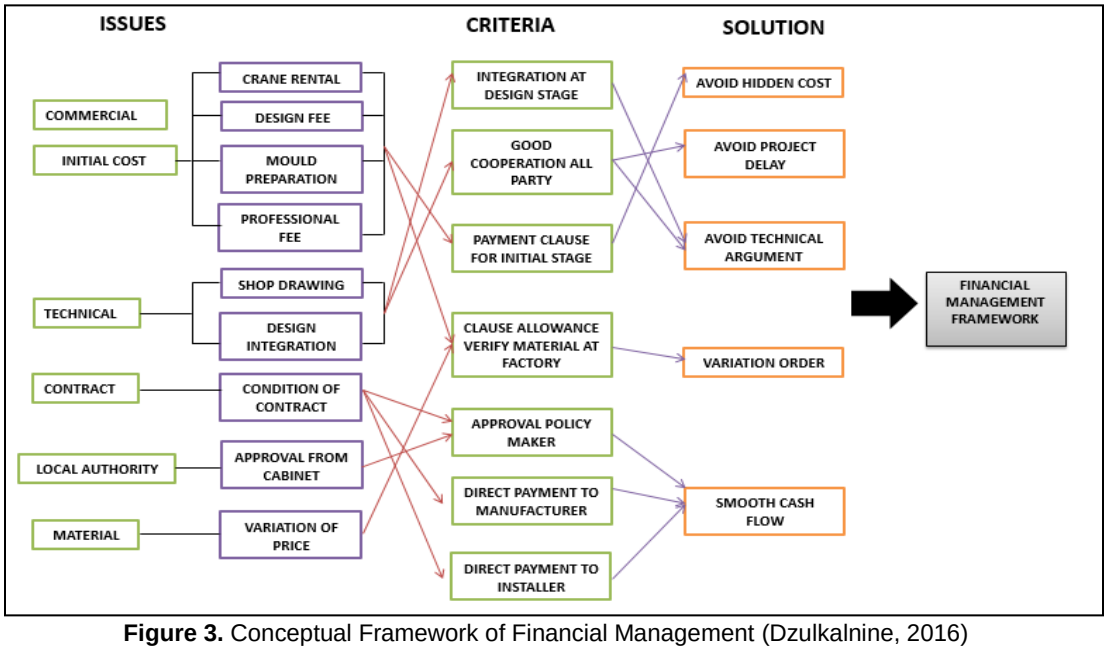

Figure 3. Conceptual Framework of Financial Management (Dzulkalnine, 2016)

METHODOLOGY

This study implied quantitative and qualitative methods. Data was collected through mail questionnaire. To strengthen the findings, the face to face interview was conducted. However, the major approach in this study is questionnaire considering the time, cost and effectiveness. Questionnaire method was chosen because it is an efficient data collection mechanism when the researcher knows exactly what is required and how to measure the variables of interest (Sekaran & Bougie, 2010).

Questionnaire was sent to the top management, project manager, architect, contractor and academician. The total number of respondents is 100 which sufficient to collect the basic information for the actual variable. The face to face interview was conducted to four (4) industry player who was involved in IBS project and experience in payment issue in their project.

Most (50%) of the respondents are 25-35 years old (refer Figure 4) and the role of the respondent's majority (59%) are from others role which included academician, main contractor, manufacturer and installer (refer Figure 5).

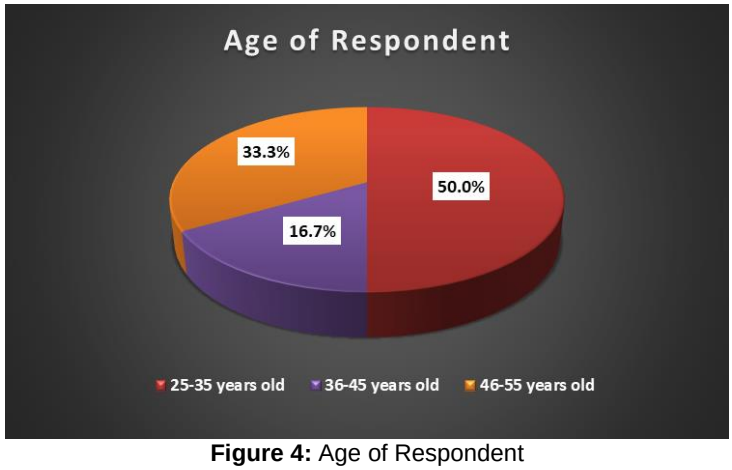

Figure 4: Age of Respondent

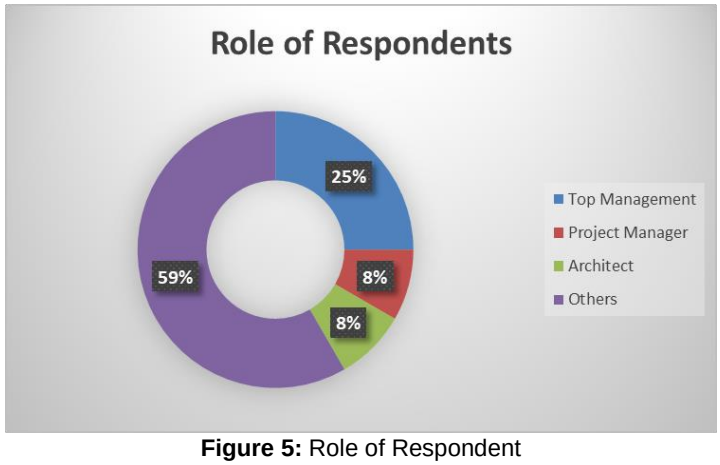

Figure 5: Role of Respondent

From Figure 6, majority (66.7%) of the respondents are involved with IBS project while another 33.3% never involved in any IBS project. This data shows that the answer from this study is reliable since most of the respondents have involved in IBS project and knows the real financial situation happen in their project.

In 66.7% of the respondents who are involved with IBS project, mostly have experience of 6-10 years (33.3%) while 8.3% have experience in IBS project with more than 15 years (refer Figure 7).

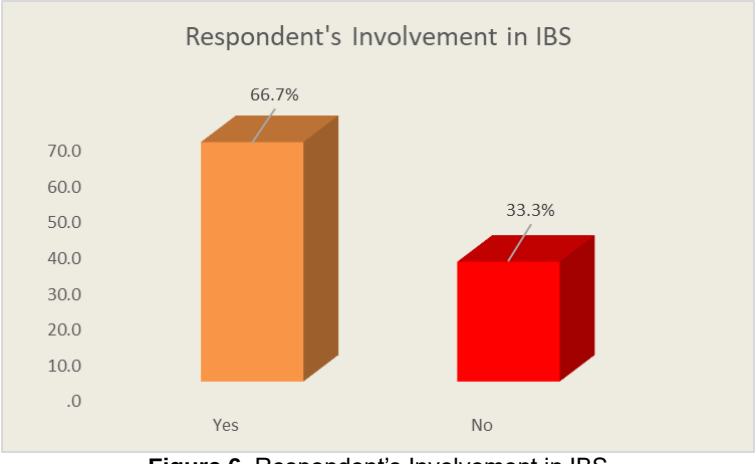

Figure 6. Respondent's Involvement in IBS

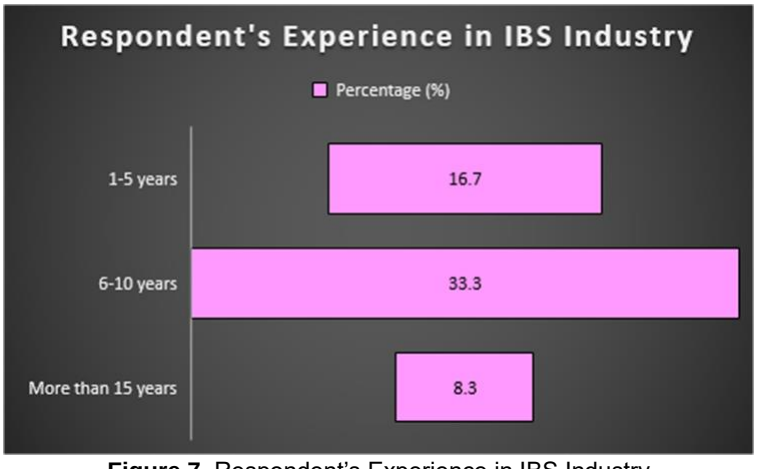

Figure 7. Respondent's Experience in IBS Industry

RESULTS AND DISCUSSION

The factors of payment issue in this study are categorised into six (6) sections which are initial cost, securing timely and adequate financing, design matters, financial institution, material and contract document.

From Figure 8, the highest mean for factors of payment issue of Industrialised Building System (IBS) are 4.5 Likert scale which are from Design Matters category and Contract Document category. In Design Matters category, the payment issue occurs at the integration design stage and it has been identified the cooperation of every party involved has been the payment issue of IBS project.

In the Contract Document category, the highest mean is the existing procurement method not suitable with the procedure of IBS. The current payment method for IBS is treated as same as conventional project which have different physical progress with payment progress.

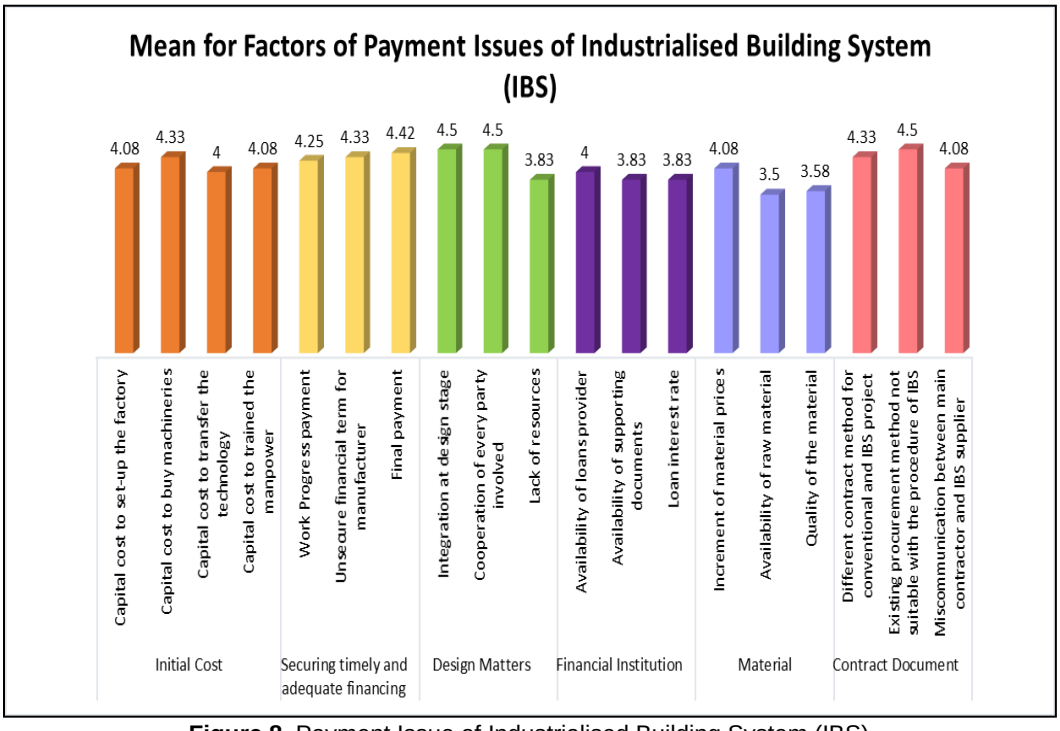

Figure 8. Payment Issue of Industrialised Building System (IBS)

CONCLUSION

A specific procurement system is required as IBS involved special procedures and processes which are different to traditional methods. It is needed to change the current method of payment for IBS project since the conventional project is totally different with IBS project in term of the process. The new payment method is essential to sustain the IBS implementation in Malaysian construction industry. This change can avoid delays of projects due to shortage of cash flow hence make it easy for contractors to get payment. The best system should cover everything in the lifecycle of the building involving procurement.

Some recommendations are suggested by the industry players to enhance the best practice of payment method in IBS industry. The recommendations are as below:

- Need modification in document contract especially in payment method
- Half payment should be made when structure has been sent to site for installation purposes
- Adjustment with existing procurement methods because the current is not suitable with the procedure of IBS
- Decoupling of IBS contract and IBS supplier contract direct to client
- Direct award to pre-caster
- Establish IBS form of contract
- New contract for IBS project
- Method to verify material on factory
- Need to highlight initial stage at prefab and manufacturing process payment in work progress

The financial issue is crucial in the IBS industry. To support the government initiative to increase the implementation of IBS, the policy maker must resolve the payment issue of IBS supply chain (manufacturer, IBS contractor, sub-contractor etc.). Therefore, to resolve the payment issue of IBS industry, the needs of new payment method is essential.

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THE ASSOCIATION BETWEEN EXTERNAL FACTORS AND THE IMPLEMENTATION OF THE GREEN BUILDING PRINCIPLES AMONG HOUSING DEVELOPERS IN KLANG VALLEY

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Abstract
Major greenhouse gas (GHG) emissions come from residential buildings that account for approximately 65% of the global total, while commercial buildings account for the balance of 35%. Thus, green housing development implementation is important to achieve a sustainable building through an energy efficient use. Unfortunately, Malaysia green building implementation in housing development is still lacking. Malaysia Green Building Index (GBI) stated that only 28 out of 818 registered housing projects delivered in Klang Valley were certified with Certified Verification Assessment (CVA) in 2016. This paper aims to identify the association between external factors and the green building implementation among the housing developers in Klang Valley. A questionnaire survey was conducted and the study received 234 responses. The data have been analyzed using descriptive, cronbach's alpha, principal component analysis (PCA) and correlation analysis. The result showed that there was significant relationship between social and cultural factors and economic factors with the green building implementation. However, there is no significant relationship between the political factors and the green building implementation among the housing developers in Malaysia.

Keywords: *External factors, green building principles, housing developers, Klang Valley*

INTRODUCTION

The emergence of more buildings particularly in city centers had created an urban island effect. Malaysia population increased by 53% in 20 years from 18 million (1990) to 27.6 million (2010) and continue to grow in the coming years (APEC, 2014). The acceleration in Malaysian population growth increases the GHG emission from 1980 to 2010 is approximately 250% from 2.0 to 7.7 metric tons per capita (Suzaini et al., 2015). Major GHG emission of the building sectors comes from residential buildings, accounting for approximately 65% of the global total, while commercial buildings account for the balance of 35% (Baumert et al., 2005). The sustainable development has been an efficient approach to manage the renewable and non-renewable energy reducing waste and pollution. Besides that, sustainable building design can improve occupant's health, comfort, satisfaction, and performance (Loo, Lau, and Foo, 2016). The Malaysia effort in reducing greenhouse gas (GHG) emission up to 40% in the year 2020, compared to 2005 was pledged by the Prime Minister at the 15th Conferences of the United Nations Framework Convention on Climate Change in 2009. Besides, the 11th Malaysia Plan is encouraging the adaptation of green building criteria in building, industries and household development to ensure the energy efficient use of resources and reduce the GHG emission (Malaysia Government, 2015).

Green residential is define as a house that can achieve long lasting, sustainable through an energy efficient use (Elias and Lin, 2015). Many efforts have been done to encourage the green housing development in Malaysia. However, the implementation of the green building

development among housing developers is still lacking. Malaysia Green Building Index (GBI) stated that only 28 out of 818 registered housing projects delivered in Klang Valley were certified with Certified Verification Assessment (CVA) in 2016. There is no clear measure on factors affecting the implementation of the green housing development among housing developers. Therefore, this research will identify the external factors that influence the green building implementation among the housing developers. This study will help to suggest the approaches to encourage the green building implementation. In pro-environmental behavior (PEB) theory by Kollmuss and Agyeman (2002), demographic, external (e.g. Institutional, economic, social and cultural) and internal factors (e.g. Knowledge, values, attitudes, emotion) have been found to have some influence on PEB. In this study, PEB is referred as green building implementation because they have the same meaning which to minimize the negative impact of one's action on nature. This paper focuses is to identify the relation between the external factor and the green building implementation among the housing developers in Klang Valley.

PRO-ENVIRONMENTAL BEHAVIOR

In environmental psychology, common measures of PEB are based on a list of PEB behaviors usually developed by the researcher (Gatersleben et al., 2002). There are 18 PEB items were developed from the literature review of more than 55 online journal, articles, papers, GBAS, and related documents. Among the PEB items that have been identified are green building should be design according to local environment, optimize local materials, apply integrated design and process, encourage green design and innovation, energy efficient, water efficiency, resource efficiency, green waste and emission management, renewable energy design approaches and better indoor environmental quality (GreenRE, 2017; United States Green Building Council (USGBC), 2016; Green Building Index (GBI), 2016; Isa et al., 2014a; Zhou, 2015; Elias and Lin, 2015; Li et al., 2014; Environmental Analytical Green (EAG), 2013). Consume reused material resources, consume green materials and resources, and sustainable sites planning and management were also found to be significant items of the green building principles (GreenRE, 2017; Zhou, 2015; Isa et al., 2014a). The green building should involve the local expertise in green technology and development (Elias and Lin, 2015; Zhou, 2015). Besides, occupy an integrated project team, and involvement of design and construction team since the early stage of planning and design process were also found as the list of the green building principles (Zhou, 2015; Li et al., 2014). Green building certificate should be applied for green projects was found as the green building principles (GBI, 2016). Table 1 shows the list of the green building principles.

The PEB models external factors include political, social and cultural and economic factors (Kollmuss and Agyeman, 2002). Many studies have stated that the provision of financial and non- financial incentives is important to ensure the green building implementation by the developer (Olubunmi et al., 2016; Elias and Lin, 2015; McGrawHill Construction, 2013). Government policy and regulation are among the political factors that were included in the list (Samari et al., 2015; Zhou, 2015; Aliagha et al., 2013). Meanwhile, there are 19 social and cultural factors were founded in this study. Some of the factors are support from NGOs, professional boards, and private sectors, better informed and well public engagement, and willing to commit in sustainable development (Olubunmi et al., 2016; McGraw Hill Construction, 2013; Zhou, 2015). The third external factor of PEB which is economic factors contains 12 factors. Among the factors are green building enhance asset

value and profits, optimize life cycle economic performance, and provision of cost and financial benefits (Elias and Lin, 2015; Li et al., 2014; Aliagha et al., 2013).

Table 1. The green building principles

Code	Green Building Principles
GBP 1	Should be designed according to the local environment.
GBP 2	Should optimize local materials/product consumption.
GBP 3	Apply integrated design and integrated process.
GBP 4	Green design and innovation.
GBP 5	Energy Efficiency
GBP 6	Water Efficiency
GBP 7	Resource efficiency.
GBP 8	Green waste and emission management
GBP 9	Renewable energy design approaches
GBP 10	Better indoor environmental quality/ Protecting occupant health and improving employee productivity
GBP 11	Consume reused material resources/ reduced waste
GBP 12	Consume green materials and resources
GBP 13	Sustainable sites planning and management/ land use
GBP 14	Involvement of local expertise in green technology and development. e.g.: green building consultant
GBP 15	Occupy an integrated project team/ Good project team characteristics
GBP 16	Involvement of design and construction team since the early stage of planning and design process.
GBP 17	Apply good project management: understanding green objectives of the project is very important.
GBP 18	Green building certificate should be applied for green projects

Political Factors

Political measure can be one of the main factors in green building implementation. The enforcement of the green building policies and regulation will higher the green developers involvement in the construction industry (Zhou, 2015; Samari et al., 2013). Promoting of green building product is a part of support from the government in creating a capable and viable local construction sector (Suhaida et al., 2011). Financial supports from the government are important to ensure the policy and regulatory work well with construction industry especially in training and adequate monetary aid to the small and medium entrepreneur (Azman et al., 2010). Several programs have been initiated by the government, professional bodies and private organization to raise the awareness and promote the sustainable application among project developers. For instance, Tax and financial incentives was the biggest encouragement in green building implementations to help with an upfront cost in green building development. The availability of comprehensive technical and financial support is important to assist the green building implementation by the developer (McGrawHill Construction, 2013; Chan et al., 2009; Sangster, 2006). Table 2 shows the list of 17 political factors of green building implementation.

Table 2. The list of political factors of green building implementation

Code	Political factors
PF 1	Provision of financial incentives (e.g. Financial and administrative incentives, rebates and density bonus such as zoning ordinance)
PF 2	Provision of non-financial incentives (e.g. Accelerating of projects approved process by the local authority and etc.)
PF 3	Rewards of certification
PF 4	Availability of long-term incentives
PF 5	Availability of administrative incentives
PF 6	Availability of mitigating split- incentives
PF 7	Availability of green technology research and infrastructure
PF 8	Availability of grant and tax for energy efficient building
PF 9	Availability of promotion and programs to increase awareness and knowledge
PF 10	Environmental/green building policy
PF 11	Development of green building assessment system
PF 12	Government policy, support and encouragement
PF 13	Availability of comprehensive technical and financial support from the government
PF 14	Green building regulations and standard systems
PF 15	Availability of information and services
PF 16	Availability of professionals and expert management
PF 17	Government enforcement such as laws and legislation

Social factors

Social and cultural plays a very important role in shaping person's behavior. All parties include consumers and stakeholders should be educated and inform about the green building knowledge to develop the buyer's interest. Interest will grow the demand of potential buyers to save costs for long periods, buyers for healthy condition and buyers that feel responsible to save the environment will be as motivational factors towards developers (Elias and Lin, 2015). The organizations, the private sector and public engagement are important in leading the green building market. Education and public awareness of the green building are essential to drive clients demand, tenants' satisfaction, and reduce the environmental problems by generating a sense of social responsibility (Chan et al., 2009). Previous study stated that negative culture in the firm will lead indifference towards environmental concerns (Hillary, 2004). Successful green building projects depends on communication and coordination skills in managing maintenance and services among people with different expertise and responsibilities, both during the construction process and throughout the buildings' lifetimes (Li et al., 2014; Isa et al., 2014b). The green culture in an organization will ensure the aims of green building achieved. Table 3 shows the list of 19 social factors of green building implementation.

Table 3. The list of social factors of green building implementation

Code	Social and Cultural factors
SF 1	Better informed and well public engagement
SF 2	Application of passive design in green building construction
SF 3	Provision of demand towards green products
SF 4	Corporate commitment
SF 5	Support from NGOs, professional boards, private sectors etc.
SF 6	Availability of energy service corporate (ESCOs)
SF 7	Availability of local green materials
SF 8	Corporate social responsibility (CSR)
SF 9	Campaign for building occupant awareness of benefits and savings
SF 10	Provision of proper education, training and advocacy on green building course, practise and skills by the government.
SF 11	Provision of education with regards to the economically viable of a green building development for developers and buyers.
SF 12	Willingness to commit in sustainable development
SF 13	Consideration of quality of space and environment
SF 14	Competitor in the green building market
SF 15	Understand the needs and business of green building
SF 16	Sustainable occupant behaviour
SF 17	Green building codes should go beyond environmental criteria (eg. Health of occupant)
SF 18	Owner tenant collaborations for win-win situation
SF 19	High efficiency appliance consumption

Economic factors

Economic factors have a strong influence on a person's decision and behavior (Kollmuss and Agyeman, 2002). People can influence by economic incentives to behave environmentally. In Malaysia, the government provides tax exemption equivalent to 100% of the additional capital expenditure to get the GBI certificate and Green Technology Financing Scheme (GTFS) which are worth of RM1.5 billion as a part of soft loan to produce GT materials for green building developers and owners (Elias and Lin, 2015). People will intent to choose energy efficient if the payback time for the energy saved is very short. Proper control and management of construction waste will reduce the cost and negative impact to the environment (Foo and Kamaludin, 2017). The green approaches offer more cost saving by lower energy consumption; reduce waste disposal and water costs, lower operations and maintenance costs. It is important to minimize the maintenance cost of a building while maintaining the best quality of the building (Che-Ani et al., 2016).

Accordingly, green building will decrease the environmental impact and carbon emissions, as well as increased the occupant productivity. Performance metrics or of the green building process can help in monitoring and achieve the green building project goals. Table 4 shows the list of 12 social factors of green building implementation. Table 4 shows the list of 19 social factors of green building implementation.

Table 4. The list of economic factors of green building implementation

Code	Economic factors
EF 1	Green building is commercially viable and high publicity
EF 2	Enhance asset value and profits
EF 3	Optimize life cycle economic performance
EF 4	A lower market risk in green building investment
EF 5	Provision of cost and financial benefits
EF 6	Reform market and energy pricing of green building development
EF 7	Familiarity and marketability of green product
EF 8	The public expectation to increase demand
EF 9	Payback investment benefits
EF 10	Competitiveness approach in green building market
EF 11	Affordable green building end price
EF 12	Affordable and achievable green certification standards

A conceptual framework was developed to summarize the literature review findings that shows the relationship of green buildings internal and external factors with the green building implementation (Figure 1). Besides, there are 24 items of internal factors and 29 items has been found to become barriers of the green building implementation. However, this paper only focus on identify the association between external factors and the green building implementation among the housing developers in Klang Valley.

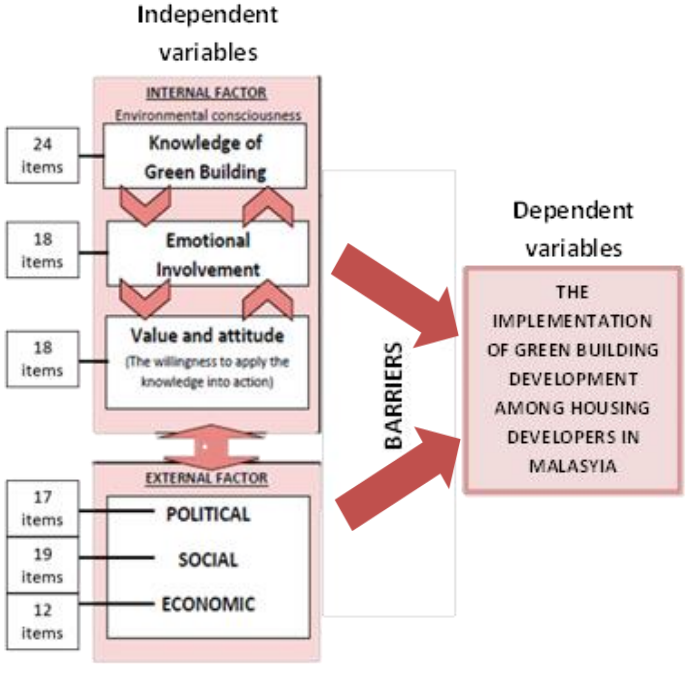

Figure 1. A conceptual framework of green building implementation factors among the housing developers

METHODOLOGY

The association between external factors and the green building implementation among the housing developers in Klang Valley was identified using quantitative approach and case study. A questionnaire survey based on the Likert scale, which required the respondents to choose within the scale of agreement (i.e. 1= strongly disagree, 2= disagree, 3= neither agree nor disagree, 4= agree, and 5= strongly agree) for external factors of political, social and cultural and economic. Meanwhile, the questions about the implementation of the green building principle required the respondent to choose either yes or no. Klang Valley was selected as the case study area of this research based on the several reasons;

i. Klang Valley has long been the pillar and the face of our country and driving the national economy with the rapid development grows.

ii. Housing developers, which have projects throughout Malaysia, have their main offices located in Klang Valley. There are more than 1400 companies registered under the private housing development business license based on the information acquired from the MHLG.

iii. As the most developed area in Malaysia, the majority of green projects are located in Klang Valley. One hundred and ten (110) out of 144 green residential GBI certified buildings were located in Klang Valley (GBI, 2016). Selangor and Kuala Lumpur have the highest registered green project (GBI, 2017). Thus, Klang Valley is the most potential and significant to be selected as the case study of this research as the housing developers are considered more expose to the green development.

The survey was conducted from April 2016 until the end of June 2016. All the questionnaires were sent out to the respondent through e-mail, manually, and google form. The stratified sampling procedure was chosen for this study. The research sample was based on the list of 519 housing developers located in Klang Valley obtain from the Ministry of Housing and Local Government (MHLG, 2016). The total population of 591 was stratified into 11 zones as listed by MHLG. This study, have successfully received 234 respondents which is sufficient for sample below 600 (Krejcie and Morgan, 1970).

The data was then being analyzed by using Statistical Package for Social Science (SPSS) software. The frequency and descriptive analysis were applied to find out the mean and normality. In addition, the Cronbach's alpha was used to explore the internal reliability. Meanwhile, Principal Component Analysis (PCA) was used to explore the dimensional reliability. The correlation analysis was performed to identify the relationship between the external factors and the implementation of green building. The results are elaborated in the next section.

RESULT AND DISCUSSION

The details of respondents' background were stated in Table 5. The analysis of the respondents' background revealed that 60% of the respondents were male. A total of 75% of the respondents working in the professional field such as Architect, Engineer, Planner, Quantity Surveyor, and Building Surveyor, and the top management team. Those people have more understanding and familiar with the subject matter and company project. A 57% of the respondents are degree holders and 24 % of them are master holders. Majority (61%) of the respondents have a working experience of 6 to 10 years of working experience. However, 65% of the respondents have below than five years of working experience in green building project. Based on the respondents background result, it shows that all of the respondents of the survey are considered to be competent to give their ideas on the subject matter.

Table 5. The background of the respondents

Demographic data		Frequency	Percent (%)
Gender	Male	141	60
	Female	93	40
Working position	Chairman	5	2
	CEO	2	1
	Director	4	2
	Deputy Director	8	4
	Professional	176	75
	Others	39	16
Highest qualification	A levels/ SPM	1	1
	HNC/HND/DIP	23	10
	Degree	134	57
	Master	57	24
	PhD	9	4
	Others	10	4
Working position	Architecture	41	18
	Building surveying	29	12
	Engineering	73	31
	Quantity surveying	29	12
	Town planning	52	22
	Others	10	4
Years of experience in building development	<5	52	22
	6-10	142	61
	11-15	26	11
	16-20	5	2
	21-25	9	4
Years of experience in green building project	<5	154	65
	6-10	65	28
	11-15	14	6
	16-20	1	1

The first stage of the quantitative analysis is to explore the internal reliability using Cronbach alpha. Table 6 shows that the Cronbach alpha coefficient is more than 0.7 which surpassed the value suggested by Sekaran (2000) that makes the questionnaire is high internal consistency and statistically reliable.

Table 6. Reliability test of the external factors and the green building implementation

Items	No. of items	Cronbach's Alpha
Political factors of green building implementation	17	0.913
Social and cultural factors of green building implementation	19	0.914

Items	No. of items	Cronbach's Alpha
Economic factors of green building implementation	12	0.913
Green building implementation	18	0.918

The dimensionality reliability was determined by using PCA was carried out to reduce a large number of variables to a smaller set of underlying factors that summarize the essential information contained in the variables. Table 7 shows that the data recorded for each groups of the items were suitable for factor analysis method, where the scores were more than the minimum requirement of 0.5 point for overall KMO measure of sampling adequacy (MSA) and significant coefficient of Barlett's test of sphericity is less than the significance level of 0.01.

Table 7. Summary results of KMO measure of sampling adequacy (MSA) and significant coefficient of Barlett's test of sphericity

External factors and the green building implementation	MSA	Barlett's test of sphericity (Sig)
Political factors of green building implementation	.873	.000
Social and cultural factors of green building implementation	.867	.000
Economic factors of green building implementation	.887	.000

The factor analysis was carried out to test the communalities. Communalities indicate the proportion of variance in the original variables that is accounted for by the factor solution. The communalities value should score more than 0.5 point for the data to be justifiable for application of this method. Communalities less than 0.5 were considered too low (Larose, 2006). The analysis revealed that, there are two items from the economic factors have been omitted which are; 'green building is commercially viable and high publicity' and 'familiarity and marketability of green product' because of the communalities is less than 0.5. The varimax rotation of PCA was applied to validate which variable significantly contribute to the dependent variables. The eigenvalue criterion stated that each component explained at least one variable's worth of variability, only components with eigenvalue greater than 1 should be retained (Larose, 2006). Rotation is used to simplify the interpretation of the extracted components. It will assign each variable into only one factor that is highly correlated with them (Hair et al., 2005).

Table 8 shows the results of total variance for political factors of the green building implementation. It states that there were four components with eigenvalue greater than 1 and the total variance explained was 69.057% of the total variance in the variables was included on the components. The results after applying rotation method of varimax with Kaiser Normalization showed that the PF can be presented by four components which have high correlation with each other. Factor 1 consists of the variables of PF16, PF15, PF17, PF14, and PF13. Factor 2 consists of the variables of PF9, PF10, PF11, and PF12. Factor 3 consists of the variables of PF6, PF5, PF4, PF8, and PF7. Meanwhile, factor 4 consists of PF 1, PF2, and PF3.

Table 9 shows the results of total variance for social and cultural factors of the green building implementation. It states that there were four components with eigenvalue greater than 1 and the total variance explained was 65.319% of the total variance in the variables was included on the components. The results after applying rotation method of varimax with

Kaiser Normalization showed that the SF can be presented by four components which have high correlation with each other. Factor 1 consists of the variables of SF18, SF17, SF16, SF19, SF15, and SF14. Factor 2 consists of the variables of SF7, SF6, SF8, SF5, and SF4. Factor 3 consists of the variables of SF11, SF13, SF10, SF12, and SF9. Meanwhile, factor 4 consists of SF2, SF1, and SF3.

Table 8. Total Variance Explained of Political Factors of the Green Building Implementation

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	7.170	42.176	42.176	7.170	42.176	42.176	3.723	21.901	21.901
2	2.063	12.137	54.313	2.063	12.137	54.313	3.092	18.190	40.092
3	1.441	8.476	62.789	1.441	8.476	62.789	2.674	15.728	55.820
4	1.065	6.267	69.057	1.065	6.267	69.057	2.250	13.236	69.057
5	.838	4.931	73.988						
6	.651	3.829	77.817						
7	.564	3.320	81.137						
8	.539	3.169	84.305						
9	.467	2.747	87.052						
10	.413	2.429	89.482						
11	.360	2.120	91.602						
12	.330	1.939	93.541						
13	.293	1.726	95.268						
14	.239	1.405	96.672						
15	.222	1.307	97.979						
16	.194	1.141	99.120						
17	.150	.880	100.000						

Extraction Method: Principal Component Analysis.

Table 9. Total Variance Explained of Social and Cultural Factors of the Green Building Implementation

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	7.513	39.542	39.542	7.513	39.542	39.542	3.555	18.711	18.711
2	1.905	10.029	49.571	1.905	10.029	49.571	3.280	17.265	35.975
3	1.671	8.795	58.367	1.671	8.795	58.367	3.116	16.402	52.378
4	1.321	6.952	65.319	1.321	6.952	65.319	2.459	12.941	65.319
5	.966	5.086	70.405						
6	.754	3.969	74.373						
7	.662	3.483	77.856						
8	.590	3.104	80.961						
9	.496	2.610	83.570						
10	.477	2.510	86.080						
11	.440	2.313	88.393						
12	.377	1.985	90.378						
13	.377	1.982	92.360						
14	.344	1.809	94.169						
15	.288	1.518	95.687						
16	.242	1.272	96.959						
17	.212	1.116	98.075						
18	.190	1.002	99.078						
19	.175	.922	100.000						

Extraction Method: Principal Component Analysis.

Table 10 shows the results of total variance for economic factors of the green building implementation. It states that there were two components with eigenvalue greater than 1 and the total variance explained was 70.658% of the total variance in the variables was included

on the components. The results after applying rotation method of varimax with Kaiser Normalization showed that the EF can be presented by two components which have high correlation with each other. Factor 1 consists of the variables of EF11, EF10, EF12, EF9, and EF8. Meanwhile, factor 4 consists of EF4, EF3, EF2, EF5, and EF6.

Table 10. Total Variance Explained of Economic Factors of the Green Building Implementation

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	5.512	55.119	55.119	5.512	55.119	55.119	3.677	36.766	36.766
2	1.554	15.540	70.658	1.554	15.540	70.658	3.389	33.893	70.658
3	.716	7.163	77.821						
4	.595	5.950	83.771						
5	.358	3.576	87.346						
6	.301	3.011	90.357						
7	.285	2.847	93.204						
8	.251	2.509	95.713						
9	.242	2.416	98.130						
10	.187	1.870	100.000						

Extraction Method: Principal Component Analysis.

From the overall results of PCA, there two item that were eliminated from the economic factors which is the variables of EF1 and EF7. Others factors were included in the proposed framework. Table 11 presents the descriptive analysis of the political factors of PEB. The result shows that the external factors have a high mean score which are political factors (M=3.94), social and cultural factors (M=3.89), and economic factors (M=3.90). The result shows that, all the external factors are important in encouraging the green building implementation among the housing developers. The green building implementation among the developers also score high which is (M=1.92). Majority of the repondents are implementing the green builidng principles in their housing project.

For the purpose of indicating the normality of the data, skewness, kurtosis, and Kolmogrov-smirnov were analyzed. The skewness and kurtosis revealed that the values of the variables under study were not normally distributed for the variables of political factors for green building. According to Chua (2012), a normal data distribution is when the value of both Skewness and Kurtosis was between ±1.96. The result of the Kolmogorov-Smirnov test stated that the variables are not normally distributed because the p -value is smaller than 0.05.

Table 11. External factors and green building implementation descriptive statistics

	Items	Means	Skewness	Kurtosis	Kolmogrov-smirrnov (p-value)
1.	Political factors of the green building implementation	3.94	-0.810	3.676	.015
2.	Social and Cultural factors of the green building implementation	3.89	-0.473	1.735	.011
3.	Economic factors of the green building implementation	3.90	-0.449	0.087	.004
4.	Green building principles implement by the developers	1.92	-1.38	0.18	.000

*Scoring Guide (1-3): 0.00-2.49=low, 2.50-3.49= moderate, 3.50-5.00= high.
*Scoring Guide (4): 0.00-0.99=low, 1.00-2.00= high.

Spearman correlations were used to test the relationship between variables because the data are not normally distributed. The Spearman correlation result in Table 12 illustrates that, there is a significant relationship between the green building implementation with social and cultural factors ($r = 0.138$, $p>0.05$) and economic factors ($r = 0.224$, $p>0.05$). However, there is no significant relationships between the green building implementation and political factors ($p<0.05$).

Table 12. Spearman correlation results

	Items	Means	IMPLEMENTATION
Spearman's rho	POLITICAL	Correlation Coefficient	.075
		Sig. (2-tailed)	.254
		N	234
	SOCIAL	Correlation Coefficient	.138*
		Sig. (2-tailed)	.035
		N	234
	ECONOMIC	Correlation Coefficient	.224**
		Sig. (2-tailed)	.001
		N	234

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

This study found that, only social and cultural, and economic factors have association with the green building implementation. Even though political factors have no relationship with the implementation, it is also considered as the important factors of green building implementation by the developers.

CONCLUSION

This paper concludes that there significant relationship between the external factors of social and cultural and economic with the green building implementation. However, there is no significant relationship between political factors and the green building implementation. Considering the social and cultural influence the green building implementation, but the economic factors have the higher relationship with the green building implementation. Social and cultural are reflected on the developers or company behavior and nature. If the organizational have the environmental consciousness, they will implement the green building development. Therefore, the developers should have a sense of responsibility in providing a sustainable housing to reduce the environmental problems and obtain the green building benefits such as money saving and good health. The economic factors play an important role in the green development. Peoples can be influenced by the economic incentives either positive or negative to practices green development. Developer with higher economic is more willingly to implement the green building principles. This shows that the economic factor has influence with the green building implementation. Correspondingly, the relation between economic, social and cultural with the green building implementation shows that both factors were the drive to the implementation.

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SEEPAGE CONTROL IN FOUNDATION OF A SMALL EARTHFILL DAM USING GROUTING METHOD

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Abstract
In 1900 to 1980 small earthfill dam built in Indonesia. The dam still functioning well but some of them need to be repaired because of seepage problem in the body and foundation of the dam. Grouting is one of the method to control the seepage. Grouting done by fill or inject fluid with pressure into the ground through a borehole to reduce the permeability and increase the shear strength. The study was done by comparing the permeability of the before and after grouting. Parameters for determining permeability with the use value of the lugeon test, whereas permeability measurement using packer permeability test. The material used as an injection material was Portland Cement (PC) and water with the initial mixture of 1: 4 and would be thickened into 1: 2 and 1: 1 mixture in a sequence. The use of Grouting was proven to reduce seepage that occurred in the dam by referring to Lugeon value before grouting was between 24.15 to 1123.08, some holes even experienced water loss. Meanwhile, Lugeon value after Grouting was 1.50 to 6.96.

Keywords: *Grouting; Seepage; Lugeon*

INTRODUCTION

The embankment dam has evolved for many centuries, which major development in 1940 with the development of soil mechanics and geotechnical engineering (Fell et al., 2000). In the world, dams are mainly constructed of earth and rockfill materials and hence they are generally referred to as embankment dams or fill-type dams. Based on ICOLD data (Foster et al., 2000) found that 1 in 25 large embankment dams constructed before 1950, and about 1 in 200 of those constructed after 1950 failed. In Australia, USA, Canada and New Zealand designed and constructed after 1930, about 90% of failures were related to internal erosion and piping. In 1900 to 1980 small earthfill dam built in Indonesia. The dam still functioning well but some of them need to be repaired because of seepage problem in the body and foundation of the dam.

Seepage pore pressure is controlled by the permeability of the zones in the dam foundation, whatever the dam is cracked by differential settlement, dessiccation or earthquake or whether there are high permeability layers in the earthfill due to poor compaction or dessiccation of layer of earhfill during construction. Grouting is one of the method to control the seepage. Grouting is the procedure to fill or inject fluid with pressure into the ground through a borehole to reduce the permeability and increase the shear strength (Warner, 2004). The grouting materials can be clay, cement, or chemicals.

Turkmen (2003) found that leakage occurs towards the downstream springs through the right bank limestone at Kalecik Dam. The prevention measured using grouting can decrease spring discharges at downstream, but the seepage paths were extended and were moved with time so that the seepage problems are still continuing. Uromeihy & Barzegari (2007) argued that grout curtain with 35 m depth at Chapar-Abad Dam, Iran with the heights for about 45 meters and thickness of alluvial deposits of over 60 m be adequate to control the water seepage. According to Kalkani (1997), curtain grouting can prevent seepage in the abutment

of Bakoyiani earth dam in greece.

This study performs testing grouting on small dams to overcome the problems of the seepage is occurring, then measured the success rate of grouting method in lowering the value of permeability which is the controller of the seepage. Parameters for determining permeability with the use value of the lugeon test, whereas permeability using packer permeability test. The material used as an injection material was Portland Cement (PC) and water.

LITERATURE REVIEW

Permeability Test

The permeability (hydraulic conductivity) is an important property seepage through dam. In soil, there are two main factors that determine the order of magnitude of the permeability are: grain size and cleavage (secondary interslices). These two properties can already have significant spatial variability, but other influencing factors make the determination of permeability coefficient even more complex (Nagy et al. 2013). In rock, permeability depends on fracture openness, number, and connectivity. Highly fractured rock with low connectivity will have low permeability, and a slightly fractured rock with high connectivity can have high permeability.

The permeability can be determined by constant head test, falling head test or water pressure test (also known as the lugeon or packer test). Lugeon test was developed by Maurice Lugeon in 1933. Houlsby (1976) proposed modified lugeon test that consists of 5 consecutive stages. The first three stages are completed at increasing pressures while the last two stages are completed at decreasing pressures. During each stage, water pressure is constant, as much water through the test interval as possible. Results of lugeon test are expressed in Lugeon (Lu) units. A Lugeon is defined as the water loss of 1 litre/minute per metre per length of test section at an effective pressure of 1 Mpa. According to Fell et al. (2005), the Lugeon value (LU) is equal to 1.3×10-5 cm/s. A schematic of Lugeon Test can be seen in Figure 1.

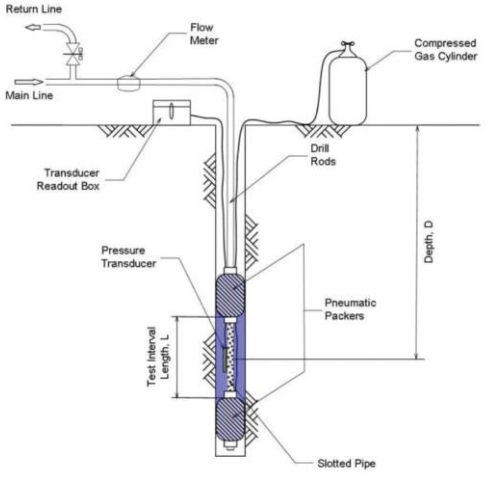

Figure 1. Schematic of Lugeon Test (Quinones- Rozo, 2010)

There are two common methods of lugeon test in a drill hole. The down stage method is recommended and involves isolating and testing succesively the bottom sections of the drill hole. This method enables progressive assesment of permeability and allows later stabilisation of the wall of the hole by casing or grouting, if caving occurs. The alternative method is to complete the drilling of the hole and water test in sections by sealing the hole above and below the test area (the double packer method). Usual test section lengths range from 3 m to 6 m but the length maybe increased in essentially unfractured rock (Fell et al., 2005). To find the Lugeon value, the following formula was used:

$$Lu = \frac{10.Q}{L \times p} \quad \text{.....(1)}$$

with:
Lu = Lugeon value
Q = flow rate (litre/minute)
L = tested section length (meter)
p = the effective hydrostatic pressure of water at joint entrance (kg/cm^2)

Lugeon values and corresponding classification values are given in Table 1.

Table. 1. Condition of rock mass discontinuities associated with different Lugeon values (Quiñones-Rozo, 2010)

Lugeon Range	Classification	Hydraulic conductivity Range (cm/sec)	Condition of Rock Mass Discontinuities	Reporting Precision (Lugeons)
< 1	Very Low	$< 1x10^{-5}$	Very Tight	< 1
1–5	Low	$1x10^{-5}$–$6x10^{-5}$	Tight	± 0
5–15	Moderate	$6x10^{-5}$–$2x10^{-4}$	Few Partly Open	± 1
15–50	Medium	$2x10^{-4}$– $6x10^{-4}$	Some Open	± 5
50–100	High	$6x10^{-4}$–$1x10^{-3}$	Many Open	± 10
> 100	Very High	$> 1x10^{-3}$	Open Closely spaced or voids	> 100

Grouting Material

Grouting material consist of water and portland cement. Water that is required as human consumption is usually adequate for grout. Portland cement are widely used as grouting material. This material is very active when exposed to the water which was called hydration. Hydration process will produce heat along with the rate of hardening process. Grout usually contain as excessive amount of water in order to achieve the necessary flowability and resulting penetrability (Warner 2004). In this research, grout material used portland cement.

Grouting Depth and Grouting Hole Layout

The grouting depth was determined by the characteristics of foundation seepage. Therefore, the grouting depth was between 0.5 H to 1.5 H until it reached the impermeable layer. Determination of grouting depth should use simulation, but in this study determined the grouting depth is 20 meters. The distance between the grouting holes depended on the injection speed, permeability, or allowable pressure. Houlsby (1990) proposed a way to implement curtain grouting that divided the hole into primary, secondary, and tertiary. The

distance between the primary holes in some cases was about 12 m but it can also be 6 m depending on the permeability and targets to be achieved. In this research only to secondary.

This study employed the hole spacing pattern as shown in Figure 2.

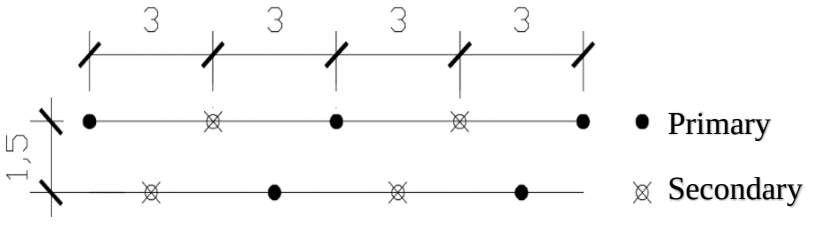

Figure 2. The Sketch of Grouting Distance Determination

Grouting Mix

According to the procedure for the implementation of cement injection in SNI 03 - 2393 - 1091, the mixture changes could refer to the Table 2.

Table. 2. Comparison of Grout Mixes According to Lugeon Value Criteria (Pangesti, 2005)

Lugeon Value	Initial Injection Mixture	The Subsequent Mixture Changes
Lu <5	1 : 6	(1 : 4), (1 : 2), (1 : 1)
5 < Lu < 10	1 : 4	(1 : 2), (1 : 1)
Lu > 10	1 : 2	(1 : 1)

The mixture used at the initial injection was 1: 4 with subsequent mixture changes being (1: 2), (1: 1) in this study.

Grouting Operation

When grout are longer than 10 m, it is usually best to divide them into shorten lengths, called stages and grout each of those stages separately. Stage grouting methods include downstage without packer, downstage with packer, upstage, circuit grouting downstage. For high standard grouting Houlsby (1981) proposed advocate downstage without packers.

There are 2 ways that are used: Grouting from bottom to top and Grouting from top to bottom. The way to be used depends on the geological condition of the rocks that can be seen from the boring log, water testing and grouting testing. This study employed bottom to top grouting as presented in Figure 3. The Grouting hole was drilled until it reached a predetermined depth. Then the packer was mounted into the borehole.

The packer tool was used to seal the hole. As a consequence, the cement mixture did not come back up and enter the side soil. After the packer tool was installed then Grouting could start with a high enough pressure (part 1). After completion of part 1, the packer tool was pulled up then Grouting was conducted again until the 2nd part was full of cement slurry (Grouting mixture) entirely. Then the packer was pulled up again. The same action was repeated that the whole section was full of cement (part 1,2,3, and so on). Therefore, Grouting was finished for one borehole. Grouting was conducted every 5 meters long in order to get the best possible results.

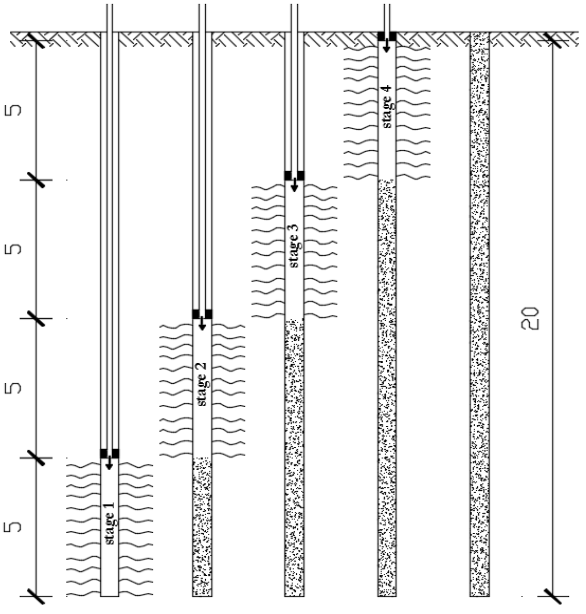

Figure 3. The Steps of Grouting

RESULTS AND DISCUSSION

Grouting Results Comparison

Grouting results are compared before and after grouting. Before grouting has been drilled and tested permeability as much as 5 points. The drilling depth varies between 15 and 20 m, while permeability testing is performed every stages (approximately five meters). Test results showed that the lugeon values on stage 1 to 3 (3.5 – 15 m) give a large lugeon value between 24.15 and 1123.08 and even at points BH-02, BH-05 to waterloss. In Stage 4, the lugeon value between 3.38 – 38.31. As table 1, the condition of rock discontinuity many open or void.

Table 3. Water Test Results before the implementation of Grouting

Bore Hole	Stage	Lu
BH-01	Stage 1 (3.5 - 5 m)	24.15
	Stage 2 (8.5 - 10 m)	131.54
	Stage 3 (13.5 – 15 m)	68.31
	Stage 4 (16.5 – 18 m)	3.38
BH-02	Stage 1 (3.5 - 5 m)	51.62
	Stage 2 (8.5 - 10 m)	1123.08
	Stage 3 (13.5 – 15 m)	waterloss
	Stage 4 (18.5 – 20 m)	4.45
BH-03	Stage 1 (3.5 - 5 m)	1069.23
	Stage 2 (8.5 - 10 m)	71.38
	Stage 3 (13.5 – 15 m)	30.62
	Stage 4 (18.5 – 20 m)	38.31
BH-04	Stage 1 (3.5 - 5 m)	1076.92
	Stage 2 (8.5 - 10 m)	203.85
	Stage 3 (13.5 – 15 m)	168.46
BH-05	Stage 1 (3.5 - 5 m)	1069.23
	Stage 2 (8.5 - 10 m)	waterloss
	Stage 3 (13.5 – 15 m)	waterloss

After grouting is evaluated by testing as much as 5 points with a depth 20 m. The permeability test performed every stage that every stage approximately 5 meter. The results show the lugeon value in stage 1 to 3 improved between 2.3 to 7.02 and stage 4 between 1.5 to 6.96. As the rule of thumb, based on Houlsby (1976) chart, grouting with two paths on urugan and wide core dams at least have lugeon luster between 5-7. So that grouting can reduce the value of permeability and seepage in the foundation and the main dam.

Table 3. Water Test Results before the implementation of Grouting

Bore Hole	Stage	Lu
CH-01	Stage 1 (0.5 - 5 m)	3.32
	Stage 2 (5 - 10 m)	5.13
	Stage 3 (10 – 15 m)	3.54
	Stage 4 (15 – 20 m)	1.50
CH-02	Stage 1 (0.5 - 5 m)	3.71
	Stage 2 (5 - 10 m)	3.07
	Stage 3 (10 – 15 m)	2.30
	Stage 4 (15 – 20 m)	4.96
CH-03	Stage 1 (0.5 - 5 m)	3.11
	Stage 2 (5 - 10 m)	1.95
	Stage 3 (10 – 15 m)	3.97
	Stage 4 (15 – 20 m)	6.96
CH-04	Stage 1 (0.5 - 5 m)	2.43
	Stage 2 (5 - 10 m)	5.90
	Stage 3 (10 – 15 m)	7.02
	Stage 4 (15 – 20 m)	3.15
CH-05	Stage 1 (0.5 - 5 m)	3.74
	Stage 2 (5 - 10 m)	2.49
	Stage 3 (10 – 15 m)	5.87
	Stage 4 (15 – 20 m)	4.25

CONCLUSION

Based on the results of the study, there was a change in permeability value which is described with Lugeon value. Before the grouting, the Lugeon value was between 24.15 – 1123.08 even on some holes experienced water loss. So the condition of rock discontinuity many open crack or void. The cracked maybe caused by differential settlement, dessiccation or earthquake or whether there are high permeability layers in the earthfill due to poor compaction or dessiccation of layer of earhfill during construction. After Grouting, Lugeon value was from 1.50 to 6.96. As the rule of thumb, based on Houlsby (1976) chart, grouting with two paths on urugan and wide core dams at least have lugeon luster between 5-7. So that grouting can reduce the value of permeability and seepage in the foundation and the main dam. But to determine the safety factor should be done further analysis. As a suggestion, the implementation of grouting should be supervised and performed by experts, since grouting pressure will be able to damage the rock mass.

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MANAGING COMMUNICATION BETWEEN ARCHITECTS AND CLIENTS DURING DESIGN PHASE

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Abstract
Architectural design is the initial phase of the project, which is based on the client's requirements and needs that are to be materialized by the architects. The success of architectural design is amongst all affected by communication between architects and clients during the design phase. However, communication management, as a part of the project management practices, between the architects and clients is evidently overlooked. Thus, this paper reviews the attributes of project communication management in the context of architectural practices during the designing phase. It lays out communication definitions from different aspects, and communication management practices in architectural industry. The findings of this study are expected to raise the knowledge of communication management among architects in enhancing the relationship between them and their clients to result in successful projects. Finally, this paper reveals the necessity for essential improvement in communication management among architects as a demanding matter to obtain performance development that eventually achieves successful projects.

Keywords: *Architects, clients, communication management, design phase*

INTRODUCTION

Architecture practice is an evolving field and an active component of the AEC (Architecture, Engineering and Construction) industry and highly dependent on effective communication, it was claimed by Gabriel and Maher (2002) that architecture is all about communication. Architects are the first and direct communicators with the client in the designing phase of the project. Design process is the initial phase of the project execution based on the client's requirements, and significantly influences the project's value (Senescu et al., 2013). Communication during the design process is a certain necessity, and it is fundamental to intensively communicate between the architect and client to avoid conflict, by determining the messages and information to be sent to the right receiver by the right sender in the right way by the right media (Kliem, 2007). However, the communication process is not only to send and receive specific messages. It is also about sharing the meanings and creating a relationship of mutual understanding between the involved parties (Ziek and Anderson, 2015).

Many studies proved the significant relationship between communication and project performance, where it is found that the more effective communication between the architect and the client, the higher project outcomes (den Otter and Emmitt, 2007). As the successful project is the one who meets certain expectations of the client, it, therefore, requires effective communication to clients (Zulch, 2014).

During the process of design, many problems occur due to poor communication between architects and clients. Poor communication majorly affects the project schedule and outcomes quality. Yet, the loss of a proper mechanism to manage the requirements and guide the clients to review solutions and feedback of the design was noted. Thus, it is essential to establish a convenient communication management system to overcome problems at the initial designing

phase of the project. Communication management is a part of project management that deals with the process of systematic information exchange between project parties, which is essential to identify goals, requirements and objectives of communication, and to coordinate project participants effectively. Communication management aligns the expectations between the sender and receiver of the messages by using project's specific standards, and it is a major project requirement to coordinate and manage the data exchange between involved parties of the project (Melzner et al., 2015).

This paper targets at introducing the proper knowledge of communication management among architects to improve and manage communication with their clients. Thus, this review is employed as a base background for a further study to be conducted among architects in Iraq, to investigate the current practices of communication management and to propose improvement strategies of this significant area of knowledge to overcome communication dilemmas that affect the designing projects outcomes.

COMMUNICATION

Communication is widely mentioned in literature as the basis of every human interaction; it is about creating common understanding. It is a dynamic process of opinions exchange among two parties: sender and receiver, who exchange the requested information in the chosen media through the channel. Following Lunenburg (2010), the term sender refers to the client who initiates the communication and encodes the message, receiver is the architect who decodes the idea, information is the outcome of the encoding and refers to the proposed design, and channel refers to the method to deliver the required design to the client. In terms of design, communication is the backbone of architecture as it refers to the messages exchange to transfer knowledge between clients and architects. As the ability to communicate is one of the significant factors that affect the project success, one of the critical skills an architect should obtain is the clear understanding of how communication takes place and how to use it effectively.

Successful designs undertaken by architects is highly influenced by the mutual understanding between participants, where project outcomes increase due to effective communication. Effective communication is when participants assume that the desired messages and information have been well-understood and correctly processed to reach the required needs (Norouzi et al. 2015). Factors of effective communication are represented in Table 1.

Communication is a complicated process of two ends that sometimes comprises some repetitions before achieving required mutual understanding. Accordingly, den Otter and Emmitt (2007) stated that it is considered to be a challenging mission to pursue, lead and motivate effective communication. In terms of architecture, clients are the most important parties of the architect-client relationship (Norouzi et al., 2015) and communication between architects and clients is an integral part of any project (Tipili and Ojeba, 2014). Some studies investigated the barriers between practicing architects and clients due to lack of mutual understanding and ineffective communication involving. Table 2 gives an overview of these barriers.

Table 1. Factors affecting effective communication

Author	Factor
Cheung et al., (2013)	Clarity of information exchanged between the client and the architect (The level to which participants understand the transmitted information by a specific method)
Kliem (2007)	Choosing the right media of communication and the message itself is clear and unambiguous to the other person
Tipili and Ojeba (2014)	Clarity of communication methods and channels
Tessema (2008)	The increment of information quality would produce better communication
Talukhaba et al., (2011)	The role of feedback whether it is positive, negative or neutral, and it is required to intervene in the case of feedback absence or delay
Ean (2011)	The importance of using the right media leads to effective communication

Table 2. Barriers to communication between architects and clients

Author	Barrier
Shen (2011)	- Clients give very little information - Clients do not get their viewpoints considered - Clients are inexperienced to understand the architectural drawings and solutions - Communication between project parties was not enough - Required designs were managed poorly - Little feedback involved in the happening communication process - Clients are unclear of their own requirements, which appear with the constant change of demands
Demkin (2001)	Client-architect relationship was fundamentally rooted in mutual understanding and effective communication, which results in satisfaction
Hettiarachchi (2016)	Clients hesitation of providing essential information to architect until they witness real results

All projects need to share information as the specific methods on how to distribute this information may vary, where each project uses relevant methods and tools to its needs and environment (Mnkandla, 2013). Literature mentioned two forms of communication: verbal and non-verbal. Verbal communication is the transition of messages by the use of written or spoken words, while nonverbal communication methods do not include words, such as signals, symbols and drawings. Smulders et al. (2008) indicated that combining and using several ways of communication can be a convenient solution for some situations and selecting communication means depend on the project requirements.

In the field of architecture, communication methods between architects and clients during the design phase vary from verbal, computerised digital technologies, virtual prototyping, two-dimensional drawings and three-dimensional volumetric renderings (Shen, 2011). Kitchens and Shiratuddin (2007) included the notable technology of walk-through architectural technologies as a valuable form of communication. Additionally, meetings are one of the oral methods that significantly take place during all stages of the project to overcome the communication impediments and raise the efficiency level (Tipili and Ojeba, 2014). Thus, in the initial phases of the design process, it is important to hold frequent meetings whenever it is needed to assure effective communication of the project and solve any occurred issues.

Selecting communication means depend on the project requirements. Xiao et al. (2014) recommended using various communication media when a task is performed because a single

media of communication is sometimes incapable of transferring information and shared knowledge. In the field of architecture, communication methods between architects and clients during the design phase vary from verbal, computerized digital technologies, virtual prototyping, two-dimensional drawings, three-dimensional volumetric renderings and the notable of walk-through architectural technologies. Furthermore, meetings are one of the oral methods that significantly take place during all stages of the project to overcome the communication impediments and raise the efficiency level, so it is important to hold frequent meetings when needed. Thus, there is a significant need to solve dilemmas by improving the communication effectiveness between the parties involved. Therefore, Norouzi et al. (2015) declared that to obtain proper information exchange, it is the architect's responsibility to create a proper venue to discuss with the client, and architects should be more open to clients and keep them updated in regards of the project progress.

COMMUNICATION MANAGEMENT

During the architectural designing process, huge and comprehensive amount of information is exchanged between architect and client. Thus, it is a major requirement to obtain a coordinated management of data exchange among the participants. Communication management is an emerging field and a significant knowledge area of project management with growing interest to study (Zulch, 2014). It has high value to any project or organization, and it includes the required processes to ensure appropriate and in-time generating, planning, distributing, retrieving and managing project information (PMI, 2013a). It is the planning process that takes a systematic way of executing, observing and reviewing the involved channels of communication. Communication management is the part of project management to be studied among architects, that concerns planning and distribution of design information in a convenient way according to the clients' requirements and agreement. Some researchers believe that communication management is a functional process. Based on Cornelissen (2017), it is a management function that proposes an effective coordination framework for all of the communication means, with the comprehensive purpose to ensure the appropriate reputations on the organisation depending stakeholder groups.

Communication management presents pivotal components for critical project decisions. This objective takes place by effectively choosing fundamental matters to be accomplished to distribute the collected project data between the participants. Therefore, Mnkandla (2013) considered it to be the backbone of the process of making effective decisions through the complete period of the project. As to Kerzner (2013), project communication is the guarantee of getting the right information during the right time to the right audience. Melzner et al. (2015) further supported this by demonstrating that the aims and goals of information and communication management are to provide proper information in the best form and at the right time to every participant in the project.

Shen (2011) noted the loss of a proper mechanism to manage the requirements and guide the clients to review solutions and feedback of the design. Therefore, it is essential to adopt proper planning for project communication. Experts of Project Management Institute (PMI) recommend to create a communication plan that assures the project information is properly communicated using the right methods and delivered to the right persons. It ensures the fulfilment of the clients' needs, tracks and report the project performance, and to document the project results in a formal way.

COMMUNICATION MANAGEMENT PLAN

The overall project management plan is the main provider of project information, and it comprises many sections, including the project communication management plan. Communication management plan (CMP) is a project-related document that determines project communications framework, and defines communication requirements and objectives to assure the process of communication exists and self-sustainable during the whole period of the project. CMP is a platform to obtain mutual understanding among project participants that describes the project communication needs and expectations, in regards to the format, time and frequency of which information is communicated.

Generally, communication management plan is carried out in the early phases of the project to keep an obvious direction to involved parties, as well as to assure convenient resources are properly assigned to the project communication activities . However, it is a constant evolving and modified blueprint of the project, and regularly revised during the project period (Bilczynska Wojcik, 2014). It assigns the responsible individuals for communicating the accurate quality and quantity of information within the accurate time in the right format. Also, it aims to obtain the correct information by choosing the proper medium and deliver it to the right audience at the right time. Communication management plan manages obstacles and limitations that impact the communication flow, and appoints relevant project documents and templates to be employed for communication. Thus, developing a communication plan guarantees that scheme of effective communication between architects and clients is established for the purpose of design delivery as requested by the client.

The process of developing project communication plan is first initiated by planning the inputs and identifying the stakeholders of the project as well as define their needs and what they expect as an outcome by the end of the project. Subsequently, preferred communication methods are then indicated according to its relevance to the client as well as to the architect. Shortly afterwards of the draft is created, it must be distributed and get the confirmation of acceptance by the client to present the final communication management plan of the project (Caltrans, 2007).

STANDARDS OF COMMUNICATION MANAGEMENT

Architectural practice generally follows the project-based approach for carrying out its projects, so, a full project understanding is required by performing adequate management. Applying standards is a significant improvement method for increasing project management effectiveness. Setting the specific components of standards as a checklist to be used by organizations aims to determine the completion level of the approaches in terms of activities and principles. Initiating standards enhances uninterrupted improvement, while it is sporadically re-evaluated and updated to assure proper implication of best practices. High considerations of the project management standards are significantly increasing, due to the value brought to the contemporary organizations. The major standards in the area of project communication management include: Project Management Body of Knowledge (PMBOK), established by the Project Management Institute (PMI), IPMA Competence Baseline (ICB®) established by International Project Management Association (IPMA), and Project in a Controlled Environment (PRINCE 2), established by Office of Government Commerce in

United Kingdom (GOC).

In this paper, following Samáková et al. (2013), PMBOK is the most engaged standard in the area of project communication management. Project Management Body of Knowledge (PMBOK) is a set of guidelines in the knowledge area of project management, and has identified three processes groups in regard to project communication management: plan communication management, manage communication and control communication.

PLAN COMMUNICATION MANAGEMENT

Plan communication management is a process of developing an adequate approach and planning for effective and efficient project communication according to the stakeholder's needs and requirements. Inappropriate planning of project communication causes issues and progress dilemmas in a form of messages delay, misunderstanding of communicated messages and wrong audience communicating. Many considerations must be taken into account; who needs information, authorized people to access information, the time they will be calling for information, where and in what format to store information and how to retrieve them. The output of this process is the project communication management plan, as a major component of the overall project management plan.

MANAGE COMMUNICATION

On the other hand, managing communication is to create, collect, distribute, store, dispose and retrieve project information according to the prior-established communication management plan. Managing communication process guarantees that the communicated project information is well generated, received and understood. Additionally, this process offers the stakeholders to request information, explanation and discussion. The output of this process is to set project communications, and the sufficient updates for the previously established project communication plan, project documents and organizational processes assets. Tools and techniques of this process include the appropriate selection of communication technology which varies according to the type and phase of the project, the relevant communication models that significantly affect the effectiveness and efficiency of the communication process, to manage and exceed the identified barriers. Moreover, information management system is implemented with the use of some tools, such as hard-copy document management; letters and reports, electronic communications management; e-mails, telephones, video conferencing and websites, and electronic project management tools; project management software, meeting and portals.

CONTROL COMMUNICATION

Finally, control communication is to observe and control the communication during the complete project time in the pursuit of meeting stakeholders' needs. This process requires the discussion project parties to allocate the most relevant way needed to update project performance and to comply stakeholders' information requests. These discussions are facilitated through different types of meetings, as an important method of communication. Moreover, PMI (2013a) indicated many skills of communication to be held by the project management practitioners to fulfil effectiveness. In this study, it is proposed for the architects to occupy these competencies to improve the communication management with their clients.

These skills are included but not limited to: listen effectively and actively, question and investigate the ideas and conditions to guarantee greater understanding, determine expectations and manage them properly, convince people to accomplish an action, as well as motivate and encourage them to communicate effectively. Additionally, solve issues that hinder good communication and debate skills to reach mutual agreements accepted by the project's participants, and finally, to set and summarise the next steps to be achieved.

As a result, architects can use the PMBOK processes of communication management as a framework included to their agendas of communicating with their clients, to assure messages and information are well-communicated and understood.

PRACTICES OF COMMUNICATION MANAGEMENT

Studies were undertaken to investigate and evaluate practices and implementations of communication management in different firms. Samáková et al. (2013) investigated the role of communication management in industrial firms of Slovak Republic. The studied sample was interested in project communication management standards, although high percentage did not follow communication management and international project management methodologies, and the majority of firms did not have the project communication written documents.

As this paper aims to improve the communication management knowledge among architects, and a further study of Iraqi current practices of this field of knowledge is to be conducted, studies show very little attention given to communication attributes of project management in general construction industry of Iraq. Al Saffar et al. (2014) examined and diagnosed the different challenges and incompetence found in the construction projects in Iraq. It proved that many dilemmas are faced due to the largely evident lack of communication management while projects are planned. Some of the remarked problems are the time and efforts loss because of inefficient communication management, confusion in tasks, delays and breakdowns of information exchange, as well as the poor flow of needed information at the right time during the period of the project. It was also demonstrated that communication issues are basically related to the little given time for communication to be planned to compare to another project process including designing phase. Furthermore, it is sometimes assumed that communication does not have that essential effect on the project designing procedure. As a result, the study demonstrated the critical demand to improve techniques of management to overcome these challenges. Subsequently, a web-based project management system was proposed to achieve the required improvement goals.

Communication management practices include immediate oral communication, management technology, and communication technology to store and retrieve information, and daily-used synchronous and asynchronous communication. Muszynska (2015) distinguished the practices of communication management into four categories according to the practice objectives: strategic, informational, practical and emotional, as represented in Table 3.

Table 3. Communication management practices

Category of communication management practice	Communication management practice
Strategic (involves communication planning and project environment)	- Clear lines and responsibilities established up front - High-quality communication planning - Good public relations - Adopt common working language among members - Well-defined client authority - High process visibility for clients
Informational (generating, collecting, storing and retrieving project information)	- Shared virtual space, websites, project tracking software - Instant messenger, e-mails - Traditional phone calls - Using various communication channels
Emotional (regarding relationships and trust building)	- Face-to-face communication, audio and video conferencing, more than written communication - Support members to communicate informally with social media - Kick-off, review and stand-up meetings - Feedback from members
Practical (clear, positive communication and behaviour rules)	- Employ basic rules for communication - Eligible attitudes and behaviours - Short, asynchronous communication loops

BRIEFING

Briefing is the process where clients formally or informally inform their needs and requirements, while the brief is a formal document that amply defines the requirement and objectives of the clients. It is a communication mean of interacting between clients and architects, and it also builds the dialogue regarding the design proposals value and quality. The general client requirements consist of some building issue such as spatial dimensions, flexibility and security. Briefing document in designing processes of projects gives a clear overview of the project budget, needs and aspirations of the client. It is a reference document of future audits in different stages of the project, and it is an evaluation criterion to guarantee the optimal resolution of building problems (Bogers et al., 2008). According to Lupton (2002), briefing is divided into two stages correlated to the design process developing: strategic briefing and project briefing. Strategic brief is a document that covers the technical, managerial and design requirements, and how to be achieved.

Whilst the project brief defines all requirements of the design, and it is considered as the basis for the design development and its measurement guideline. Furthermore, a checklist consisting the tasks needed to be completed by the end of the strategic briefing is proposed by Lupton (2002) that includes four categories: general, planning and building considerations, environmental and financial, as shown in Table 4.

Table 4. Strategic brief checklist

Category	Information
General	• Quality standards • Life expectancy of building and components • Security requirements • Health and safety policy • Site history, topography and exact location of boundaries • Spatial relationships and orientation, plans for future expansion
Planning and building considerations	• Constraints arising from previous consents or conditions; • Impact of Local Development Plan; • leasehold/freehold interests and party walls, rights of light, access
Environmental	• Services below ground • Parking requirements
Financial	• Funding requirements or restrictions • Approximate cost per square meter

Sufficient time must be spent on a briefing between clients and clients. However, briefing process can be compressed on the domestic-scale designing projects, while architects should work on it thoroughly without leaping to rapid design solutions that may not fulfil client's requirements. Studies reviewed that architects see briefing as inconvenient restrictions and it limits their creativity, whilst interviewed architects by Bogers et al. (2008) acknowledged that briefing is usually underestimated, yet it is considered to be one of the essential documents of the designing process.

CONCLUSION

This paper gives an overview of communication management area of knowledge that help architects to establish a well-based background to improve and manage communication with their clients. It highlights the importance of communication management to architects, as an effective part of project management field of knowledge. Communication management requires the relevant planning to properly distribute and communicate designing information between project participants. In the same context, architects need to establish the essential document of communication management plan in the early phases of project commencement. It determines the major communication matters of the project. Finally, practices of communication management were introduced, and briefing, as an architectural practice was presented. It helps the architects to well-understand and fulfil clients' needs. It is an essential practice to raise architect's communication knowledge and improve client-architect relationship, which eventually helps to achieve successful project outcomes.

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AN ANALYSIS OF KEY IMPORTANCE FACTOR FOR IBS FORMWORK SYSTEM AMONG MALAYSIAN CONSTRUCTION STAKEHOLDERS

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Abstract
The goals of this paper is to analysed the key importance factors of driving or hindering the used of Industrialised Building System (IBS) formwork system in the Malaysian construction industry. A survey among 157 respondents which are construction personnel was employed for the study. The survey result shows that fifteen (15) identified factors for IBS formwork implementation are further ranked according to the average mean score perceived by construction personnel as follow: *(F6: Government Initiative), (F12: Roles of Agencies), (F13: Procurement), (F7: Training), (F14: Incentives), (F15: Manufacturer Availability), (F11: Familiarity of IBS System), (F4: Qualified Technical Team), (F8: Cost & Financial), (F3: IBS Score Index), (F1: Project Trend), (F10: Compliance of Policy), (F5: IBS Scoring Manual), (F9: Promotion) and (F2: Contractor Involvement).* This findings suggest that through improvement of most importance factor, the IBS formwork system implementation will be increase and success.

Keywords: *Industrialised Building System; formwork system; key importance factor.*

INTRODUCTION

According to Baharuddin et al., (2016), IBS formwork system consist the significant element of sustainable formwork which is a speeds of construction, lower life-cycle costs, almost indestructible and the most important thing is in reducing the additional site work which basically involved by foreign worker. According to Kamar et al., (2009), formwork is very important in producing concrete structure which allows contractors to cast the main parts of a building which are required to be strong and support the structure. In fact, this type of formwork much cheaper and quicker to use in the long run than traditional formwork and it is extremely strong and rarely need replacing, reducing cost in terms of manpower (Chung L.P. & Kadir A.M. 2007). Besides that, it has very high reuse rates, more precise dimension, minimum construction waste, cleaner and safer jobsite, environmental friendly, reducing finishing coats and reducing overall foreign workers. Hence, IBS formwork is one of the intelligent component in construction that was introduced with a hope can reduce the chaining of various problems which comes from construction industry. As a sustainable element technology, IBS formwork was full of benefits in fulfil the basic goal of construction; time, resources and quality (CIDB Malaysia, 2007). Nevertheless, the expectation in application of IBS formwork in construction industries sounds mushrooming seen contradictive. Even the CIDB of Malaysia actively promoting the use of IBS in construction, the application of IBS by Malaysian stakeholder was lack and still below the target when stakeholder needs not realign and change the paradigm from the conventional construction process which lack of efficiency (Zawawi, 2009).

PROBLEM OVERVIEW

Based on Baharuddin et al. (2015), the implementation of IBS formwork is known as one of the best alternative in completing the construction project nowadays. The existence of this IBS formwork seems to be one of the problem solving in reducing the used of conventional formwork which famous of additional site work and quiet waste based on time, cost and safety (Haron et al., 2009). Nevertheless, production of IBS formwork with full of advantages seems not glowing enough when their application still not rapidly embracing (Nawi et al., 2011). Based on the study conducted by Azman et al. (2011), the adoption of the IBS formwork system still lack as there is only twelve (12) number of IBS manufacturers in 2009 which operate in three states mainly in Klang Valley. In fact, the implementation of this system will facilitate the Malaysian stakeholders especially the contractors in a way to reduce a harmful effects to the environment by achieving the sustainable agenda.

Currently, the take up of IBS formwork was below than the target of IBS used as stated in IBS Roadmap 2003-2010 (CIDB Malaysia, 2007) and the participation of contractors to involved in the IBS project is currently poor (Baharuddin et al., 2015). With regards on that scenario, the identification of critical factor and difficulties through empirical study is vital in way to overcome the shortcomings. In general, a critical factor is defined as the factors which contribute the ineffective result and achievement towards successful of building construction with considering of time, quality and cost. According to study been done by Baharuddin et al. (2016), there are fifteen (15) numbers of importance factor found in his study which been develop by conceptual framework after 1st phase of research part which are identifying of critical factors through extensive literature review was completed. The fifteen (15) factors as follow:

Table 1. Importance Factor for IBS formwork system implementation

Factor	Perception
F1	Project Trend
F2	Contractor Involvement
F3	IBS Score Index
F4	Qualified Technical Team
F5	IBS Manual
F6	Government Initiative
F7	Training
F8	Cost & Financial
F9	Promotion
F10	Compliance of Policy
F11	Familiarity of IBS System
F12	Roles of Agencies
F13	Procurement
F14	Incentives
F15	Manufacturer Availability

RESEARCH METHODOLOGY

This research is developing the Readiness Framework for IBS Formwork among Malaysian Construction Stakeholders. This paper is part of this research which the main

objectives is to identify the critical factors that contribute to difficulties in adopting IBS formwork, secondly, to determine the importance factors in application of IBS formwork among Malaysian stakeholder and thirdly to develop a conceptual of readiness framework by the importance criteria from the relation between critical success factors and importance factors. For this paper, only second objective was discussed. The development of critical factor was confined to the literature published from 2003 onwards in academic journals and published proceedings. A thorough examination was carried out in order to develop in depth-understanding about which factors are likely to happen due to IBS formwork implementation. A qualitative research approach has been adopted for this study which requiring the development of semi structured interview question to the relevant stakeholder which is contractors to seek their opinion and suggestion for interview question. There are no matters arising being identified and therefore there is no amendment needed to be done with the critical factors. Then, the process to obtain a data was employed through the quantitative phase involved a questionnaire survey. A descriptive technique was adopted to validate factors and sub factors of IBS formwork implementation. The questionnaire was conducted on a sample of drawn from a database of contractor listed in the Construction Industry Development Board (CIDB) Malaysia. The full-scale survey was constructed among B01 (Pre Cast Concrete Contractor) and B19 (IBS Formwork System Contractor) which focusing on technical construction personnel. A total of 400 copies of the questionnaires were delivered to the potential respondents by email and online survey. However, only 157 copies and response of the questionnaire were received. The response rate was 39.25% which was consistent with the norm of 20-30% for most questionnaire surveys in the construction industry (Yang et al., 2009).

FINDINGS AND DISCUSSION

Respondents comprised 157 industry personnel working with construction organization related with IBS in Malaysia consisting of 144 Contractor, 6 Consultant, 3 Developer, 4 Authority Agencies and 1 Designer. Most of the respondents, which is 50.8%, had relevant experience of between 6-20 years in the industry and the majority of them were positioned as Clerk of Work and Site Engineer. Table 2 show the tabulation of position hold by construction personnel.

Table 2. Descriptive statistic

Position	Frequency	Valid Percent (%)	Cumulative Percent (%)
Director / Principal	1	1.3	1.3
Project Director	12	7.6	8.9
Architect	15	9.6	18.5
Engineer	44	28.0	46.5
Quantity Surveyor	20	12.7	59.2
Building Surveyor	4	2.5	61.8
Site Supervisor	54	34.4	96.2
Others	6	3.8	100.0

Table 3 shows the rating for each factor from Malaysian Construction Stakeholders by using rating scale from (1) ‘strongly disagree to (5) ‘strongly agree’. This table portrays the mean value of responses obtained for each factor which indicating that all IBS formwork key importance factors have a strong level of agreement amongst each stakeholders.

Referring on the survey result, from the perspective of construction industry stakeholders, the majority of respondents highlights that (F6: Government Initiative) is the main importance factor which could lead to enhancement of IBS formwork implementation. Then, it followed by (F12: Roles of Agencies), (F13: Procurement), (F7: Training), (F14: Incentives), (F15: Manufacturer Availability), (F11: Familiarity of IBS System), (F4: Qualified Technical Team), (F8: Cost & Financial), (F3: IBS Score Index), (F1: Project Trend), (F10: Compliance of Policy), (F5: IBS Scoring Manual), (F9: Promotion) and (F2: Contractor Involvement).

Table 3. Survey Result

Factor	Perception	Mean	Overall Ranking
F1	Project Trend	4.07	11
F2	Contractor Involvement	3.78	15
F3	IBS Score Index	4.11	10
F4	Qualified Technical Team	4.15	8
F5	IBS Manual	4.00	13
F6	Government Initiative	4.66	1
F7	Training	4.39	4
F8	Cost & Financial	4.11	9
F9	Promotion	3.96	14
F10	Compliance of Policy	4.04	12
F11	Familiarity of IBS System	4.17	7
F12	Roles of Agencies	4.46	2
F13	Procurement	4.42	3
F14	Incentives	4.39	5
F15	Manufacturer Availability	4.19	6

Table 4. Rating Scales and Classification (Mc Caffer, 1997)

Rating	Rating scale	Classification
1	Very low or extremely ineffective	1.00≤ Average index score ≤ 1.50
2	Low or ineffective	1.50≤ Average index score ≤ 2.50
3	Medium or moderately ineffective	2.50≤ Average index score ≤ 3.50
4	High or very effective	3.50≤ Average index score ≤ 4.50
5	Very high or extremely effective	4.50≤ Average index score ≤ 5.00

With refer to the Table 4, it can be summarize that the top five (5) ranking of IBS formwork which is F6, F12, F13, F7, F14 can be considered as a key importance criteria which classified as a 'Strategic Level Implementation' since the entire factor shows the government role and responsibility in a way to emphasize the utilization of IBS formwork. Receiving a strong support from a government or its agencies will facilitate the implementation of IBS at national level. Other than that, according to Nawi et al., (2015), among obstacles faced in implementing IBS concept is procurement method since IBS project requires immediate payment for components delivery at site during initial stage of construction. He added, high cost factor also will be identified as a main issues since the contractor have to bear the cost of purchase of new machinery, mould manufacturing, tax for machinery and any tools and equipment which imported from overseas. With the strong support from government such as the lowest tax enforcement, special incentive from the government to the IBS stakeholders and other initiative could give a positive development on

IBS formwork system implementation. He also suggested to the government to impose condition obligatory to use IBS, fast development process on local authority side, and a part of that is to convince consultants to use this system.

Furthermore, (F11: Familiarity of IBS System), (F4: Qualified Technical Team), (F8: Cost & Financial), (F3: IBS Score Index), (F1: Project Trend) has received moderate response from the respondent. According to Baharuddin et al., (2016), familiarity of IBS system through a great promotion is vital since most of the industry player especially contractor unfamiliar with IBS formwork terminology itself. In the context of F4 which ranked on 8th place, Qualified Technical Team could bring a significance impact of successful for IBS formwork implementation. The details and proper procedure of IBS formwork installation need to be documented as a 'manual' to give a clear view to the installer in way to install the system as well as to assure a safety and health issues during concreting process. It was agreed by Nawi et al., (2015) shows that lack of skilled labour and relating training scheme in the context of IBS formwork is importance even though the assemble and dissemble of the IBS formwork system product such as 'table form', 'half tunnel form' and others is uncomplicated.

In addition, survey result also shows that F8, F3, F1, F10 and F13 is above a 4.00 mean value which can be considered as high or very effective factors towards IBS formwork implementation (Ghazali et al., 2016). Cost & Financial is the most common factors which bring a challenge in any field. It is same goes with IBS formwork system implementation while most of the respondent responses that a high initial cost in the IBS project as well as to purchase IBS formwork to be use in the construction project will effect small scale contractor. The IBS Score Index and IBS Manual should be declared extensively through mass media and any related 'channel' as to give comprehensive understanding about IBS system inclusive of IBS formwork system.

In any cases, compliance of policy, regulation and other related enforcement issues should be in place in a way to ensure all the policy, steps and any procedure outlined by the government is well executed. In the context of IBS formwork system, most the respondents agree on that particular issue with mean score 4.00.

Meanwhile, through this survey also identify F2 and F9 has received fewer responses in the context of key importance factor of IBS formwork system. Although the promotion and contractor involvement looks like significance with these issues, most of respondent stated that both factor could be overcome since the IBS project is not involving on the contractor itself, but it is more linking with other parties such as manufacturer and client side. That is why, government has plays a significance roles which could give a huge benefit in the context of IBS formwork implementation.

CONCLUSION

The main objective of this paper is to highlight the key importance factors of IBS formwork system application among Malaysian construction stakeholders. In determining which of the factors most importance to the IBS formwork system, the descriptive technique of evaluating the mean frequencies was conducted. By employing a descriptive technique, the fifteen (15) identified factors for IBS formwork implementation are further ranked according

to the average mean score perceived by construction personnel. The result indicate the ranking as follow: *(F6: Government Initiative), (F12: Roles of Agencies), (F13: Procurement), (F7: Training), (F14: Incentives), (F15: Manufacturer Availability), (F11: Familiarity of IBS System), (F4: Qualified Technical Team), (F8: Cost & Financial), (F3: IBS Score Index), (F1: Project Trend), (F10: Compliance of Policy), (F5: IBS Scoring Manual), (F9: Promotion) and (F2: Contractor Involvement).*

In addition, the test also found that a factor related to 'Strategic Level' which define as a government roles and responsibility was the top-ranked and therefore most importance factor for IBS formwork implementation.

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INCORPORATING SPATIAL SELECTION CRITERIA WITH DECISION PREFERENCES IN MCE-GIS-BASED SITE SELECTION OF A PRECAST MANUFACTURING PLANT

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Abstract
The Construction Industry Development Board of Malaysia has been actively promoting the use of precast manufacturing in the local construction industry over the last decade. In an era of rapid technological changes, precast manufacturing significantly contributes to improving construction activities and ensuring sustainable economic growth. Current studies on the location decision of precast manufacturing plants aimed to enhanced local economic development are scarce. To address this gap, the present research establishes a new set of spatial criteria, such as attribute maps and preference weights, derived from a survey of local industry decision makers. These data represent the input parameters for the MCE-GIS site selection model, for which the weighted linear combination method is used. Verification tests on the model were conducted to determine the potential precast manufacturing sites in the state of Penang, Malaysia. The tests yield a predicted area of 12.87 acres located within a designated industrial zone. Although, the model is developed specifically for precast manufacturing plant but nevertheless it can be employed to other types of industries by following the methodology and guidelines proposed in the present research. The findings of this study can be recommended as a guideline or decision support module to the precast manufacturers. Consequently, the model is applicable to be suitable to other states as well using the same decision makers' weight and criteria but essentially replacing the attribute maps according to the selected state.

Keywords: *Spatial criteria, multi criteria, Industrialised Building System, precast manufacturing plant*

INTRODUCTION

The expansion of precast manufacturing plants is decided on the basis of demand and contract value-based projects. However, some factories in the United Kingdom (BBC 2010) and Malaysia (BBC, 2010; Kamar, 2011) have discontinued production or were closed. High-tech precast manufacturing plants operate in accordance with project demands and may fail if they incur high operational costs and maintenance under low production demand. Therefore, a feasible location study is critical to understanding the setup of precast manufacturing to warrant continuous production and demand. High and repetitive production implies low production costs. The volume of production is important because precast construction requires repetitive and continuous projects to be profitable.

The review of current literature does not reveal identical findings on precast manufacturing plants plagued by site selection issues. Nevertheless, certain studies provide insight into this problem. For example, Shen (2005) investigated manufactured housing (MH), which is similar to the precast manufacturing system. He evaluated the accessibility of MH

to community services by GIS analysis and provided justification for why MH projects are not constructed near large facilities. The majority is located outside cities or suburban locations, and some are located in rural areas. The author recommended the inclusion of more MH zoning concepts in policy and accessibility practice. Policy is a key driver of the development of precast manufacturing.

The decision process entailed by location selection is also crucial in defining the determinants of a good location because most of the important location criteria emerge from the initial stages of site selection. Understanding the location decision process may improve the development of local economic activities and generate sustainable business environments (Badri, 2007). Multi-criteria evaluation (MCE) is frequently used to assess allocation issues, facilitating conceptualization and decision making; these processes include a full range of social, environmental, technical, economic, and financial criteria (AbuSada and Thawaba, 2011; Carver, 1991; Jelokhani-Niaraki and Malczewski, 2015).

Jankowski and Nyerges (2001) agreed that experimentation on decision making tools with GIS technology is feasible through the use of the "classic" site selection reference problem. GIS-based solutions highlight the voice of decision makers and enable the recognition that differential access to GIS data, hardware, software, and "human ware" are significant components of spatial decision making (Harris and Weiner, 1998). MCE-GIS models for site selection are therefore dynamic, and their integration becomes a powerful tool that can provide better cartographic display and infinite database systems (Malczewski and Rinner, 2015).

The current research establishes a site selection model for new precast manufacturing plants within the Northern Corridor Eastern Region (NCER) of Malaysia to fulfill the demand of precast components where supply remains low. The model was tested in Penang, Malaysia, which has only one precast manufacturing plant despite the fact that the state has the highest GDP growth of the manufacturing and construction sectors among the other states (NCER) of Malaysia (Statistics, 2010).

LITERATURE REVIEW

This study provides a useful method for examining an alternative approach to evaluating the criteria that reduce uncertainties in decisions. Each criterion is represented as a map layer in a GIS database. Thus, each layer that represents the evaluation criterion is referred to as an attribute map (Malczewski, 1999). Two types of attribute maps are available: factor and constraint maps (Eastman, 2003). A factor is a criterion that enhances or detracts from the suitability of a specific alternative for the activity under consideration; it is measured on a continuous scale. A constraint serves to limit alternatives under consideration and is expressed in the form of a Boolean map [i.e., 1 (true) or 0 (false)] (Azman et al., 2012a).

Once the attribute maps are developed, the evaluation stage combines the information presented by the maps and defines the parameter limits of various factors and constraints (Eastman, 2003). Subsequently, the aggregated information from the attribute maps are used as input parameters for the MCE-GIS module that evaluates multiple criteria by Boolean overlay and weighted linear combination (WLC) techniques. The subsequent section discusses the additional implementation stage of these procedures.

Despite the limitation of a statistical approach to determining new potential sites for precast manufacturing plants, it can be alternatively implemented using the MCE-GIS method. Most statistics are based on probability concepts. An observation in which statistics is impossible is very unlikely. When drawing conclusions in statistical analysis, the line at a certain level of probability should be drawn. Many common statistical calculations and tests have an important assumption on populations studied; that is, that populations are characterized by normal distribution. This assumption indicates that the characteristics of interest in a population are evenly distributed. Traditional statistics is inherently non-spatial because it seeks to represent a data set by its typical response regardless of spatial patterns. The mean, standard deviation, and other statistical values are computed to describe the central tendency of the data in abstract numerical space without consideration for the relative positioning of the data in real world geographic space. Given the size limitation of population samples for precast manufacturers (25 respondents) a value smaller than the number of independent variables (49 variables) additional statistical analyses, such as binary logistic regression or multiple linear regression, are unsuitable (Azman et al., 2013). The literature review indicates that no specific rule is applied in determining the adequacy of sample size for logistic regression, but multivariate statistics scholars have recommended a minimum ratio of 10 to 1, with a minimum sample size of 100 or 50, plus a variable number that is a function of the number of predictors (Peng et al., 2002).

From statistical data on multiple decision makers, the weight of each criterion can be determined using the aggregation of individual priorities (AIP). These weights multiplied by the spatial data layers that represent each criterion are the input parameters for the WLC or simple additive weighting model to determine new potential sites for precast manufacturing. Aside from generating the weights of multiple decision makers, preparing attribute maps is important in spatial data analysis. GIS analysis and databases are employed in a variety of decision making contexts in the main preference of decision sensitivity to the prediction technique in GIS-based models (AbuSada and Thawaba, 2011). GIS technology is unique because the criteria for decision makers can be measured, evaluated, and stored in GIS databases for analysis (Figure 1). Thus, decisions are based on criteria (Effat and Hegazy, 2010).

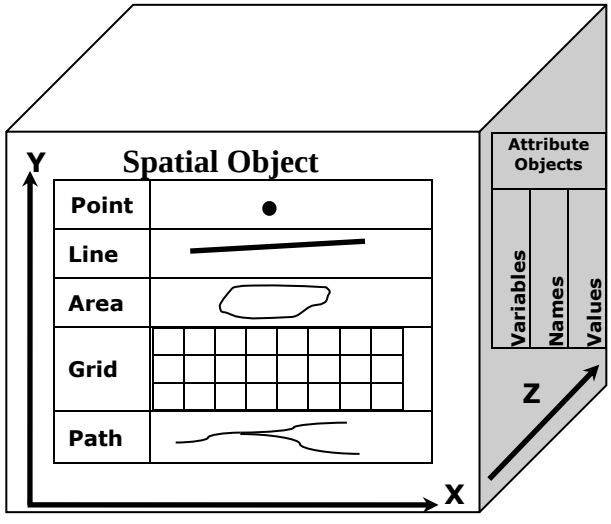

Figure 1. Geomorphic Applications Needed for a Three Dimensional GIS

Studying MCE-GIS using the WLC model necessitates appropriate parameters for the attribute maps determined through literature reviews. In addition, these maps are classified as factor and constraint maps. The decision makers' weights are multiplied by the factor maps, whereas the constraint maps require only a buffer or re-class spatial analytical process that restricts the site screening process. Thus, the areas restricted by rules and physical constraints are excluded from the selection area and assigned a value of 0 during the data preparation stage. These constraint maps are regarded as Boolean images and simply act as masks in the last step of WLC. The WLC process overlays all factor maps and the final mask determines the results for new potential sites.

METHODOLOGY

The total number of precast manufacturers currently registered with the Construction Industry Development Board (CIDB) of Malaysia is 36 (IBSCentre, 2011). Only 25 manufacturers have permanent factories and the rest are temporary in nature, dependent on the terms of a project. The site selection criteria were determined by a multi-criteria decision-making technique. We conducted a survey on decision makers, who are manufacturers, contractors, academicians, and policy makers. The decision maker preferences are used as preference weight parameters in the GIS model to locate new potential precast manufacturing plants.

Statistical Approach for Decision Maker Weight

A quantitative survey is the most suitable survey instrument for data gathering, analysis, and subsequent action planning. This type of survey also provides details on the types of data used in a quantitative survey. The first section of the survey in this study aims to obtain background information, which includes the name, designation, affiliation, number of years working in the construction and IBS industries, and contact details of the respondents. The respondents' survey was the result of the various stages of the quantitative survey, as proposed from the outcomes of previous surveys, preliminary surveys, and focus group discussions. Respondent decision should focus on the 25 precast manufacturers in Peninsular Malaysia through the use of a population survey. The overall rate of return of the survey was 80%. Higher response rates ensure more accurate survey results and show signal legitimacy achievement (Hager et al., 2003). The response rate improved because of consistent follow-up through phone calls. The survey has 49 questions for which the respondents are required to tick preferences on the basis of a seven-point Likert scale. Surveys of varying pages and questions, distributed to companies, enable higher returns than questionnaires with few pages and questions (Greer et al., 2000).

The second section of our survey requires the respondents to choose their preferences in accordance with a seven-point Likert scale for the site selection criteria on precast manufacturing. Likert scales are ordinal scales used to transform the opinions of respondents into a scale, thereby facilitating statistical analysis (Osgood et al., 1957). The seven-point Likert scale is described in Table 1. Flynn et al. (1990) indicated that interval measures may be added or subtracted at points compatible with various statistics. Selecting criteria through the design stage and on the basis of literature reviews is crucial. Therefore, all criteria are important but differences between the criteria are ranked on the basis of the intensity of importance, as introduced by Saaty (1980).

An important aspect in determining the type of statistical test (e.g., parametric or nonparametric tests) is the scale of measurement for the data generated during a survey. Fellows and Liu (2008) described four types of measurement scales that can be used for statistical analysis: nominal, interval, ordinal, and ratio scales. The current work uses ordinal and interval scales. Ordinal scales are used to rank responses with no indication of distance between scaled points or commonality of scale perceptions by respondents. In essence, the scale provides a hierarchical sequence and indicates that the value of one observation is greater or more important than others. An ordinal scale measures each variable when each respondent is asked to assign a level of importance (Table 1).

Table 1. Definition of Seven-Point Likert Scale (Voogd, 1983)

Intensity of Importance Seven-Point Likert Scale	Definition
1	Not Important
2	Less Important
3	Moderate Important
4	Important
5	Strongly Important
6	Very Strongly Important
7	Absolute Important

Conversely, an interval scale is a cardinal scale that employs units of measurement for the scale; the zero point is arbitrary. Interval scales indicate the order of responses and distances between them. Using an interval scale permits statements about the distance between respondents but not about the relationships in ratio terms between scores. Table 2 identifies the various types of scales used in this study.

Table 2. Scale of Measurement of Variables

Section	Variable	Measurement	Scale
Background of Respondents	Working Experience in Construction	1-5 years 6-10 years	Interval
	Working Experience in IBS	11-15 years > 15 years	
Site Selection Criteria	Transportation and Optimum Distance Environment Risk Costs Market Access Resources and Utilisation Land Sites Population Political and Regulation Capacity Labour Competition Work Suitability Inter-Industry Linkage Safety	1= Not Important 2= Less Important 3= Moderate Important 4= Important 5= Strongly Important 6= Very Strongly Important 7= Absolute Important	Ordinal

The dependent and independent variables of this research were formulated on the basis of the site selection criteria for precast manufacturing plants. The dependent variable defines the suitability of precast manufacturing plants. The circumstances for developing the model of site selection criteria for precast manufacturing plants can be determined by MCE-GIS, which has 11 criteria. The criteria are separated into two groups of maps, namely, seven factor maps and four constraint maps. Then, the maps are ready to be applied together with the input from multiple decision makers' preferences in the MCE-GIS model.

Production of Attribute Maps

Table 3 shows the parameters of attribute maps in the form of factors and constraints, which represent the 11 criteria. The 26 attribute maps involved in the study are stored in two types of data: geographic definitions of earth surface features and the attributes that these features possess. These data are presented in IDRISI® GIS software in the form of fundamental map representation techniques; that is, vector and raster techniques (Eastman, 2003).

Table 3. Parameters of Attribute Maps

Code	Criteria	Attribute Maps	Parameter of Factor Maps and Constraint Maps
F1	Costs (Ngah, 1993)	Land cost	Re-class: - Pastures and Scrub < RM 50/m^2 - Agricultural land RM 50 to 75/m^2 - Manufacturing Zone RM 75 to 125/m^2
F2	Resources and Utilization (Braun et al., 2008)	Cement and Sand Steel	10 km 10 km
F3	Transportation and Optimum Distance (Warszawski, 1999)	Expressway Highway Primary Road Secondary Road Urban Road Local Road	50 km
F4	Safety (Buchmueller, Jacobson, & Wold, 2006; Clymer, 1998; Truls, 1997)	Police IPD Fire Station Hospital	35 km 6 km 8 km
F5	Competition (JPBD, 2005)	IBS Factory Pulau Pinang	3000 m
F6	Infrastructures (Ahamad, Hussin, & Shamshad, 2011; JPBD, 2005)	Water Supply Electricity Airport Railway Sea port	500 m 30 m 10 km 50 m 10 km
F7	Politics and Regulation (Warszawski, 1999)	Government Offices	50 km
C1	Land Sites (JPBD, 2005)	Land Use	Re-class: - Agricultural land - Manufacturing zone - Pastures and scrub
C2	Market Access (JPBD, 2005)	Residential Centre	Re-class: - Primary Residential Centre - Minor Residential Centre - Rural Growth Centre
C3	Environmental Risk (Lin & Kao, 1999; Rachdawong & Apawootichai, 2003)	River Single River Double DEM Forest	Away 100m from stream Away 100m from stream Re-class (10% below) Re-class for selected area of non-forest
C4	Population (Rachdawong & Apawootichai, 2003)	Population map	Active population 800–5000 m (10× for each cell)

The digital map data on Pulau Pinang in different layers of spatial information are at the topographic scale of 1: 25,000. This information was officially obtained from the Department of Surveying and Mapping Malaysia (i.e., Jabatan Ukur dan Pemetaan Malaysia (JUPEM)). These maps are of the latest version available (2006) in the format of Rectified Skew Orthomorphic (RSO) and have been converted to a 25 m x 25 m resolution raster attribute map in IDRISI® GIS software.

Map Preparation

Before the application of WLC, all unsuitable areas were excluded from the study area by assigning 0 in the data preparation stage to form constraint maps. All the factor maps were converted into raster maps and multiplied by the mask map to make them accessible for ranking. The results were overlaid with a land use map that acts as a base map to identify the location of potential sites. Additionally, SA was applied to identify the sensitivity of multiple decision makers in the MCE-GIS model and to determine which criteria are significant to the study.

After the preparation of all input data layers, the MCE-GIS model was selected among other decision rules. The model applied the WLC method in the spatial analysis of suitable sites. The outputs produced the WLC score map from the result of multiplying factor maps, weights, and constraint maps (mask map) (Figure 2). Suitable sites were further analyzed to determine the type of precast manufacturing plants, suitable for either mobile- or permanent-type construction.

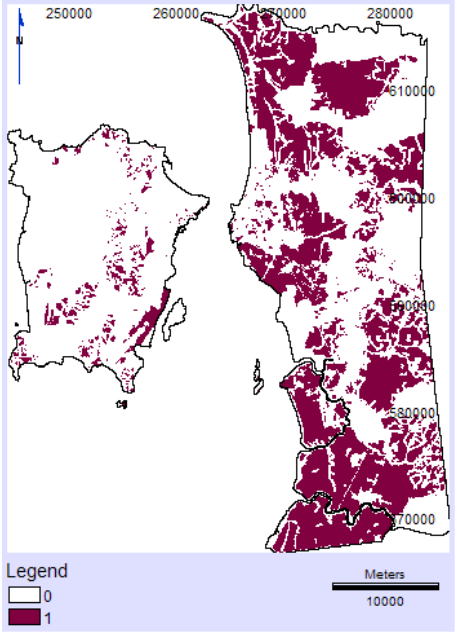

Figure 2. Mask Map (Combines Seven Boolean Maps)

Weight Calculation by WLC

Determining the final set of criteria and attributes before assigning the weights of the factor maps is important. These weights are the input parameters for WLC. The weights of the criteria are obtained from the final statistical analysis of the site selection criteria (Table 5). The criteria are ranked in accordance with the AIP mean. The method of calculating the AIP mean starts with the individual grouping of the attributes by using the geometric mean. Then, the final priorities of each group attribute are aggregated using the arithmetic mean, which represents the final AIP mean of the seven factor maps (Table 4). The detailed coding for each attribute is shown in Table 3.

Table 4. AIP Means of Seven Factor Maps

Criteria	Geometric Mean for Each Attribute	Arithmetic Mean for Each Criterion
Costs (F1)	CS1 = 5.56	6.04
	CS2 = 6.27	
	CS3 = 6.09	
	CS4 = 6.30	
	CS5 = 6.08	
	CS6 = 5.90	
Resources and Utilization (F2)	RS1 = 4.92	5.41
	RS2 = 5.48	
	RS3 = 5.94	
	RS4 = 5.29	
Transportation and Optimum Distance (F3)	TD1 = 4.80	5.27
	TD2 = 5.38	
	TD3 = 5.08	
	TD4 = 5.28	
	TD5 = 5.82	
Safety (F4)	SF1 = 5.59	4.91
	SF2 = 3.39	
	SF3 = 5.62	
Competition (F5)	CP1 = 4.89	4.83
	CP2 = 4.79	
Infrastructures (F6)	IN1 = 2.32	3.70
	IN2 = 3.08	
	IN3 = 2.82	
	IN4 = 3.55	
	IN5 = 5.01	
	IN6 = 5.37	
Politics and Regulation (F7)	PR1 = 3.63	3.63

Figure 3 shows the seven standardized criteria (factor maps) and seven constraint maps used in the WLC method. First, the arithmetic mean was determined and then normalized to represent the multiple decision makers' weights (Table 5). Finally, these normalized weights were assigned to the seven factor maps. The WLC algorithm in IDRISI® GIS software was linearly combined with these maps to produce an output score map of suitability value.

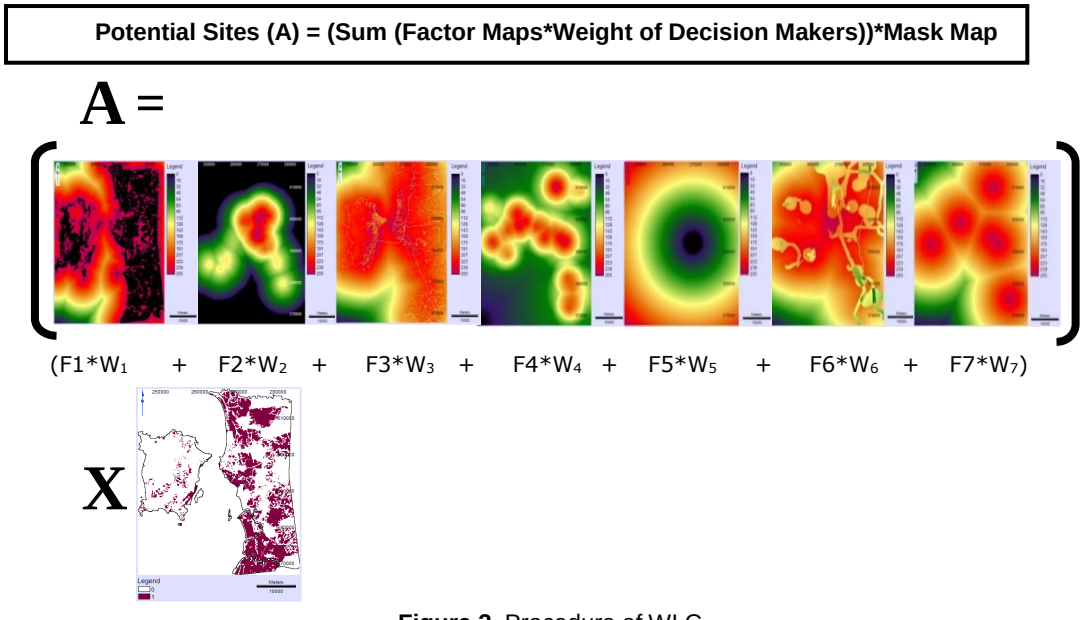

Figure 3. Procedure of WLC

Table 5. Normalized for Seven Weighted Factor Maps

Factor Maps	Arithmetic Mean	Normalized Weight
F1	6.04	0.1788
F2	5.41	0.1601
F3	5.27	0.1560
F4	4.91	0.1453
F5	4.83	0.1429
F6	3.70	0.1095
F7	3.63	0.1074

Results of WLC Method

The resultant potential sites derived by the WLC method are shown in Figure 4. Most of the suitable sites are located in North Seberang Perai, Central Seberang Perai, and North East Pulau Pinang Island. The potential sites fall within the manufacturing zone and potential agricultural land, as indicated by the clustered cells in black (circles in Figure 4). The five potential sites are classified as A1, A2, A3, A4, and A5. The detailed descriptions of the locations are as follows:

- A1 is located in George Town (North East Pulau Pinang Island).
- A2 and A3 are located at Mukim 13 (North Seberang Perai), which is in the manufacturing zone. A3 is located at the Mak Mandin Industrial Estate.
- A4 and A5 are located at Mukim 1 (Central Seberang Perai), which partially falls within the potential agricultural land but most of the areas are in the manufacturing zone. In addition, A5 is located in the Perai Industrial Zone.

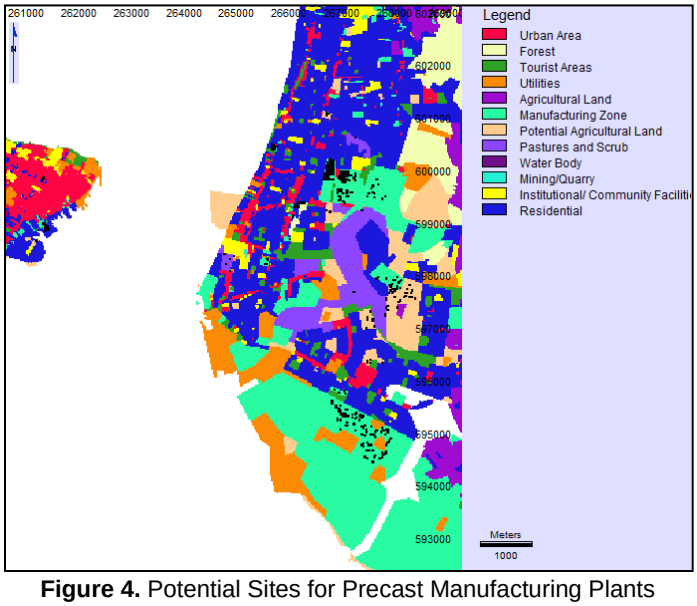

Figure 4. Potential Sites for Precast Manufacturing Plants

In this study, the classes of potential sites are grouped into four levels of suitability, as adapted from Chen et al. (2010). These levels indicate high suitability, moderate suitability, marginal suitability, and unsuitability (Figure 5). The cell size (resolution) of the image map is 25 m, representing an area of 625 m^2 on the ground (Joerin et al., 2001).

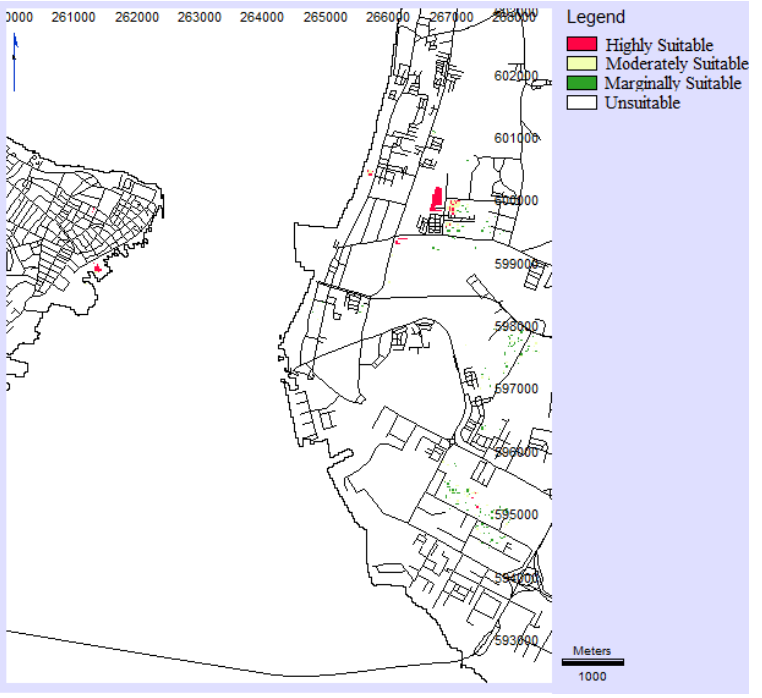

Figure 5. Suitability Classification of Potential Site in Pulau Pinang

Furthermore, the size suitable for precast manufacturing plants is important and is related to the factory productivity and storage space of precast products. The earlier part of the study identified the suitable size for establishing precast manufacturing plants. Five acres are allocated for mobile precast manufacturing plants and a minimum of 15 acres are allotted for permanent precast manufacturing plants as showed in Table 6.

Table 6. Comparison of Permanent and Mobile Precast Manufacturing Plants (Azman et al,. 2012b)

Criteria	Permanent Manufacturing	Mobile Manufacturing
Annual Project	RM100 million above	RM10 million and above
Capital	High	Low
Technology	Prefabricated, semi-auto, automatic	Prefabricated
Maintenance	High bill electricity	Low bill electricity
Land Capacity	Minimum 15 acres	Can start with 5 acres
Mould	Flexible size	Flexible size
Roof of IBS Manufacturing	Permanent Protected from rain	Mobile Develop portable roofing to protect the concrete
Manpower	Maximum 500 workers and average 200 workers Specific task High payment	25 workers Multi tasking Low payment
Product	Hollow Core Slab Half slab Stair case Beam Column Wall panel	Half slab Stair case Beam Column Wall panel
Crane	Permanent At factory: 25-30 tonnes At site: 50-260 tonnes	Permanent or mobile At factory: 25-30 tonnes At site: 50-260 tonnes
Concrete	Required batching plant concrete	Outsource or setup a new batching plant

The results indicate that the site suitable for the minimum size allowed for mobile precast manufacturing plants is class A3. Class A3 also has two potential sites—P1 and P2—where P1 presents a highly suitable site of 12.87 acres and P2 (5.88 acres) is a mixture of highly suitable, moderately suitable, and marginally suitable site, representing the second most important site. On the basis of their sizes, therefore, P1 and P2 are regarded as suitable for mobile precast manufacturing plants. The site satisfies the condition established; that is, an area spanning more than 5 acres but less than 15 acres. Furthermore, the position of the cells in class A3 is contiguous and well clustered. Classes A1, A2, A4, and A5 are not suitable because the cells are not homogenous. They also do not satisfy the criteria on permanent manufacturing or mobile manufacturing.

CONCLUSIONS

A precast manufacturing plant site selection model is applied the State of Penang. The state has the highest CDP growth among the other states in Malaysia. The role of GIS in site selection analysis via the MCE-GIS model has evolved along with the changing perspectives on planning, from scientific approaches to collective design approaches (Malczewski, 2004). The MCE-GIS model was used as a platform to enable the management of criteria data, the production of factor maps and constraint maps, the combination of multiple decision maker preferences with attribute maps by WLC, and the production of potential site maps. This model was verified to ensure its accurate development in accordance with its specifications. The highly suitable site (P1) for precast manufacturing plants was determined using the MCE-GIS model; the site is located in Mak Mandin Industrial Zone, spanning an area of 12.87 acres. Although the potential site falls on a currently industrial activity area, the MCE-GIS model is capable of discovering potential sites on the basis of the specification design of attribute maps. Conversely, spatial statistics extends traditional statistics on two fronts. First, it seeks to map the variations in a data set to show where unusual responses occur, instead of focusing on a single typical response. Second, it can uncover numerical spatial relationships within and among mapped data layers; for example, it generates a prediction map that identifies where likely customers are within a city on the basis of existing sales and demographic information.

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A QUALITATIVE STUDY OF BLOCKWORK PLANTS IN MALAYSIA

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Abstract
The Malaysian Government has been continuously encouraging the engineers, the practitioners, and the construction industry to use the Industrialised Building System (IBS), which is considered to be an important part of modern method approach of construction. According to Construction Industry Development Board (CIDB), there are five main parts of IBS, namely precast component systems, steel framing systems, formworks systems, prefabricated timber framing systems, and blockwork systems, which have started to replace the traditional construction method. The objective of this study is to identifies the blockwork manufacturing process and also to identifies the decisive factor to setting up blockwork manufacturing plant. The methodology used in this study is relied on the qualitative approach. Data collection process was done by conducting observation to the location of the blockwork manufacturer and conducting interview with duration 45 minutes to 1 hour. The number of interviewee that involved in this interview process is three interviewees from three different blockwork plant. The data was analysed and processed into a textual statement that could be used as scientific data. The study finds that to manufacture a blockwork, the material that will be use must been chosen and treated wisely so it will not reduce a quality of blockwork. And also it need a good machinery because the production is heavily relied on the machinery. Machine maintenance must be done so that the machine will not easily broken and affecting the quality of blockwork. A quality control of blockwork in two of three companies that have been observed is relied on the laboratory tests and audited by Malaysian Government through SIRIM (Scientific and Industrial Research Institute of Malaysia). From this quality control, it found that the compressive strength is the main factor to determine whether the block is feasible to use or not. Number of workers, machinery and wide of plant area are contributes to production capacity. For example, in Company A with number of workers range to 4 to 7 people, two types of machine with one machine of each type, and wide of plant area of ±810 m^2 produce 3.125 m^3 blockwork per day. Compare to Company B with number of workers range to 8 to 12 people, one type of machine with two number of machine, and wide of plant area of ±8,093 m^2 could produce 11.25 m^3 blockwork per day. The study also finds problems in blockwork manufacturing process. The main problem that manufacturers may have to face is quality of the material and machinery. Quality of the material could affect the quality of the blockwork, while machinery problem could affect the capacity production and the line of production, meaning that if this problem is not handled by manufacturers, the plant could be shut down as there is no machine that could work.

Keywords: *Industrialised Building System (IBS), Blockwork System, Blockwork Manufacturer, Blockwork Production Process, Qualitative Data*

INTRODUCTION

Industrialised Building System (IBS) is a definition where the components of the building such as wall, slab, beam, column, and other components are manufactured at either factories on-site or off-site and then assembled at construction site with minimum wet site work. The term of IBS is used in Malaysia, whereas the term of prefabrication is used in other countries such as UK, Australia, Singapore, and Hong Kong (Jaillon & Poon, 2009;

Lovell & Smith, 2009). In onsite prefabrication, the structural components are cast at the construction site. While the offsite prefabrication describes the components manufactured or assembled remote from a building site prior to installation in their final position. The product is transported to site and installed using structural connections or joints; this results in high quality works, and also accelerates the completion time of the projects (Azman et al., 2012a).

IBS has been promoted in Malaysia since the 1960s when the government representatives visited several European countries and evaluated their housing development programme (Azman et al., 2012b; Majid et al., 2010). Since then, construction industry in Malaysia has shifted their conventional methods to IBS method, and the Malaysian government has been pressing all player in construction industry to use IBS for their project.

However, there is still some problem that occurred during the implementation of IBS such as some contractor that still use a conventional method that resulted a delay in construction project. In some cases, such as low labour productivity, lack of skills, the completion dates are not achieved and poor quality of material are the problem that also occurred during the construction work.

Therefore, in 1994 the Malaysian Government found Construction Industry Development Board (CIDB). The purpose of CIDB is to educate the construction industry players and to regulate and register the construction firm. The aim of the education to the construction industry players is so that they can understand and know how to implement the IBS appropriately. In terms of structural aspect, IBS could be divided into 5 major types (CIDB, 2003; Nasly & Yassin, 2009) they are:

1. Pre-cast Concrete framing, panel and box System
2. Steel framing system
3. Formwork system
4. Prefabricated timber framing system
5. Blockwork system

The blockwork system is the simplest system from of all the system in IBS. Other than the simplicity that blockwork system has, it also affordable for new entrepreneur who want to set up blockwork plant since it only need a small investment with minimum worker and small area of plant. Because of the simplicity, the convenience and the effectiveness that blockwork system has, a qualitative study was conducted to study the manufacturing process and the plant operation of the blockwork system that can be used as important factors to set up blockwork plant.

LITERATURE REVIEW

Bricks are a building material used to make walls, sidewalks, and various other constructions related to masonry construction. Traditionally, the term of bricks refers to a unit consisting of clay, but is now used to denote a rectangular object placed on mortar. Bricks may consist of clay, sand, and limestone, or concrete materials.

Brick and block is the most favourite to be used by people as their walls structure. However, 85% of the new homes built in UK are still constructed using traditional 'brick and block' masonry methods (Lovell and Smith, 2010). Therefore, the UK Government has played their important role in educating and promoting the construction industry players from 'brick and block' masonry methods to modern methods of construction However, bricks has several disadvantages, like need more time to construct, not suitable for more than 2 storeys building because it will increase the dimension of column and beam, and tend to be wasteful in the use of the adhesive material.

So that is why, to eliminate these disadvantages, some innovator tries to make some innovative to replace brickwork. The innovation itself is called blockwork, the use of the blockwork is same as the use of brickwork. But the differences are lies on the size, and the material. For the size, blockwork is bigger than usual brickwork. The dimension of blockwork mostly is 400 x 200 x 100 mm, is bigger than the brick, which is the average dimension is 200 x 100 x 75 mm. And for the material, the brickwork usually using clay, water, and sometimes cement. But for blockwork, the materials are cement, sand, gypsum, and water, it depends on the types of the blockwork.

Blockwork is construction with concrete or cement blocks that are larger than a standard clay or concrete brick. To make them lighter and easier to work with, they have a hollow core that also improves their insulation capacity. They are available in a variety of densities to suit different applications. Their convenience and cost effectiveness have made them a popular alternative to clay bricks although they require an additional finish for reasons of aesthetics and water resistance. They are often used to build internal partition walls and retaining walls (Reardon, 2013).

A block is the same term that also refers to a rectangular building unit and consists of the same material, but is usually larger than a brick. The lightweight brick (also called lightweight block) is made of an expanded clay aggregate. The successful use of the first documented concrete block began in 1837 on Staten Island, New York, where a house was built of concrete blocks constructed by George A. Ward, Esq (Hall, 2009).

However, the use of new concrete blocks was widely used in the early 1900s, when Harmon S. Palmer invented the block-making machine in 1899 and was successfully commercialized in the early 1900s (Hall, 2009). In the mid-1920s, Dr. Johan Axel Eriksson created the AAC (Autoclaved Aerated Concrete) type block and successfully marketed the product under the name 'Ytong' (Berg, 2004). In 1943, Josef Hebel also produced AAC type blocks, and was widely used in Germany when the country was rebuilt after the defeat of the Second World War (CFG Concrete Ltd, 2010).

In addition to the type of AAC, in the 1920s also created a type of block based foam concrete known as CLC block (Cellular Lightweight Concrete). However, this type of block was only studied in about 1950-1960 (Rudnai, 1963) and was only used in building construction in the late 1970s and early 1980s (Simon, 1991). Both types of blocks (AAC and CLC) are one group of blockwork types called lightweight concrete or lightweight bricks.

Blockwork in Malaysia is considered as the one of prefabricated technology, known as Industrialised Building System (IBS). The history of the development of the Blockwork is begin from the development of brickwork. The use of the brickwork system in Malaysia, was begin when Netherlands came to Malacca in 1650s and build the Stadthuys, the first church in Malacca (Arman Ali, 2005). Since then, the use of brickwork became more widely in Malaysia.

In an attempt to accelerate the construction completion time, in this case is the wall construction work, the use of brickwork is replaced by the blockwork. The blockwork system that is used in the construction should be based on the IBS Standard. In Malaysia, the block system consists of lightweight bricks and various other concrete blocks (CIDB, 2003). CMU blocks are used to build column components and load-bearing wall. While lightweight brick, usually used to build walls. There are at least two types of lightweight brick in Malaysia, they are Autoclaved Aerated Concrete (AAC) and Cellulose Lightweight Concrete (CLC).

Blockwork are identical to brick methods but their size adapted from modular coordination guides on buildings (MS1064: section 8 coordinates the size and size of options for brick and block work) (CIDB, 2016). Table 1 and Table 2 show differences in brick and block size (Malaysian Standard, 2009). This is a revolution against conventional building systems based on brick and concrete systems as well as light concrete developed based on time factor and work productivity of construction.

Table 1. Recommended size for bricks in Malaysia

Length (mm)	Height (mm)	Width (mm)
190	90	90
290	90	90

Table 2. Recommended size for blocks in Malaysia

Length (mm)	Height (mm)	Width (mm)
290	190	90
290	190	140
390	190	90
390	190	140
390	190	190

METHODOLOGY

The methodology used in this study relied on a qualitative approach through a series of interviews and observations (Azman et al., 2012b; M. Nawi et al., 2015). The interviewees have been selected selectively by selecting someone who has more in-depth knowledge and has a long experience in this field.

Interview data that have been recorded through the recording device, will be processed into a textual statement that could be used as scientific data (Miller & Crabtree, 1992). A series of prepared questions lists are used to obtain the information needed. This research, also supported by the observation activities in order to get a better understanding about the process of making blockwork.

The questionnaire could be mentioned as follow:

1. Interviewee's background
2. Material that has been used
3. Manufacturing process
4. Production capacity
5. Quality control that conducted in plant
6. The number of worker that have been used
7. The size of plant area
8. Problem that occurred during manufacturing

DATA FINDING

Interview method has been used as the process to collect the data. There is some criteria that should be fulfilled by the interviewee such as it is should be the person who is in the highest management positions and also required to have experience at least 5 years in the field of blockwork manufacturing. Because of the circumstances of time availability, from 6 interviewees that have been contacted, only three from three different blockwork manufacturers agreed and gave a permission to conduct an observation. Data collection process was done by conducting observation to the location of the blockwork manufacturer and conducting interview with duration 45 minutes to 1 hour.

Table 3. Interviewee's Profile

	Position Held	Company	Experience (in year)	Gender	Location
P1	Owner/Technical Engineer	Company A	8	M	Sungai Behrang, Perak
P2	Technical Advisor	Company B	6	M	Port Klang, Selangor
P3	Technical Engineer	Company C	10	M	Pulau Meranti, Selangor

RESULTS AND DISCUSSION

Blockwork in Malaysia has various types including Solid Block, Hollow Block, Lightweight Block, Interlocking CMU, and Interlocking Soil Block. Of three factories observed, two of them, Company A and Company B are manufacturing Interlocking Soil Block. While Company C manufactures CLC (Cellular Lightweight Concrete) Lightweight Block.

Material

For the Interlocking Soil Block, the material are consists of soil, sand, water, and cement. The soil itself comes from areas nearby to the plant. However, there is a requirement that must be fulfilled for the soil that will be used, as presented by participant (P1):

"Soil, it must not be taken randomly, it could not be taken carelessly. It should be tested first, check the stone content of the soil, the content should be or at least 65%"

While for CLC Lightweight Block, the material consists of sand, cement, water, and foaming agent. For material foaming agent itself, the material could only be imported directly from United Kingdom (UK).

Blockwork Characteristics

The dimension of Interlocking Soil Block that manufactured by Company A and Company B have similarities, since both of these factories follow the standard IBS regulations, i.e. with dimensions of 300 x 150 x 100 in mm. The physical form of the Interlocking Block from Company A and Company B could be seen in Figure 1. Because of the main material of the block is soil, the colour of the Interlocking Block itself is following the main material itself which is red (or depends on the soil colour).

The dimension of Lightweight Block that manufactured by Company C has dimensions of 500 x 200 x 100 mm. The physical form of the Lightweight Block could be seen in Figure 2.

(a) (b)

Figure 1. Physical form of Interlocking Soil Block manufacture by; (a) Company A, (b) Company B

Figure 2. Physical form of Lightweight Block manufactured by Company C

Manufacturing Process

Interlocking Soil Blocks are manufactured with special mold where the forming process is done mechanically. There are three types of machines that could be used to, namely manual machine, semi-auto machine, and automatic machine. The use of manual machine, can be seen in Figure 3(a), still require manpower starting from the mixing process, the forming process, until the process of removal of blocks.

For semi-auto engine, could be seen in Figure 3(b), mixing process and block lifting process, still need manpower. But for the forming process is done by machinery. While the automatic machine starting from the mixing process, the forming process, until the process of removing the block from the forming machine, all done automatically by the machine. For this type of automatic machine, the worker only works as a machine supervisor only.

(a) (b)

Figure 3. Type of machine that are used in Company A; (a) manual machine, (b) semi-auto machine

In production process, Company A is using two types of machines, namely manual and semi-auto engine. While Company B is only use semi-auto machines. The process of manufacturing of Interlocking Soil Block in these two factories has no difference. The manufacturing process of Interlocking Soil Block could be described in Figure 4.

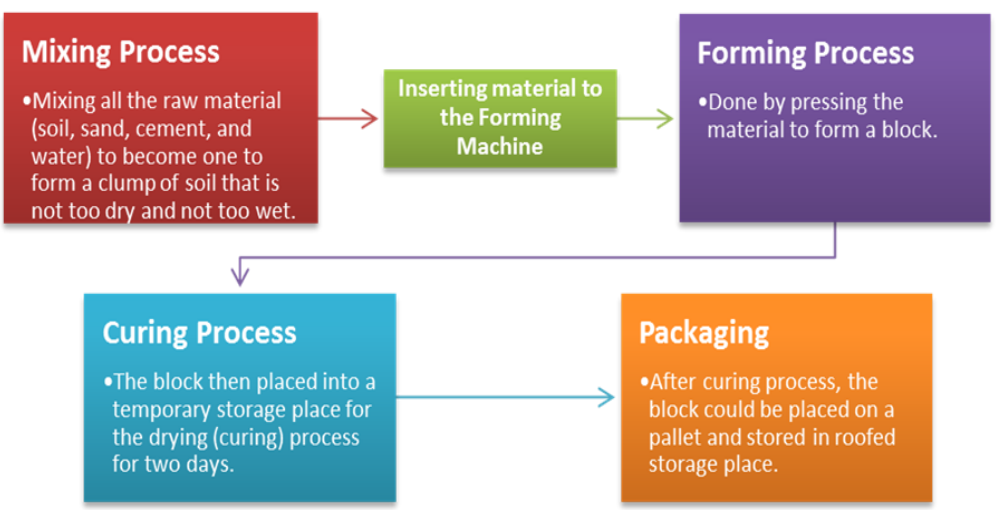

Figure 4. The manufacturing process of Interlocking Soil Block

Lightweight Block manufacturing process in Company C is done by using semi-auto machine, where mixing process, forming process and cutting process are done by machine. But for the process of moving from the forming process to the cutting process still requires human labour. For a better understanding, Figure 5 and Figure 6 will explain the process flow of the Lightweight Block manufacturing easily.

(a)

(b)

(c)

Figure 5. The process of lightweight block manufacturing; starting from the mixing process (a), then continue by pouring it into a mold that already queued (b), and continue to cutting process after the paste hardened (c)

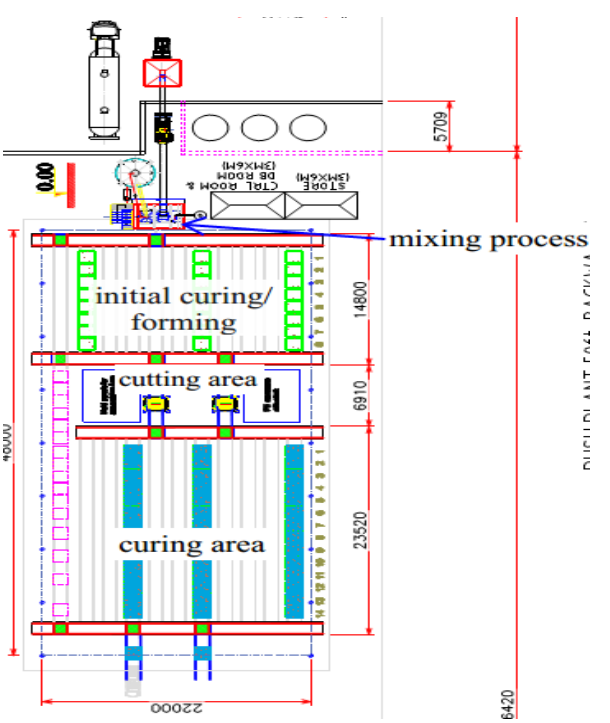

Figure 6. The layout of Company C plant

For the reason why the Company C built the layout of the plant as shown in Figure 5, participant (P3) stated that:

"We plan this layout because it depends on how many mold that we want to have, how many blocks that we want to manufacture in a day, and how many minutes it would takes, so that's why we designed the layout that way"

The manufacturing process of Lightweight Block done by Company C could be described in Figure 7.

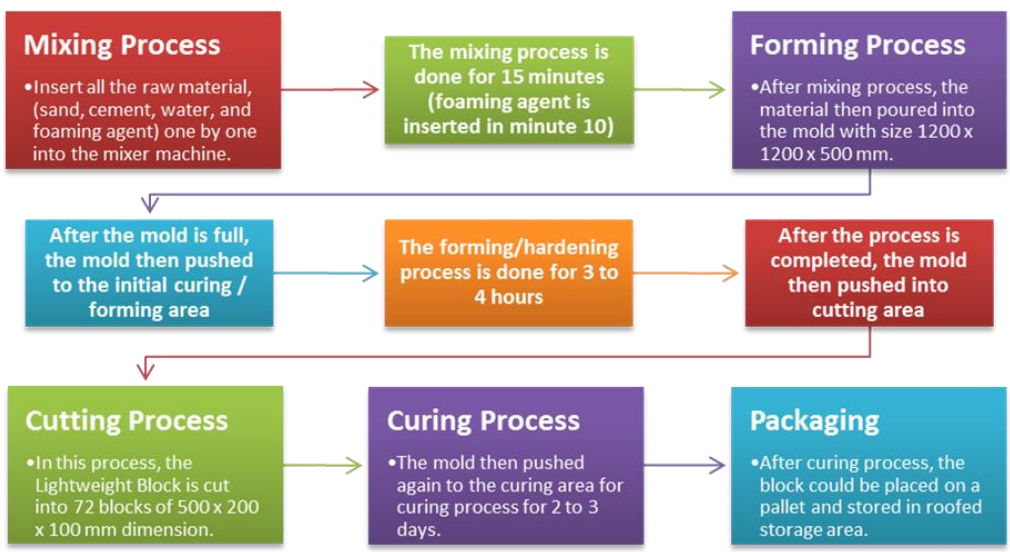

Figure 7. The manufacturing process of Lightweight Block

Quality Control and Strengthness

Controlling the quality of product is an obligation that must be implemented by the manufacturers so that the product that has been produced have the best quality and have no defects. If the manufacturers are found to have a defective product, it affects the manufacturer's reputation and will reduce the consumer's confidence to the manufacturers.

For that reason, the three companies that have been observed, do the process that so-called quality control. Two companies, Company B and Company C, perform quality control based on laboratory tests and the data of the test will be audited by the audit agency of the Malaysia Government, namely SIRIM (Scientific and Industrial Research Institute of Malaysia). While Company A, perform quality control with its own method which is doesn't involved the laboratory test.

The process of the blockwork quality control carried out on Company A is done simply, by watering the Interlocking Soil Block that is ready on the pallet and then wrapped with plastic so that the steam in the block can come out during the curing process. In addition, another simple test is performed by Company A by placing the block into the water to check out for the density possessed by the block (Figure 8). Participant (P1) stated that:

"So, we would like to know the density of these blocks, are they really solid or not. We could place it the block into the water, and we could look, is there any bubbles come out or not. If there is so many bubbles to come out, it means that the blocks are not solid"

Figure 8. Density test of the blocks that have been performed by Company A

The process of the quality control in Company B is performed while the production process is in progress. As the participant (P2) explained that:

"We are doing the quality control process while we are in production line. Worker, will do a measurement check by taking one block from 100 blocks, and he begin to check the height and the size of dimension of the block"

In addition, the quality control process on Company B also involves the audit agency from the Malaysian Government (SIRIM) to check whether the products are made in accordance with predetermined standards or not. As participant (P2) mentioned that:

"And for the strength test, humidity test, and the water absorption test, that all have been done by the SIRIM. Because we are audited by the SIRIM two times a year. They will choose the pallet randomly, and they will take, maybe one block from one pallet for one month or two months, and then, they will take it to their lab, and they will do the test"

The compressive strength of the Interlocking Soil Block that Company B produced as participant (P2) stated is 40 N/mm^2, the evidence could be affirmed in the following statement:

"Minimum (strength), because at the beginning, this interlocking brick was listed in the ministry, so the one who make the guideline and the standard is the consultant of the ministry. So, SIRIM just follow the standard (from the consultant) and do the test for the interlocking brick. So the strength if they are following the euro code, they will be 40 N/mm^2, but in Malaysia, just considered as 10 N/mm^2"

The interesting point in that statement is that 40 N/mm^2 is actually same as compressive strength of concrete (NRMCA, 2003). Because of the similarity with concrete, it show that the Interlocking Soil Block can be use as load-bearing wall construction and can construct two or more storeys buildings with the requirement of the height of the wall is not more than 20 times of the thickness and wall sections without buttresses or cross walls do not exceed 4.5 meter length (Nasly et al., 2009).

At the Company C, the quality control is performed by laboratory test. Blocks that have been produced, delivered to the lab for testing, and on the day of the test, the production process is suspended until the test results are issued. Participant (P3) declared that:

"Today, the plant is not in line, because I had to repair the goods, checking the machinery, and having a test for the block. So later, after doing the test I will review if there any goods that have defects or not"

The results of laboratory test conducted by Company C, will be audited by SIRIM to check whether the blocks that have been manufactured complies with the terms issued by the Government of Malaysia or does not comply with the terms. If complying with the terms, usually the company will be given a Product Certificate License, the example could be seen in Figure 7, indicating that the blocks that have been produced has been approved by the Malaysian Government, in this case represented by SIRIM. The strength of the CLC Block based on laboratory test results obtained at 1.5 - 2.8 N/mm^2.


LESEN PENSIJILAN BARANGAN
Product Certification Licence
AGGREGATE CONCRETE MASONRY UNITS (LIGHTWEIGHT BLOCK)
Please refer to detail in the SCHEDULE

Figure 7. The example Product Certificate License issued by SIRIM

Production Capacity, Area, and Problems

In general, the production capacity of a company is strongly influenced by the wide of the plant location area owned by the company. In addition to the wide of plant area, the number of workers, production methods, and the machinery are used also affect the production capacity of a company's goods. For example, Company A has a production capacity of 3.125 m^3/day which have area of ± 810 m^2 wide and the total number of worker are 4 to 7 people.

Company B has a production capacity of 11.25 m^3/day which have area of ± 8,093 m^2 wide and the total number of worker are 8 to 12 people. Company C has a production capacity of 20-40 m^3/day which have area of ±10,117 m^2 wide and the total number of worker are 10 to 12 people. For simplicity, the comparison could be seen in the Table 4 below:

Table 4. Comparison Table of Company's Capacity Production, Area, and Workers

Point	Company A	Company B	Company C
Capacity Production Per Day	3.125 m^3	11.25 m^3	20-40 m^3
Area	±810 m^2	±8,093 m^2	±10,117 m^2
Workers	4 to 7 people	8 to 12 people	10 to 12 people

The findings from the observation question identified problem that have been faced by the manufacturers who were interviewed. The problems that have been highlighted are described below:

- Material – all interviewees are acknowledging that the quality of material is one of the main problems they may face. The problems such as the quality of sand (P1 & P3), soil (P2), and cement (P3) are very interfering and could affect the quality of the blocks that have been produced.

- Machinery – other than the material, the company may face the machinery problem. This problem could affect the line of production of the blockwork manufacturing, and also affect the capacity production. However, this problem is not a big deal if the company always do maintenance of their machines. For example, in Company A, they always check their machines regularly for every one month.

CONCLUSION

The blockwork system is fully prepared to replace the brickwork system as a wall construction on any building construction across Malaysia. The factors that affecting to that matter are the Malaysian Government's promotional efforts through CIDB (Construction Industry Development Board), production and installation processes are faster than the traditional brickwork system, and have lower prices with greater strength than the brickwork system.

In related to setting up of the blockwork plant, the main factors as found in the study are following: practices in design and build, wide of plant area, skilled worker, and sufficient machinery. With this study, practitioners, manufacturers and the Malaysian Government are expected to participate to expand the use of the blockwork system (which is an IBS component) in Malaysia so that could accelerate the development of building construction throughout Malaysia.

And in addition to speeding up development, with the use of blockwork system (IBS), it also could reduce the number of foreign workers that are used in construction so that could minimize the construction costs. Lastly, a future research should be continued to improve the understanding of the blockwork system for the benefit of construction industry in Malaysia.

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THE MECHANICAL AND PHYSICAL PROPERTIES OF CONCRETE CONTAINING POLYSTYRENE BEADS AS AGGREGATE AND PALM OIL FUEL ASH AS CEMENT REPLACEMENT MATERIAL

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Abstract
One of the disadvantages of normal concrete is the high self-weight of the concrete. Density of the normal concrete is in the range of 2200 kg/m^3 to 2600 kg/ m^3. This heavy self-weight make it as an uneconomical structural material. Advantages of expended polystyrene beads in lightweight concrete is its low in density which can reduce the dead load (self-weight) Improper disposal of the large quantity of palm oil fuel ash which has been produced may contribute to environmental problem in future. In this study, an alternative of using palm oil fuel ash as a cement replacement material is to improve the properties of lightweight concrete. The tests conducted in this study were slump test, compression strength, splitting tensile and water absorption test. These samples were cured under water curing condition for 7, 28 and 56 days before testing. Eight types of mixtures were cast based on percentage (25%, 50%) of polystyrene beads replacement for control samples and (25%, 50%) of polystyrene beads by different ratio 10%, 15%, and 20% replacement of palm oil fuel ash, respectively. Samples with 25% polystyrene beads and 10% palm oil fuel ash obtained the highest compressive strength which is 16.8 MPa, and the splitting tensile strength is 1.57 MPa. The water absorption for samples 25%, 50% polystyrene and 20% palm oil fuel ash is 3.89% and 4.67%, respectively which is lower compared to control samples.

Keywords: *Polystyrene beads; Palm oil fuel ash; Compressive strength, Splitting tensile; Water absorption*

INTRODUCTION

Lightweight concrete has the strength comparable to normal weight concrete, but it is lighter and normally 25% to 35% less in strength. According to Kenneth (2006), lightweight concrete provides flexibility in structural design and major cost savings by providing less dead load and improve the seismic structural response, extends for a longer period, better fire rating, and thinner sections, lower the height of the storey, and the smaller size of a structural members. Polystyrene become a phenomenon in the packaging world. They are light and practical, economic and health is the most significant factors for food packaging. However, the waste generated not balancing work recycling, since polystyrene is a material no degradable, thus becomes a waste polystyrene great environmental concern (Mindess, 2005). The utilization of waste material such as Palm Oil Fuel Ash (POFA), Pulverize Fuel Ash (PFA) and Rice Husk Ash (RHA) has producing a good normal concrete. Recently in Malaysia there are about 200 palm oil mills are operating where by thousand tonnes of ash are produced annually and simply disposed without any commercial return (Awal and Hussin, 1997). Palm Oil Fuel Ash (POFA) is introduced by Abu from Universiti Teknologi Malaysia (UTM) in 1990 (Abdullah et al., 2006). He has discovered that this material is a pozzolanic material. From that moment, POFA has attracted some researchers such as (Awal and Hussin, 1997; Abdullah et al., 2006; Tay., 1990; Kartini., 2001; Sata et al., 2010; Tangchirapat et al.,

2007) for conducting study on utilisation of POFA in concrete. It is expected that pozzolanic reaction will contribute into good quality of concrete (Neville, 1995). Thus, in this study, Palm Oil Fuel Ash (POFA) has been used for producing good lightweight concrete.

MATERIALS AND METHODS

Materials

The materials has been used in this project are cement, palm oil fuel ash, fine aggregate (sand), expanded polystyrene beads and water. The cement used for this study is an Ordinary Portland cement. The cement is stored in airtight steel drum in the Material Laboratory of University Tun Hussein Onn Malaysia (UTHM). Fine aggregate used is the natural sand with sieve in order to remove bigger size of aggregate and impurities. The fine aggregate is stored in the Material Laboratory of University Tun Hussein Onn Malaysia (UTHM).

Palm oil fuel ash (POFA)

Palm oil fuel ash (POFA) is a waste product obtained in the form of ash. In this t study, POFA has collected from a factory processing palm oil Kluang, Johor. The collected POFA were dried in the oven at the temperature of 110ºC ± 5 for 24 hours.

Bulk density for materials

Bulk density for materials is fine aggregate, cement, palm oil fuel ash and polystyrene beads was done calculated by using cylinder metal calibration of the cylinder. All the value of bulk density for each material are as shown in Table 1.

Table 1. Density for materials

Materials	Density (kg/m^3)
Fine Aggregate	1464
Ordinary Portland cement	1268
Palm oil fuel ash	966
Polystyrene beads	13.2

Mixture proportion

Eight different samples of lightweight concrete have been prepared, which is labelled as PB25-0, PB50-0, PB25-10, PB25-15, PB25-20, PB50-10, PB50-15 and PB50-20. These specimens differ from each another by various percentages of the polystyrene beads content and POFA in their mixes. Because the beads are very light in weight and density; the mixes were prepared by volume for sand and weight for cement. The control samples has proportion of 25% , 50% polystyrene is 1: 2.25 : 0.75 and 1: 1.5 : 1.5 which indicates for 1 part of cement, 2.25 part of fine aggregate and 0.75 part of polystyrene, respectively . The ratios of replacements are as shown in Table 2.

Table 2. Mix proportion for the different specimens

Specimen	Polysyrene Content (%)	POFA Content (%)	Cement (kg)	POFA (kg)	Fine Aggregate (kg)	Polystyrene beads (kg)
PB25-0	25	0	20	0	45	0.14
PB50-0	50	0	20	0	30	0.28
PB25-10	25	10	18	1.52	45	0.14
PB25-15	25	15	17	2.29	45	0.14
PB25-20	25	20	16	3.05	45	0.14
PB50-10	50	10	18	1.52	30	0.28
PB50-15	50	15	17	2.29	30	0.28
PB50-20	50	20	16	3.05	30	0.28

TESTING OF FRESH CONCRETE

Workability Test

The workability of concrete is one of the functions of the relative quantity of the different components of the concrete. From this test, slump is deduced by measuring the drop from the top of the slumped fresh concrete. This test was conducted according to the BS EN 196-1.

TESTING OF HARDENED CONCRETE

Compressive Strength

The compressive strength is most important characteristic of hardened concrete and normally for the purposes of the specification. Concrete cube test is the test the most knowledgeable, and is used as a method to measure the strength of the standard pressure for quality control purposes. The concrete cubes were tested according to BS EN 12390-3:2002 for 7, 28 and 56 days of curing.

Splitting tensile

The splitting-tension strength of the specimens was tested at 28 days after casting and conducted in accordance with ASTM standard C496. The test was carried out by using universal testing machine.

Water absorption

Water absorption is an important factor due to the porous structure of the polystyrene lightweight concrete. The water absorption test was conducted by using the samples that have been prepared at age of 28 days according to BS 1881: Part 122.

RESULTS AND DISCUSSIONS

Slump test

The results of slump test are as presented in Fig.1. Based on the result, this test has fulfilled its expected outcome. The true and shear slump were occurred in the range from 65 to 55 mm and these explained that there was a good bonding of polystyrene beads in concrete. It is noticeable after adding expanded polystyrene beads to concrete at 25% replacements and it can be seen that slump values of the fresh concrete the value of slump test was good slump occurred so the slump condition with an acceptable range of settlement related to lightweight concrete The value of slump was decreased from 65 to 55 mm due to high porosity of POFA particles which absorb some water, and thus reduce the free water content needed for workability this test turned out to be when adding polystyrene beads, it produces a concrete mixture has good scalability and can be used in the lightweight polystyrene concrete. When the percentage of polystyrene increases from 25% to 50%, the mix becomes high in consistency that results in high slump value. After POFA by different percentage 10% to 20% was added, the slump value may have great impact on the workability of concrete. On the other hand, good slump may mean that there is excessive fineness content in one or more of the cement. Apart from that, when the POFA percentage increases from 10% to 20%, the slump tends to decrease and obtained optimum result by 15% of POFA replacement and this is due to greater bonding contributes from POFA. Incorporation of POFA as partial cement replacement in the mix has increase workability of the mix since this ash has a big surface (Neville, 1995; Koh et al., 2004).

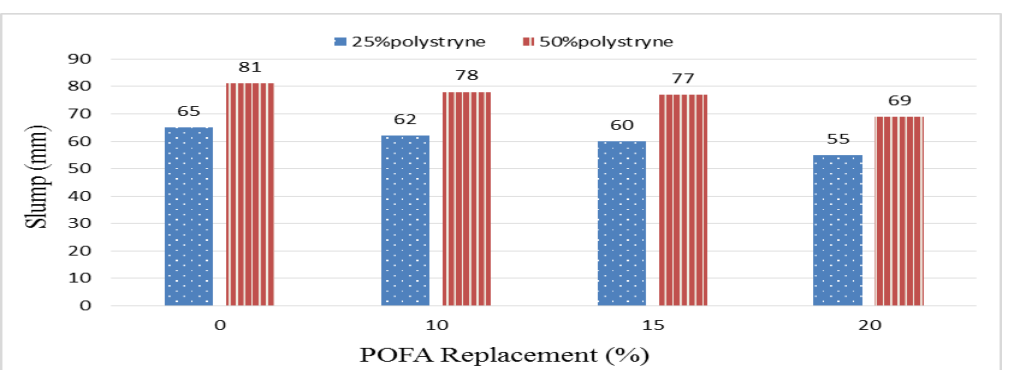

Figure 1. Slump test results for 25% and 50 % polystyrene bead

Compressive strength of Lightweight concrete by using 25% and 50% percentage of polystyrene beads

The results of compressive strength of lightweight concrete by using 25% percentage of polystyrene beads with various percentage of POFA are as shown in Fig. 2. In this figure it shows that sample with replace of POFA by 10% has the highest compressive strength compared to other samples. The maximum value concrete strength for 7 days, 28 days and 56 days compressive strength for all the replace samples decrease by increasing the replacement of palm oil fuel ash the contribution of palm oil fuel ash through role of pozzolanic reaction in producing secondary C-S-H gel (Boon et al., 2004) which increases the ability of concrete to sustain load. The increase in strength of polystyrene lightweight concrete with POFA could

be attributed to the improvement in the bond between the hydrated cement matrix and the fine aggregate. The results of compressive strength of lightweight concrete by using 50% percentage of polystyrene beads with various percentage of palm oil fuel ash are as shown in Fig. 3. This figure illustrated that the highest concrete strength is obtained by concrete with 10% of POFA replacement and this is due to greater bonding contributes from POFA. This figure also revealed that concrete with obtained higher in compressive strength compared to sample without POFA. The ultimate strength for concrete containing 10% POFA is 12.2MPa at 56 days and concrete containing 10 % to 20% of POFA start to show pozzolanic reaction with a significant increase in strength for 28 and 56 days.

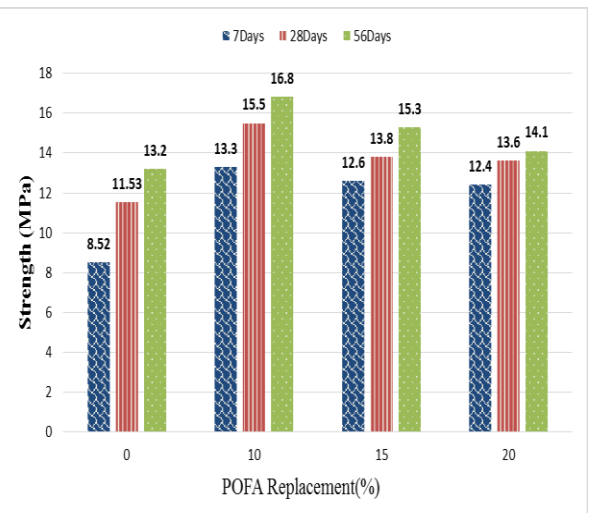

Figure 2. Compressive strength with 25% EPS and various POFA

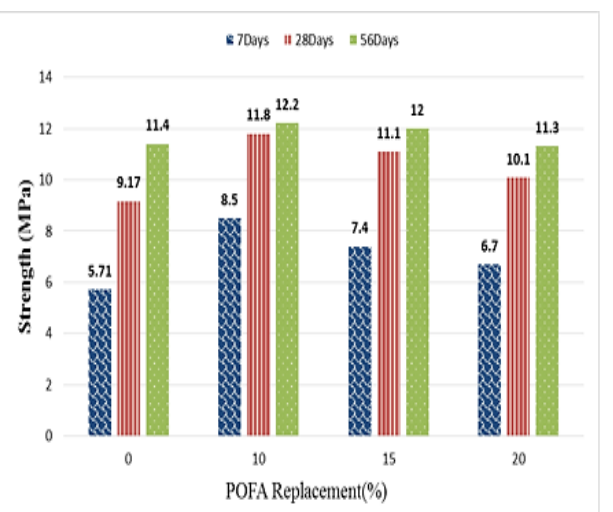

Figure 3. Compressive strength with 50% EPS and various POFA

Splitting tensile tests

The results of splitting tensile tests are presented in Fig.4. This figure shows that the splitting tensile strength is increased when the percentage of POFA is increased compared to control sample. Incorporation of POFA in lightweight polystyrene concrete has enhanced the splitting tensile strength as compared with the control sample. For samples with POFA replacement, it can be seen that 25% polystyrene and 10% POFA obtained highest splitting tensile strength compared to concrete with 15% and 20% POFA. The similar pattern of result is obtained for concrete with 50% polystyrene. The replacement of 25% polystyrene content and POFA 10% attained 1.57 MPa compared to control sample without POFA which is1.35 MPa. Referring to Fig.4 for various percentages of polystyrene beads and POFA, it can be seen that higher value of splitting strength. This is due to that concrete sample with (C-S-H) and calcium alumina hydrate which serves to cover up cracks and pores also increase the strength of concrete (Kroehong et al., 2011).

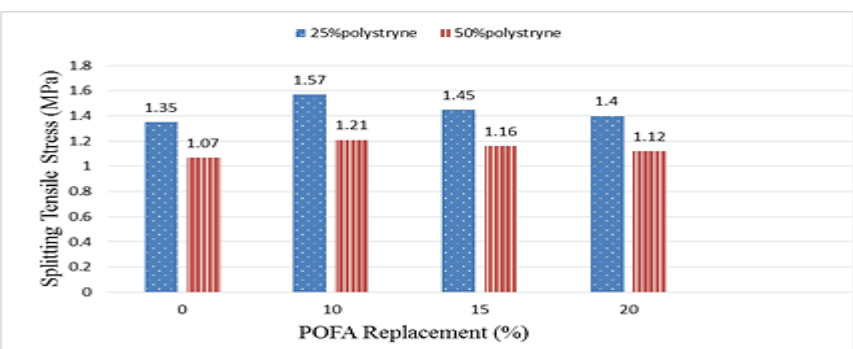

Figure 4. Splitting tensile strength corresponding to polystyrene and pofa percentage at 28 days

Water absorption

Water absorption test was conducted by using the samples which have been prepared at the age of 28 days. Fig. 5 shows the result of water absorption for various percentages of POFA and polystyrene. This figure demonstrates that concrete with POFA acquire lower in water absorption compared to concrete without POFA. That is because the higher percentage of polystyrene applied in each sample, the beads distributed in the samples will be increased the voids (Alexander and Mindess, 2005). The pozzolanic reaction was occurred between the silica or lime (from POFA) and calcium hydroxide during the hydration of OPC. Then, it was produced calcium silica hydrate suitable which lead into lower water absorption in concrete. The POFA particles were more porous and possessed a greater specific surface than that of cement and will cause densification of the pore structure due to the pozzolanic reactions. Also, incorporation of POFA reduces the pore sizes in lightweight concrete due to pore refinement.

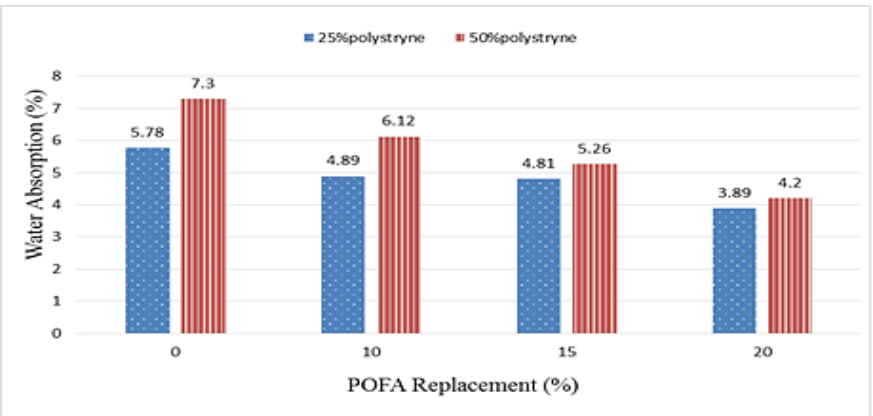

Figure 5. Water absorption variation percentage of POFA and polystyrene at 28 days

CONCLUSIONS

From this study, it can be concluded that:

- The replacement of polystyrene beads and POFA in the lightweight concrete mix has increases the workability of fresh concrete.
- 25% and 50% replacement of polystyrene beads and 10% replacement of POFA has the acceptable value of strength with the result of 16.8MPa and 12.2 MPa, respectively. The strength of lightweight concrete decreases as the polystyrene beads content is increases.
- POFA in polystyrene lightweight concrete exhibits the high result of splitting tensile strength of concrete which is 1.57 MPa due to the inclusion of 10% POFA as partial cement replacement. This POFA promotes better hydration process and pozzolanic reaction that lead to the generation of a larger amount of C-S-H gel. This is in turn, enhances the gel that occupies the existing voids in concrete making it denser and stronger.
- Lower water absorption has been obtained with the POFA in the concrete mixes compared to concrete mixes without POFA. This is due to the pozzolanic reaction which caused the pore size structure of the mix to change from coarser pores to finer pores which reduce the entering water into concrete.
- For future works, it is recommended that concrete mixes should not exceed 25% to 50% of the polystyrene substitution in the lightweight concrete mixture. It is to ensure the good performance of lightweight concrete containing polystyrene beads.

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THE APPLICATION OF MICRO UAV IN CONSTRUCTION PROJECT

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Abstract
In every outstanding construction project, there is definitely have an effective construction management. Construction management allows a construction project to be implemented according to plan. Every construction project must have a progress development works that is usually created by the site engineer. Documenting the progress of works is one of the requirements in construction management. In a progress report it is necessarily have a visual image as an evidence. The conventional method used for photographing on the construction site is by using common digital camera which is has few setback comparing to Micro Unmanned Aerial Vehicles (UAV). Besides, site engineer always have a current issues involving limitation of monitoring on high reach point and entire view of the construction site. The purpose of this paper is to provide a concise review of Micro UAV technology in monitoring the progress on construction site through visualization approach. The aims of this study are to replace the conventional method of photographing on construction site using Micro UAV which can portray the whole view of the building, especially on high reach point and allows to produce better images, videos and 3D model and also facilitating site engineer to monitor works in progress. The Micro UAV was flown around the building construction according to the Ground Control Points (GCPs) to capture images and record videos. The images taken from Micro UAV have been processed generate 3D model and were analysed to visualize the building construction as well as monitoring the construction progress work and provides immediate reliable data for project estimation. It has been proven that by using Micro UAV, a better images and videos can give a better overview of the construction site and monitor any defects on high reach point building structures. Not to be forgotten, with Micro UAV the construction site progress is more efficiently tracked and kept on the schedule.

Keywords: *project management, site monitoring, micro UAV technology*

INTRODUCTION

A civil engineering construction project comprises of various field such as construction and operation of buildings, bridges, and construction of infrastructure. Construction is a high-risk activity, which must be managed from procurement, through the design process and to the end of the construction stage. The management of construction project requires knowledge of modern management as well as an understanding of the project's specification and construction process.

This study was focused solely on construction management. One of the needs in construction management during on site construction stage is to provide a documentation consists a report of progress work. Project progress monitoring and control is one of the most important tasks of construction project management. According to Section 4.21-b of the International Federation of Consulting Engineer (FIDIC) book series (Red Book), Conditions of Contract for Construction (FIDIC 2006), photographs are among the requirements for the progress report that a contractor should regularly daily, weekly, and monthly send to the owner (Jadidi et al., 2015). The conventional method of photographing on the construction site is by using common digital camera which is lack in viewing the construction site mainly

on the building structures. Unsolved issue that site engineer or site supervisor are facing now is the limitation of monitoring on high reach point and entire of the construction site. Although conventional method for monitoring work must be an efficient way through our current time, it can be questionable on time effect, cost impact, efficiency in co-ordination, legal documentation for court issues, safety and health perspective, and business perspective (Zainuddin, 2015).

The aim of this study is to explore the Micro UAV technology in monitoring construction progress on construction site through visualisation approach. Micro UAV can be remote controlled aircraft such as flown by a pilot at a ground control station or can fly autonomously based on pre-programmed flight plans or more complex dynamic automation systems. This operation relies mostly on human involvement. The very first application of this device was within military missions and now they have their permanent position in the military arsenal (Nisser & Westin, 2006).

The aim of this study is to replace the conventional photographing method to Micro UAV in monitoring construction site. Another objective is to propose the application of Micro UAV in facilitating site engineer and site supervisor to monitor work in progress on the construction site. This study can visualize overall view of the construction building that give many advantages to the site engineer and site supervisor in monitoring work progress and the preparation of progress document. This study will facilitate and expedite the project management in construction project.

LITERATURE REVIEW

The construction industry is the largest industry in the world which is an economic investment and its relationship with economic development is well posited. In order to ensure this contribution is continuous, every construction project must be managed properly based on the construction management guidelines. There are several phases in construction management, which are preliminary stage, feasibility studies design stage, contract stage, construction stage and completion and handover stage.

Construction Management

Construction management focuses on time, cost and quality of the project. Time, cost and quality as three critical objectives of construction management, are not independent, but intricately related (Rezaian, 2011). Time, cost and quality of a construction project are influenced by the decisions made by project manager (Golparvar et al., 2009). Most construction projects employ scheduling methods to monitor and control the progress of work and develop progress reports (Zubair et al., 2006).

One of the method to monitoring construction progress is using Micro UAV which is also used in forest and agricultural applications, photogrammetry for 3D modelling and many more domains (Saari et al., 2011). This is mainly due to the low cost, fast speed, high manoeuvrability, and high safety of Micro UAV systems for collecting images.

Unmanned Aerial Vehicles (UAV)

Drones are Unmanned Aerial Vehicles (UAV) that operate under remote or autonomous control without a pilot on-board. This operation relies mostly on human involvement. However, a quad copter is a particular type of helicopter design employing 4 rotors. In short, a drone and a Micro UAV mean the same thing when in used today. Basically, they both mean unmanned aerial aircraft. All UAVs are drones, but drones that cannot fly are not UAV. Drone and UAV are effectively synonymous in common usage.

The type of drone that is being used in this research is Phantom 3 Advance is manufactured by the DJI Company. This drone categorized as Micro UAV Watts et al. (2012), as it can fly less than one hour and weight less than 5kg. It was built with its own smart camera with 720p/30fps HD video support, and can be used by iOS or Android application control. The 3-axis stabilization gimbal helps to hold perfectly stable no matter how the Micro UAV fly and makes it easier for hovering in long exposure photos. It is also completed with safety features such as unparalleled safety for first-time pilots and fly only within a given distance and altitude. The autopilot mode enables the drone to auto take-off, automatically mark the home point when GPS available and automatically return to take off point when the battery is running low. By using DJI Phantom 3 Advance App, it enables to remotely control the camera on the smart phone.

3D Modelling

Photogrammetry in definition is to obtain reliable measurements and 3D models by means of photograph. The classical close-range photogrammetric consists of camera calibration and orientation, image point measurements, 3D point cloud generation and texturing (Remondino et al., 2005). Photogrammetric data processing is needed to generate a geo-referenced 3D point cloud from the unordered, overlapping and airborne image collection of the surface. Existing Structure from Motion (SfM) algorithms automatically extracted features in the images (Siebert & Teizer, 2014). A lot of researches have been conducted the UAV photogrammetry for 3D mapping and modelling. UAV can be used as a platform for collecting images offers large-scale terrain modelling that are effective, efficient and accurate (Hudzietz and Saripalli, 2011).

An algorithm for 3D reconstruction of city buildings from multiple images using a single UAV have been designed and implemented by several researchers (Jizhou et al., 2004). The UAV has the ability to derive both geometry and texture information from UAV images. Lately, UAV has been exploited for capturing images of a building of interest from multiple different perspectives, which resulted in a 3D model of the building (Wefelscheid et al., 2011).

METHODOLOGY

This study consisted of four phases which were planning and preparation, data collection, image processing, video and image analysis. Initially, the preparation and the planning were carried out in order to handle the Micro UAV perfectly without crash. The determination of flight route at early phase also can ease the process of data collection. The Ground Control Points (GCPs) should be determined at least for four points around the construction building

and these coordinates were recorded by using the navigator. During the process of collecting data, the UAV's pilot must be able to communicate with the observers in order to keep a safe distance which is about two to four meters from the building structure. The second process was collecting data consist of recording videos and capturing images of Sri Manjung Specialist Centre building in Perak by using Micro UAV. There are two methods to capture images of the building which are by snap shooting photos from the video recorded or capture images directly from the Micro UAV's camera. There are several features provided that can help to ease the process of data collection such as Interval Feature, Point of Interest (POI) and Waypoint Navigation Feature.

The third process was image processing which is selecting an adequate images for further use. Then, these images were processed by using Agisoft Photoscan Professional Software it can be converted to 3D model. Generating 3D model by PhotoScan involve several steps including the process of estimating camera positions and pictures to build point cloud as shown in Figure 1. The last step was analyzing the images and videos and showed the construction progress, identified any defects on the building and viewed the whole building in 3D model.

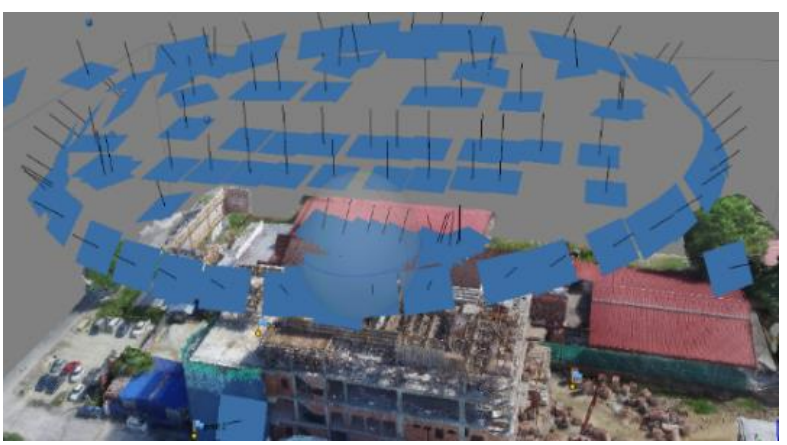


Figure 1. Estimating camera positions to build point cloud

RESULTS AND DISCUSSIONS

The results from the images and videos can be used to meet the needs of this study which were visualized the whole construction progress of the building as well as generating 3D model. To build a complete 3D model for the whole construction building, a total of 480 images were collected; 123 images from the first fly, 153 images from the second fly and 204 images on the third fly.

Generation of 3D Model

Daily or weekly UAV flights can help site engineer or site supervisor to capture the progress across an entire job site. The 3D model produced have shown the full view of the construction building. Figure 2shows the 3D model of the first fly session and the third fly session respectively. Site engineer or site supervisor can use this 3D model during the progress presentation that can give the comprehensive view of the construction progress.

(a) (b)

Figure 2. First and third fly 3D model. (a) First fly and (b) Second fly.

Image and Video Analysis

The images captured from top and side view of the building can be used to visualize the building construction as well as the construction progress work. The images from the top and side of the construction can be used as a progress photography in progress document. Figure 3 till Figure 6 shows the images from top and side view of the construction building.

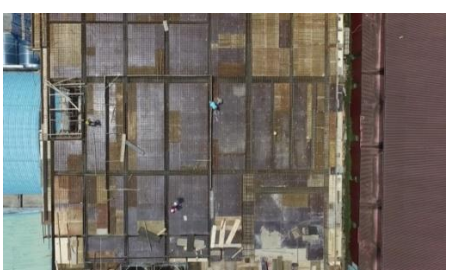


Figure 3. Image from top of the building during first fly on 23rd september 2016

Figure 4. Image from top of the building during third fly on 25th november 2016

Figure 5. Images from first side of the building

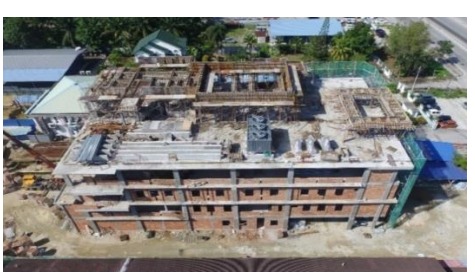
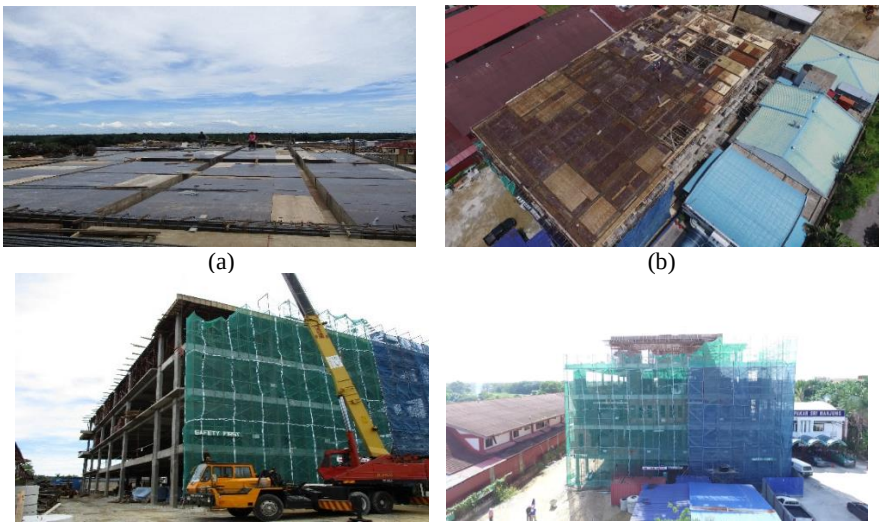


Figure 6. Images from second side of the building

Figure 7 shows the difference between image captured by using common digital camera and Micro UAV. From the observations, the images captured by using common digital camera has limitation in angles compared to the image from Micro UAV where with Micro UAV, users can have a better angle view.



(a) (b)

(c) (d)

Figure 7. The difference between images captured by common digital camera and captured by UAV (fRONT View). (a) Image from common digital camera and (b) Image from UAV

The videos and images from close range to the building can be used by the site engineer or site supervisor to monitor the building structure in contemplation of detecting any issues. As shown in Figure 8, site engineer can detect the honeycomb defects on the concrete of the column structure. Site engineer or site supervisor also can monitor the labor activities using the Micro UAV to ensure the work is done according to the construction specification.

(b) (b)

Figure 8. (a) Honeycomb defects, (b) concrete casting work in progress

Ultimately the purpose of construction monitoring is to provide information on the most updated state of ongoing operations so that the practitioners can control potential or actual poor performances or deviations. A foreseeable future is that construction progress can be analyzed and project schedule can be revised automatically through observation from the visual images and video.

CONCLUSIONS

In this study, the application of Micro UAV has proven its capability to become an alternative measure in monitoring progress of construction building and also can replace the conventional method in capturing images on construction site. This study can visualize overall view of the construction building that give many advantages to the site engineer and site supervisor in monitoring work progress and for documentation. This study will facilitate and expedite the project management in construction project.

It is recommended to improve on future exploration of the UAV's pilot where the person must be efficiently flying the UAV to ensure a better perspective and quality of images and videos. Besides, operating the UAV stably will saving much time and usage of UAV's battery lifetime. Recorded videos and captured images should covers a clearer view and not from a close range of the building to generate a good 3D model. Using the images that captured directly from the UAV's camera are also recommended to generate a better quality of 3D model. Flying the UAV at close range on the construction site for inspection purpose only and the application of safety accessories such as guard propeller will help to secure the UAV from any accidents.

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PROPERTIES IMPACT FROM WASTEWATER TREATMENT SLUDGE UTILIZED INTO FIRED CLAY BRICKS

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Abstract
Disposal of wastewater treatment plant sludge waste into landfills has become a serious threat to the global environment due to the massive generated every year. Nevertheless, a relevant alternative solution could be developed as recently rapid growing interest in the usage of sludge material to the manufacturing of fired clay brick has been observed. The utilization of these waste materials in fired clay bricks usually has positive effects on the properties such as lightweight bricks with improved shrinkage, porosity, and strength. The primary objective of this study is to focus on the properties impact of the wastewater treatment sludge incorporated into fired clay bricks. The characteristics of raw materials obtained by using the X-ray Fluorescence Spectrometer showed that the chemical composition of the raw materials of clay soil and wastewater treatment sludge was high with silicon dioxide and with the same chemical composition Type A and Type B of wastewater treatment sludge are suitable to replace clay soil as raw materials. The recommended percentage of wastewater treatment sludge incorporation was up to 20% with better physical and mechanical properties. The physical and mechanical properties were tested according to BS 3921:1985. The results showed that the utilization of Type A and Type B into brick manufacturing complied with BS 3921:1985 standard requirements. Therefore, wastewater treatment sludge can be material for brick production with appropriate mix and design and as an alternative environmentally friendly disposal method.

Keywords: *Wastewater sludge; Sewage sludge; Bricks; Compressive strength; Shrinkage; Density; Initial rate of absorption*.

INTRODUCTION

In Malaysia, about four million cubic meter of domestic sludge being produced every year. By the year 2015, Malaysia is expected to produce about 5.7 million cubic meters of domestic sludge and to be increased to about 6.6 million cubic meters by the year 2020 (Kabbashi et al., 2011). Disposal of sludge is a serious global environmental issue. In general, wastewater sludge was disposed by landfill or being burned in incinerators after pre-treatments such as dewatering, drying and firing. The disposal of this sludge will become a critical issue due to public concern and limited availability of land thus alternative disposal method is essential, as landfill is not an ideal disposal method anymore for this waste. Moreover, according to Environmental Quality (Scheduled Wastes) Regulations 2005, referring to Scheduled Waste 204 stated that sludge that contains one or several metals including Chromium, Copper, Nickel, Zinc, Lead, Cadmium, Aluminium, Tin, Vanadium and Beryllium has to be disposed as scheduled waste. Direct disposal of hazardous heavy metal sludge may cause serious effect in soil and underground water pollution.

Therefore, for the sake of assuring that the environment will not polluted by heavy metal sludge after landfill, incorporation of wastewater treatment plant sludge into fired clay brick could be one of the environmental friendly methods to dispose and reused the sludge. The main raw material for bricks is clay, clayey soils, soft slate and shale, which usually obtained from open pits with the attendance of disruption of drainage, vegetation and wildlife habitat (Hendry and Khalaf, 2001). Clay brick has been regarded as a superior building material in various applications. In view on the importance of energy saving and conservation of resources, efficient recycling of industrial waste is now a global concern. The feasibility of clay allows its combination with different types of wastes without significant modification of the production process and final product usage (Kadir and Mohajerani, 2012). Moreover, this replacement will reduce the content of clay soil in the fired clay brick that eventually reduce the manufacturing cost (Kadir et al., 2015; Kadir and Mohajerani, 2015). Nevertheless, the properties of bricks such as compressive strength, durability, leaching characteristics and indoor air quality must harmonize with the growing demands of the quality (Arsenovic et al., 2012). Utilization of sludge as an addition in construction and building material including building bricks, lightweight artificial aggregates, and cement-like materials is a win-win strategy because it will not only converts the wastes into useful materials but it also alleviates the disposal problems (Weng et al., 2003)

There were some researchers have successfully attempts the utilization of wastewater treatment sludge into fired clay bricks (Yadav et al., 2014; Garcia et al., 2012; Quesada et al., 2011; Ingunza et al., 2013; Wang et al., 2012; Liew et al., 2004). Due to the promising potential, this study was focused on investigating the optimum percentage of wastewater treatment plant sludge replacement in the manufacturing of fired clay brick due to physical and mechanical properties condition.

MATERIALS AND METHODS

Physical and Mechanical Properties

Two type of wastewater treatment plant sludge namely Type A and B was collected at wastewater treatment plant in Johor, Malaysia. The sludge was collected in a semisolid condition. Clay soil was collected at the local brick company. Both of the materials, clay soil and wastewater treatment sludge was kept properly in the box separately and been storage in the laboratory before being used. Both wastewater treatment plant sludge and clay soil were dried in the oven for 24 hours. Chemical composition and concentration has been detected by using XRF procedure. Wastewater treatment plant sludge and clay soil were crushed with suitable tools and weighed with suitable ratio. Pellet shape was made before being tested with X- ray fluorescence (XRF) machine by using model S4-Pioneer Bruker-AXS (Germany). In the brick moulding process, different percentage of wastewater treatment plant sludge were mixed with clay soil using mixer machine (1%, 5%, 10%, 15% and 20%). Water content is an important factor affecting the quality of the brick. Therefore, the compaction test was conducted to determine the optimum moisture content (OMC). By using the OMC results, the mixtures with various proportions of wastewater treatment plant sludge and clay soil were prepared to manufacture the brick. The mixtures were put into brick moulds (length 215mm, width 102, and thickness 75mm). Brick control mixtures were also made as reference. After 24hours in room temperature followed by another 24hours at 105˚C oven-dry period, the moulded mixtures were fired into a furnace at temperature of 1050˚C. As a requirement by

BS 3921:1985 standard, the brick properties including firing shrinkage, water absorption, density, compressive strength and the initial rate of absorption were determined.

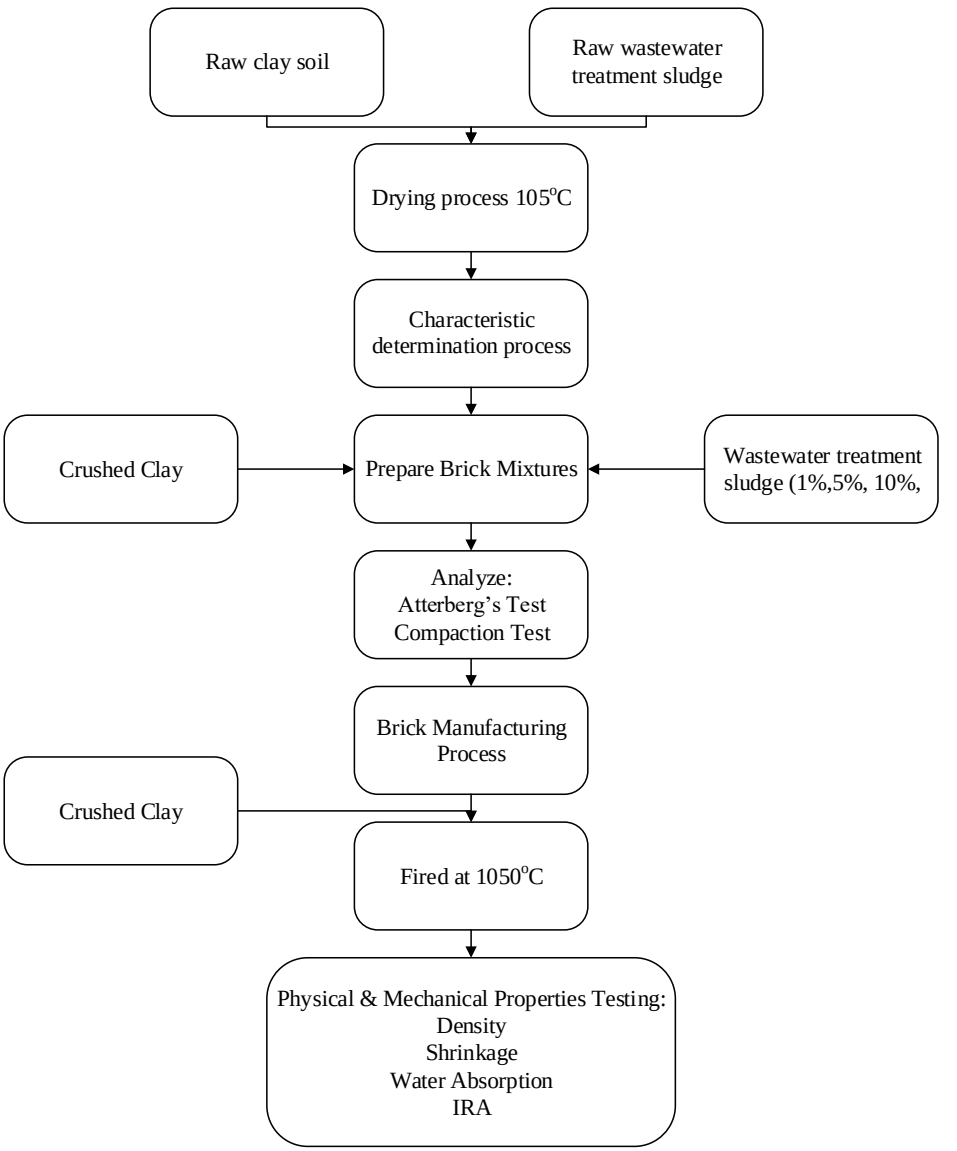

Figure 1. Flowchart for Experimental Procedure

RESULTS AND DISCUSSION

Physical and Mechanical Properties Result

X-ray Fluorescence (XRF)

Based on Table 1, it shows the element of chemical composition of raw materials for this study. The results indicated the higher percentage of chemical composition for Type A and

Type B sludge is Silicon Dioxide (SiO2) which is 14.30% and 16.30% respectively. Next, the lowest percentage of chemical composition for Type A sludge, the lowest percentage is Barium Oxide (BaO2), Strontium Oxide (SrO) and Carbon (C) which is 0.10%. For Type B sludge is Barium Oxide (BaO2) which is 0.25% and followed by Carbon (C) which 0.10% respectively. Meanwhile, for clay soil the result shows that the higher percentage is Silicon Dioxide (SiO2) which is 49.30% and followed by Aluminium Sulphide (Al2SO3) which is 18.4%. Besides that, Titanium Oxide (TiO2) shows the lowest percentage which is 0.9% then followed by Magnesium Oxide (MgO) and Carbon (C) which is 0.8% and 0.1% respectively.

Table 1. Chemical composition in raw clay soil, Type A and Type B wastewater treatment plant sludge

No	Chemical	Formula	Composition (%)		
			Type A	Type B	Clay
	Orig-g			8	
	Added-g			2	
1	Calcium oxide	CaO	6.55	2.40	ND
2	Potassium oxide	K_2O	0.71	1.07	3.09
3	Titanium dioxide	TiO_2	0.50	0.52	0.94
4	Ferric oxide	Fe_2O_3	9.85	9.35	6.78
5	Zinc Oxide	ZnO	0.39	0.37	ND
6	Carbon	C	0.10	0.10	0.10
7	Silicon dioxide	SiO_2	14.30	16.30	49.30
8	Magnesium oxide	MgO	1.15	0.85	0.80
9	Aluminum oxide	Al_2O_3	6.66	4.79	18.40
10	Chlorine	Cl	0.34	0.12	ND
11	Phosporus Pentoxide	P_2O_5	5.58	6.68	ND
12	Sodium oxide	Na_2O	0.23	ND	ND
13	Barium Oxide	BaO	0.14	0.25	ND
14	Strontium Oxide	SrO	0.12	ND	ND
15	Sulfur Trioxide	SO_3	9.20	4.61	ND

Table 2 shows the concentration of heavy metals between clay soil and both wastewater treatment sludge. The results indicates that the highest concentration of heavy metal in Type A sludge is Zinc (Zn) which is 1126 ppm followed by Barium (Br) which is 716 ppm. Next, the lowest concentration is Scandium (Sc) and Uranium (U) which is 6 and 4 ppm respectively. Other than that, the result presented that the highest concentration of heavy metal in Type B sludge is Barium (Br) with value 1223ppm followed by Zinc (Zn) which is 983 ppm. The lowest concentration is Gallium (Ga), Niobium (Nb) and Uranium (U) which is 6 ppm respectively. Next, the result obtained shows the highest concentration of clay soil is Barium (Br) which is 338 ppm and the lowest concentration is Cobalt (Co) and Uranium (U) which is 6ppm respectively.

Table 2. Heavy metals concentration in raw clay soil, Type A and Type B wastewater treatment plant sludge

No	Element	Formula	Concentration (ppm)		
			Type A	Type B	Clay
	Orig-g			9	
	Added-g			3	
1	Titanium dioxide	TiO_2	5700	5800	10200
2	Scandium	Sc	6	7	19
3	Ferric oxide	Fe_2O_3	43800	40700	60200
4	Manganese Oxide	MnO	600	500	400
5	Vanadium	V	41	44	150
6	Chromium	Cr	130	126	100
7	Cobalt	Co	8	8	6
8	Nickel	Ni	28	30	15
9	Copper	Cu	97	122	23
10	Zinc	Zn	1126	983	33
11	Gallium	Ga	8	6	17
12	Arsenic	As	12	9	8
13	Rubidium	Rb	22	29	97
14	Strontium	Sr	189	58	32
15	Yttrium	Y	18	25	37
16	Zirconium	Zr	80	80	337
17	Niobium	Nb	9	6	16
18	Molybdenum	Mo	5	8	ND
19	Tin	Sn	23	26	ND
20	Cesium	Cs	9	7	7
21	Barium	Ba	716	1223	338
22	Lanthanum	La	29	43	43
23	Cerium	Ce	90	77	95
24	Lead	Pb	55	52	30
25	Thorium	Th	26	14	23
26	Uranium	U	4	6	6

Atterberg Limit and Compaction Test

Atterberg limits and compaction test were conducted for determining the soil before proceeding with the manufacturing process of brick. Atterberg limit was carried out according to Methods of Test for Soils or Civil Engineering Purposes; Part 2: Classification Tests (BS 1377-2:1990). The properties of soil tested summarized in Table 3 below:

Table 3. Classification of soil

Soil Physical Properties	Test Results
Liquid Limit (%)	29.50
Plastic Limit (%)	21.86
Plasticity Index (%)	7.64
Degree of Plasticity	Medium Plastic
Type of Soil	Silty clay or clayey silt

Meanwhile, standard proctor test was conducted to determine the optimal moisture content (OMC) at which a given soil type will become denser and achieve its maximum dry density. The standard AASHTO compaction test was used in this study. The obtained results for Control Brick (0% sludge), Type A sludge Brick (1%, 5%, 10% and 20%) and Type B sludge Brick (1%, 5%, 10%, and 20%) were recorded and plotted. Maximum dry density was obtained from the peak point of the compaction curve (also known as optimum moisture content). OMC was summarized in Table 4. From the result show the increasing of sludge proportion increased OMC result.

Table 4. Percentage of moisture content

Mixture (%)	Moisture Content (%)	
	Type A	Type B
Control brick	17.0	17.0
1% brick	17.8	17.4
5% brick	18.2	18.1
10% brick	20.4	20.3
20% brick	21.9	21.0

Mechanical properties

Density

Generally, value of bulk density for bricks that was made with clay is 1500 kg/m3 to 2000kg/m3. The result of fired clay brick with different percentage of wastewater treatment sludge was illustrated in Figure 2 and tabulated in Table 5. As shown, the pattern of the graph was illustrated decreasing due to the increasing percentage of wastewater treatment sludge. This is related with the result of water absorption. The finding of Benlalla et al., (2015) stated bricks that absorb more water will exhibits a large pore size and the density of bricks will becomes smaller. From the result for Type A and Type B sludge show that Wastewater treatment plant sludge Brick (20%) obtained the lowest density at 1226.55kg/m3 and 1247.24kg/m3 respectively compare to Wastewater treatment plant sludge Brick (1%) at

1530.46kg/m3 and 1562.52kg/m3. From this study, lightweight of brick were produced. However, the control brick obtained the highest value of density but still complying with the standard. Nevertheless, lightweight brick provide advantages in terms of transportation cost because it is lighter than normal brick (Kadir et al., 2011).

Table 5. Density of the manufactured bricks

Mixture Identification (%)	Density (kg/m^3)	
	Type A	Type B
Control	1610.64	1610.64
1	1562.52	1530.46
5	1544.56	1448.86
10	1436.45	1414.75
20	1247.24	1226.55

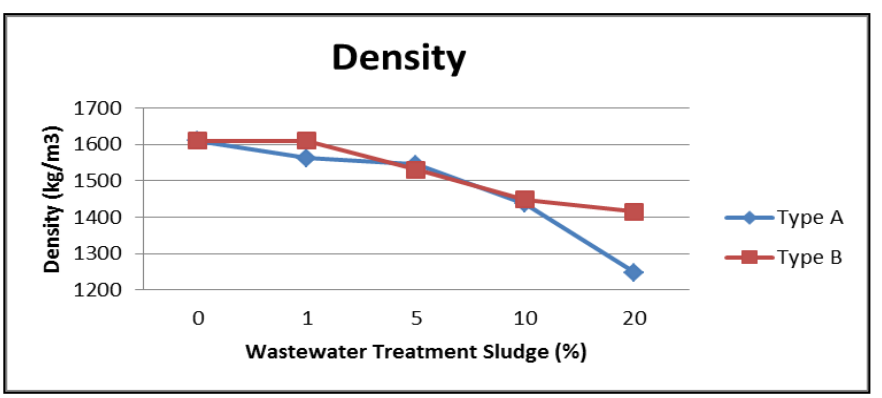

Figure 2. Density of brick manufacturing

Shrinkage

In this part, shrinkage of brick was determined after firing with temperature up to 1050oC. Firing shrinkage was defined as the contracting of mixture hardened due to the loss of capillary water (Koratich, 2009). Shrinkage was measured by determining the length before and after firing occurred. The good quality of bricks exhibits shrinkage is below 8%. From this study shows that increasing sludge proportions will increase the shrinkage of bricks. Based on Table 6, shrinkage of control brick is lower than the brick with additional sludge with 1.63%. Additional sludge 1% of the sludge of Type A and Type B, the percentage of shrinkage increase with value 3.57% and 3.07% respectively. Meanwhile, for 20% percentage of sludge, the shrinkage is increasing up to 6.61% and 6.18%. Nevertheless, all manufactured bricks do not exceed 8% of shrinkage. Based on Weng et al., (2003), normally, a quality of brick can be further assured according to the degree of firing shrinkage. The result of shrinkage of bricks was summarized in Table 6 and demonstrated on Figure 3 below.

Table 6. Shrinkage of Fired Clay Brick

Mixture Identification (%)	Shrinkage (%)	
	Type A	Type B
Control	1.63	1.63
1	3.57	3.07
5	4.88	4.86
10	5.76	5.76
20	6.61	6.18

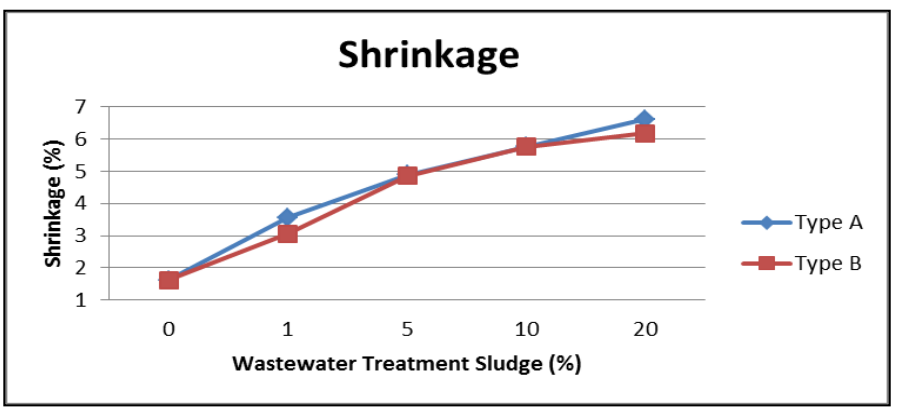

Figure 3. Shrinkage of brick manufacturing

Water Absorption

Amount of water that a brick can absorb was measured by using water absorption test. Water absorption test was conducted after firing process and it is a key factor of bricks durability. The less water infiltrates into brick, the more durability of the brick and resistance to the natural environment are expected. Weight of the brick before and after firing was measured in order to get the percentage of water absorption value. Based on Table 7, it shows that the percentage water absorption of control brick is lower compared to brick with additional sludge with 8.22%. According to John et al., (2001), the percentage of water absorption is increased almost linearly with the increase in wastewater treatment sludge content. The same trend was demonstrated in this study, with up to 20% of sludge, it shows the increasing amount of water absorption which 21.19% is for Type A wastewater treatment plant sludge and 19.69% for Type B wastewater treatment plant sludge.

Table 7. Water Absorption of Fired Clay Brick

Mixture Identification (%)	Water Absorption (%)	
	Type A	Type B
Control	8.22	8.22
1	14.95	8.71
5	15.35	16.97
10	15.68	18.83
20	21.19	19.69

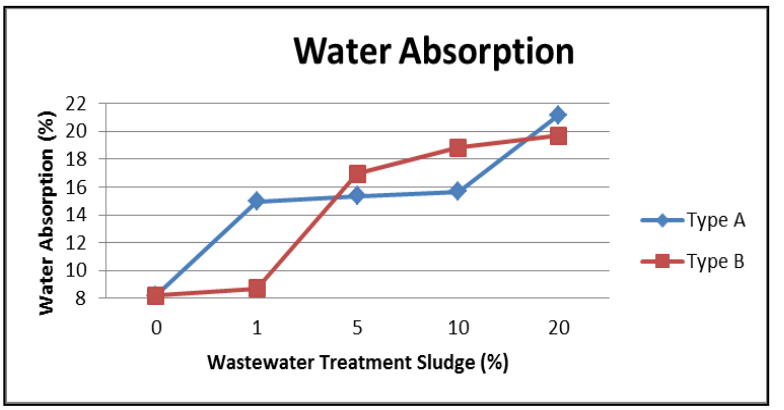

Figure 4. Water Absorption of brick manufacturing

Initial Rate of Absorption (IRA)

The initial rate of absorption (IRA) was measured in kg/m2.min and Table 8 and Figure 5 showed the result of IRA from two types of sludge's that have been incorporated into fired clay brick. Based on the results, it was recorded that the control brick has the lowest value of IRA compare to other percentages of sludge. For Type A sludge, it also shown that the increasing value is due to the increasing percentage of sludge. For 1% and 5% of sludge, it indicates that the value of IRA is 5.15 kg/m2.min and 6.21 kg/m2.min respectively. As for Type B sludge, it shows that increasing value of IRA which is 5.53 kg/m2.min. Next, for 5% and 10% of Type B sludge with value 9.33 kg/m2.min and 9.76 kg/m2.min respectively. At 20% of sludge, Type B sludge indicates IRA value is 12.60 kg/m2.min higher that Type A sludge which is 10.98 kg/m2.min. Based on IRA result, it can be concluded that the increasing percentage of sludge will increase the value of IRA. An unacceptable high value of IRA can lead to volume changes that would result in cracking of the brick structural (Kadir et al, 2009).

Table 8. Initial Rate of Absorption of Fired Clay Brick

Mixture Identification (%)	Initial Rate of Absorption (IRA) (kg/m^2.min)	
	Type A	Type B
Control	4.36	4.36
1	5.15	5.53
5	6.21	9.33
10	7.14	9.76
20	10.98	12.60

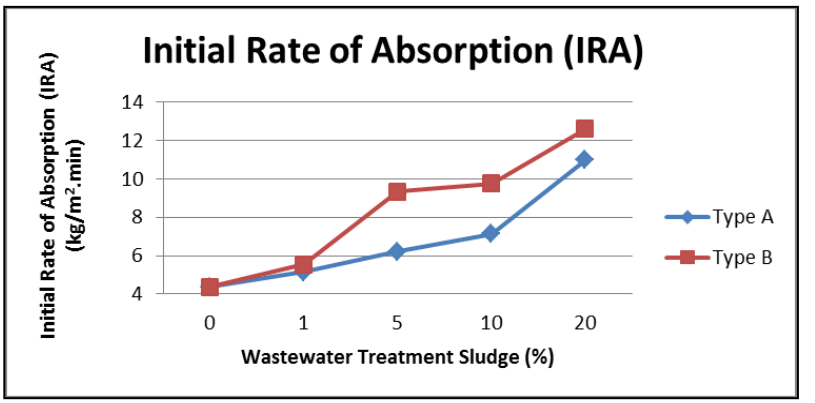

Figure 5. Initial Rate of Absorption of brick manufacturing

Compressive Strength

The compressive strength is the most important test for assuring the engineering quality of building material (Lin and Weng, 2001). In this study, strength of brick was determined by using Universal Testing Machine (UTM) for every percentage of sludge that has been incorporated into fired clay brick. Table 9 and Figure 6 shows the value of compressive strength at different percentage of brick. The result is indicates the strength of brick with different percentage of sludge after firing process. The highest value of compressive strength was control brick with 27.1MPa. In this study, the value of compressive strength highly related with the amount of sludge. The increase of sludge proportion will decreased the compressive strength of bricks. As for maximum value of sludge proportion which is 20% for both sludge, it shows the lowest value of compressive strength which is 2.6MPa for Type A and 2.1Mpa for Type B. Increasing percentage of sludge has decreased the strength of the brick but the strength of brick is still complying with minimum standard of compressive strength which is less than 5MPa except for 20% of sludge utilized.

Table 9. Compressive Strength of Fired Clay Brick

Mixture Identification (%)	Compressive Strength (MPa)	
	Type A	Type B
Control	27.1	27.1
1	23.0	22.3
5	15.0	11.3
10	9.3	6.8
20	2.6	2.1

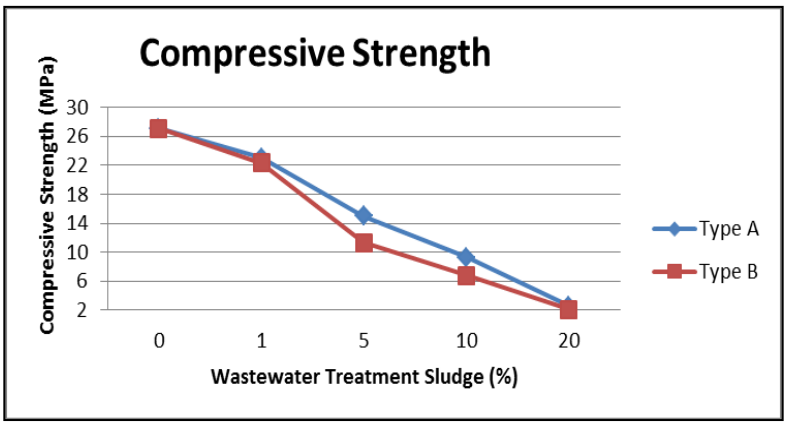

Figure 6. Compressive Strength of brick manufacturing

CONCLUSION

As a conclusion, all the characteristic, percentages of sludge, physical and mechanical properties incorporated with wastewater treatment sludge waste (Type A and Type B) were determined. The characteristic that was found by XRF shows the chemical composition of the raw material of clay soil and wastewater treatment sludge was high with silicon dioxide (SiO2). Therefore, the same characteristic of wastewater treatment sludge is adequate to replace clay soil as a raw material. From the result obtained shows density value for control is 1610.64 kg/m3 and with additional 20% of Type A sludge incorporated into fired clay brick, the value decreased to 1247.24 kg/m3. As for Type B sludge, the value of density decreased to 1226.55 kg/m3 with 20% of sludge. The shrinkage value of Type A sludge brick was increased from 1.63% (control brick) to 3.57% (for 1% of sludge), 4.88% (for 5% of sludge), 5.76 (for 10% of sludge) and 6.61% (20% sludge) of wastewater treatment sludge content respectively. Next, for Type B sludge, shrinkage value also shows the same pattern with Type A sludge. It increased from 1.63 % for control brick to 3.07%, 4.86%, 5.76% and 6.18% for 1%, 5%, 10%, and 20% of wastewater treatment sludge content respectively. The density and shrinkage for all brick were satisfied with average mass (1500kg/m3) and complied with the standard and shrinkage which is below 8%. In addition, water absorption values of Type A and Type B were increased in the range 14.95% to 21.19% and 8.71% to 19.69%. The initial rate of absorption (IRA) results is 4.36 kg/m2/min for control brick and increased to 12.60 kg/m2.min for 20% of Type B sludge brick and 10.98 kg/m2.min for Type A sludge brick respectively. The compressive strength of brick was reduced from 27.1MPa (control brick) to 2.6MPa for Type A sludge brick and 2.1 MPa for 20% of Type B sludge brick respectively. As a conclusion, the result found that the brick with 5% Type A sludge produce a good condition of brick due to its physical and mechanical properties that have been tested and complied with the standard. The different percentage has shown the different result obtained. It could happen due to a relation between the suitable proportions of soil and wastewater sludge that has been incorporated. The mixture of clay soil and wastewater treatment sludge can be mix properly and balance accordingly to suitability on the bond. Nevertheless, all the wastewater treatment sludge brick comply with the British Standard. It can be concluded that wastewater treatment is suitable as one of an alternative to replace clay soil in brick manufacturing while providing an appropriate waste disposal method.

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GOOD GOVERNANCE IN NATIONAL SOLID WASTE MANAGEMENT POLICY (NSWMP) IMPLEMENTATION: A CASE STUDY OF MALAYSIA

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Abstract
The National Solid Waste Management Policy (NSWMP) was introduced in 2007 under the Act 672. The execution of NSWMP involves stakeholders from various government agencies and a collaboration with the private sectors. Despite the initiatives taken by the stakeholders, the objectives of NSWMP failed to materialise. One of the major constraints is weak governance among stakeholders with regards to the NSWMP implementation. This paper will explore the good governance practices implemented by the stakeholders. Identifying the current good governance practices implemented by the stakeholders is crucial as it will serve as a guideline to improve good governance practice in the future. An exploratory research approach is applied in this study through in-depth interviews with several government agencies and concessionaires involved in the NSWMP implementation. A total of six respondents took part in this study. The findings of this study show that there are several good governance practices implemented in policy promotion, participation of stakeholders, and capacity enhancement programme for the staff. This study also proposed some points on good governance practices in the context of policy promotion and staff development. A paradigm shift by the stakeholders is imperative so as to enhance the good governance practice in NSWMP implementation towards an efficient solid waste management in Malaysia.

Keywords: *Waste management; government practices; stakeholders*

INTRODUCTION

For the past several decades, the culture of consumerism in Malaysian society is quite disturbing. The amount of solid waste generated in Malaysia is increasing drastically every year (Abas, M. A., & Wee, S. T. (2014). Negligence in solid waste management will cause a negative impact to the environment, quality of life, and economics development (Bernstein, J. (2004). This critical issue is confronted by many developing countries including Malaysia (Manaf, et al., (2009). Therefore, the Malaysian government has introduced the national solid waste management policy (NSWMP) in 2007 as the main guideline for solid waste management. The goal of this policy is: i) to build a solid waste management system which is holistic, cost-effective, socially acceptable and sustainable, and ii) to implement solid waste management based on the hierarchy of solid waste which emphasises on waste reduction through the concept of 3rs (reduce, reuse, and recycling). Currently, the implementation of NSWMP is still ineffective. The solid waste management facilities were unhygienic, exposing the workers to the risk of diseases and affecting their quality of life (Periathamby et al., 2009). In addition, the recycling rate among Malaysians is still low at 15% compared to the neighbouring countries such as Singapore and Thailand (Abas & Wee, 2014).

Several empirical studies showed that various factors contributed to the failure of solid waste policy implementation, namely insufficient of a fund, lack of expertise, lack of technology and facilities, ineffective monitoring and law enforcement system (Lau,2004; Nicolli et al., 2012; Abas & Wee, 2014). However, the main factor leading to the failure of the solid waste policy implementation is poor governance (Lingard et al., 2000; Paudel, 2009;

Konteh, 2009). Poor governance leads to various problems in solid waste management at every level (Wee & Abas, 2015). Good governance approach is expected to bridge the gaps of governance in solid waste management policy implementation at all levels of stakeholders. Hence, the objective of this study is to explore the governance practice in the implementation of NSWMP. Good governance practice at all levels of stakeholders is crucial so that the NSWMP implementation is comprehensive and holistic.

LITERATURE REVIEW: NSWMP GOVERNANCE

The Malaysian government has restructured the governance of NSWMP through the division of power, known as decentralisation. As a result, the policy implementation involved various stakeholders (Nadzri and Larsen, 2010). An efficient governance is one of the most important factors contributed to an effective implementation of NSWMP. Elbakidze et al., (2010) suggested that a study related to governance often discussed the process of how an institution is managed, controlled, and obligated when implementing the agreed objectives. Governance includes aspects such as settings of staff at all levels of management duties in a transparent and prudent way in terms of delivering results, corporate culture, and strategy to deal with various stakeholders (Andrews, 2008).

There are four major stakeholders involved in the governance of NSWMP, namely the Ministry of Urban Wellbeing, Housing and Local Government, Department of National Solid Waste Management (DNSWM), Solid Waste Corporation (SWCorp) and the concession company. Each institution has different roles and job scope with regard to the NSWMP implementation. Nevertheless, each stakeholder is dependent upon each other. For example, DNSWM is responsible for the coordination of NSWMP; thus, DNSWM will require cooperation from Solid Waste Corporation (SWCorp) and the concessionaire to ensure the NSWMP is implemented according to the policy objectives. Similarly, SWCorp and the concessionaires need DNSWM to establish a clear strategic plan and guideline for NSWMP implementation. The objectives of NSWMP are significant and fit with the solid waste management current operation

METHODOLOGY

A qualitative approach is applied in this study because its rules are simple and easy to comply and the study can be explored with more in-depth. A qualitative approach is often used to interpret and understand a complex reality of a given situation through personal perspective and experience, especially when researching on sensitive topics. A qualitative approach is also useful in improving the understanding of the investigated issues which cannot be explained explicitly. In addition, a qualitative approach is frequently used to identify specific factors that influence a phenomenon of interest (Mayoux, 2013). Accordingly, the purposive sampling was adopted to select respondents of this study for in-depth interviews.

In-depth Interview

In-depth interviews are used to collect data and information from respondents in the Department In-depth interviews are used to collect data and information from the respondents of DNSWM, SWCorp, and the concession company (Alam Flora Sdn. Bhd.). Semi-structured interviews were conducted to enable researchers to explore more closely on the issues

discussed during interviews (Suanders et al., 2009; Flick, 2015). The questions asked in the interview are related to good governance practices implemented by the stakeholders during the policy implementation.

Sampling

Purposive sampling was applied to select respondents for the interview session. This type of sampling is a convenient method to gather data more quickly and effectively in exploratory studies. The sampling in this study was selected based on knowledge and experience of the selected individuals representing the population. Therefore, only respondents that met the criteria fixed by the researcher were selected for the study. The main criterion for selecting the respondents is their knowledge and experience with NSWMP implementation in Malaysia. A total of six respondents were interviewed in this study (Table 1).

Table 1. Number of Respondent Selected

Stakeholders	Number of Respondents
Department of National Solid Waste Management (DNSWM)	1
Solid Waste Corporation (SWCorp)	4
Concession Company (Alam Flora Sdn Bhd)	1

Data Analysis

In qualitative methods, primary data is collected from interview sessions with the respondents. Therefore, data gathered from the respondents are recorded using a voice recorder and documented through transcription. Once the voice data are transcribed, they were analysed using content analysis method based on categories as well as themes and sub-themes. The determination of themes and sub-themes are tailored according to the needs of data with reference to the objectives (Suanders et al., (2009). Content analysis is used to analyse good governance practices employed by the stakeholders in NSWMP implementation. The themes are identified based on the literature reviewed and theoretical framework of this study. These data are categorised into specific themes and sub-themes and they are used in accordance with their purpose, which is to explain the phenomenon in detail.

RESULT AND DISCUSSION

The practice of good governance in NSWMP implementation is crucial. Therefore, exploring the good governance practice in the NSWMP implementation is the basis for gaining a deeper understanding of the system's strengths and weaknesses. The findings of this study are extremely important and useful for future suggestion or addition with regards to the good governance policy. This study discovered that there are three main good governance practices implemented by the stakeholders, namely the policy promotion, various

stakeholders' participation in the decision-making process, and staff capacity enhancement programme for NSWMP implementation.

Promotion of NSWMP

Policy promotion is one of the important components introduced in the policy implementation. Promotional activities for the policy should be conducted before and after the policy execution, so as to give more exposure and create awareness on the importance of the policy to all stakeholders. There are several studies on the importance of policy promotion by previous researchers (Yusof and BHATTASALI, 2008; Villarreal, 2010). The literature reviewed also showed that there are a variety of methods used to promote effective policies such as through the media, physical promotion, and verbal promotion (Cave and Curtis, 1999; Issing, 2005).

The result of this study has revealed that the NSWMP promotion was mostly done by the DNSWM through its official website and other social networks such as Facebook. Other stakeholders, namely SWCorp and the concessionaires are not involved in promoting NSWMP. However, this kind of promotion is not good enough because it is limited to the internet user only. The information about NSWMP was also being promoted verbally through meetings, workshops, and conferences. The majority of respondents highlighted that physical promotion of NSWMP is very limited, especially at SWCorp and the concession company. In fact, physical promotion of the policy is imperative to enhance the staff' awareness on the policy's objectives (Issing, 2005). Physical promotion of NSWMP was only conducted during sharing session with DNSWM.

This study revealed that NSWMP was promoted through various mediums so as to ensure that the policy is recognised by all level of stakeholders. The promotion of this policy to various type of stakeholders shows that the government is really open in what they are doing and they strive towards a better governance of NSWMP. However, the effort to promote NSWMP was conducted exclusively by DNSWM. Other stakeholders believed that matters related to NSWMP is under the sole responsibility of DNSWM. Most of the respondents commented that they are mainly receiving instruction from DNSWM. Therefore, this study suggested that several aspects of the NSWMP promotion need to be improved. For example, more physical promotion by the executing agencies is highly recommended, namely the Solid Waste Corporation and Alam Flora Sdn Bhd. The staff from the executing agencies should be exposed more to the NSWMP policy. Additionally, constant discussions between the executing agencies and DNSWM on the issues related to NSWMP is very crucial to build mutual understanding.

Stakeholder's Participation

Stakeholder's participation is a critical element in policy transparency. In fact, stakeholders' participation is one of the significant indicators of a good governance practice. A number of international organisations such as the United Nations, the European Union and the World Bank emphasise on the importance of stakeholder's participation so as to ensure a successful policy implementation. Previous studies have discussed on factors affecting the stakeholder's participation in policy implementation (Matland, 1995). A study by Read

showed that stakeholders' participation in the policy implementation is important in order to increase their knowledge and awareness of the policy (Read, 1999).

This current study found that the stakeholders' participation in NSWMP may occur in two platforms, namely the Regional Implementation Committee (RIC) and Service Level Committee (SLC). The RIC was set up in each state to provide a platform for the stakeholders to express their opinions and suggestions for improving the quality of services. In addition, the purpose of this committee is to resolve any issues or problems related to the operations at the state level. The membership committee for RIC consisted of a representative of the State Secretary, a representative of the local authority, and a representative from the concession company. This session was chaired by the director of the SWCorp.

The SLC was established for the stakeholder's governance at the federal level. The meeting of SLC was chaired by the Director General of DNSWM. In a year, a total of four meetings were held at the DNSWM office and SWCorp was responsible for providing information and reporting on the collection operation and public cleansing services, and proposing an improvement to the quality of services. It is also the SLC role to address any unresolved issues in the RIC meeting. A majority of the respondents pointed out that stakeholders' participation in the policy clarification also occurred in meetings conducted by DNSWM and SWCorp. However, the stakeholders' participation in meetings is determined by the issues discussed.

The finding of this study showed that there are plenty of platforms provided to encourage the stakeholders' participation. However, the practice of stakeholder's participation was often found with SWCorp, whereby the participation of stakeholders with DNSWM is rather limited. In fact, DNSWM is the main actor in regard to NSMWP implementation and coordination. Hence, stakeholders' participation programme should be encouraged and conducted more frequent to ensure the issue related to this policy is unambiguous and addressed comprehensively. Moreover, stakeholders will become more acquaint with the policy context if they get the information direct from DNSWM.

Capacity Building

Staffing is one of the crucial components in policy implementation. Several past studies focused on staff's capacity (Brown and Squire, 2007; Halász and Michel, 2011; Galavan, 2015). Many researchers agreed that the key factor to a successful policy implementation is related to staff's capacity. The finding of this study disclosed that the capacity improvement programmes for staff were conducted through training, workshops, seminars, sharing of knowledge, and by encouraging the staff to continue their studies. However, each stakeholder has its own approach to increasing the capacity of their staff according to their responsibilities and job scope.

The staff of DNSWM were given freedom to participate in any training and workshop. Staff attendance in the training conducted by the department is not compulsory. The management of SWCorp conducted training and workshop regularly to enhance its staff's competency. The majority of respondents from SWCorp pointed out that most of the staff development programmes are controlled by the organisation headquarters, whilst training conducted by the branches were very limited. Moreover, the training and workshop conducted at the branch of SWCorp were wide-ranging and not specific to the staff's roles. The

concession company also ran their own training programmes to increase their staff capacity which focused on solid waste services and public cleansing. It is understandable because the concessionaire must maintain the company's good reputation and their service quality in order to secure a position in the solid waste management services sector.

Knowledge sharing is one of the good governance practices in staff development and enrichment. It is a good practice for the staff to increase their confidence and competency. The study also revealed that every stakeholder practices knowledge sharing in its organisation. Knowledge sharing sessions at DNSWM were conducted by the executive and interested staff. However, knowledge sharing sessions or programmes in SWCorp were practised only at its headquarters and the sessions were often presented by its executives. Conversely, there was no knowledge sharing session conducted at SWCorp branch, namely the SWCorp KL. Meanwhile, Alam Flora Sdn Bhd also advocates knowledge sharing. In the knowledge sharing sessions, staffs were often inspired by the board of directors and executives committee.

These findings indicated that the training programmes increased staff's ability to implement solid waste policy, specifically, based on the role and scope of work of the stakeholders involved. DNSWM instigated training to improve their staff capacity to produce a more comprehensive strategy with regards to NSWMP. In contrast, SWCorp conducted training to increase their staff's capacity so as to ensure the NSWMP policy is implemented effectively in the field. The concessionaires are responsible for improving the ability of their staff in order to provide solid waste management services, guided by the goal of DPSPN. The practice of enhancing the ability of staff should be sustained and intensified to ensure the DPSPN objectives are achieved. Similarly, all stakeholders practice knowledge sharing; however, most of the knowledge sharing conducted were presented by their staff. For a more interactive knowledge sharing sessions, exchange of knowledge among stakeholders would be excellent. The involvement and participation of stakeholders in knowledge sharing session could improve their understanding and communication skills.

CONCLUSION

The governance of National Solid Waste Management Policy (NSWMP) involved many stakeholders who have different roles and responsibilities. However, the objective of every stakeholder is the same, which is to accomplish an effective solid waste management. Therefore, the problems and issues that arise in the implementation of NSWMP should be resolved through a good governance approach. This study has revealed that there are good governance practices implemented by stakeholders in NSWMP implementation such as policy promotion, participation of stakeholders, and capacity enhancement program for the staff. However, these good governance practices still have much room for improvement. Therefore, every stakeholder needs to be proactive to improve their good governance practices in the NSWMP implementation. Further study on the good governance constraint in NSWMP implementation is highly recommended so as to explore the issues of poor governance in a broader perspective. Likewise, the study of good governance framework in NSWMP

implementation is also crucial as a guideline to stakeholders to improve their good governance practice.

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INVESTIGATION OF RISING DAMP AND SALT ATTACK PROBLEMS OF HERITAGE BUILDINGS

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Abstract
Conservation is a new issue in Malaysia as compared to other countries. Conservation is a more challenging task which requires a deep understanding of the structure of the buildings and the problems of the buildings. A proper dilapidation is a must before conservation work takes action to ensure that appropriate action is being taken. Salt contamination and rising dampness, which are the interrelated problem, are the most common problem among the rest due to the geographic location of Penang Island as it surrounded by sea water. Moreover, salt contamination and rising dampness are also considered as the most challenging problem. In this paper, five inheritance buildings that have salt contamination and dampness problem are chosen as the case study. Dilapidation survey is done and salt contamination sample collected from the case studies is sent to laboratory for X-Ray Fluorescence (XRF) test to determine the salt content of the sample. The finding of this study can be used for reference before the conservation works take place and it could improve the effectiveness and outcome of the outcome of the building from the conservation works.

Keywords: *Conservation; rising dampness; water penetration; salt attack*

INTRODUCTION

In Penang, we have a lot of heritage buildings or buildings inherited from the past generations. Since the reorganisation by the UNESCO World Heritage in year 2008, conservation issue is highly concerned. However, building conservation practice is relatively new in Malaysia compared to some other countries. As such, the practice of conservation work in Penang is considered challenging. The practice of conservation or conserving normally contains two activities, to care and safeguard from being destroyed without careful planning. Furthermore, a well conserved heritage will boost up the tourism in the local (Ahmad, 2004). Conservation works doesn't mean only to the architectural works or aesthetic value but the safety and health to the occupants or users in the building. While conservation, dilapidation survey is a must before any conservation works applied. This is due to it is important to understand the extent and nature of the building defects on the building. A precise and appropriate remedial and repairing works only can be carried out when the cause of the defects is known. There are many types of defects occurred in inheritance buildings such as dampness, salt crystallization, termite attack and other defects. However, rising dampness and salt contamination are the most common defects can be found in the buildings. This is due to the installation of Damp Proof Course (DPC) is not common during the construction work in nineteenth century (Brian, 2005). Generally, rising damp is caused by capillary action (or suction) drawing water from the ground through the network of pores in a permeable masonry material. Capillary suction become stronger as the pore size gets smaller, if the pore size is fine enough damp may rise many meters in a wall, until the upward suction is balanced by the downward pull of gravity (Burkinshaw and Parrett, 2004). This research is aiming to identify the extent and nature of salt contamination and rising damp problems in selected inheritance buildings in Penang. Moreover, this paper will be analysing the type of salt and possible cause

of salt contamination occurred in the inheritance buildings based on the laboratory results. Thus, appropriate treatment and remedial action will be proposed based on the possible cause of defects occurred in the building.

REVIEW OF RELATED LITERATURES

Types of building defects

It is very natural that building has defects especially for those aged buildings. This is due to no building is maintenance free especially the building has been through ages. Defects can also be the result of improper construction, poor workmanship; building design is not accordance with the usage, lack of proper building practice, lack of or incorrect maintenance and other factors. Apart from the above stated factors, there are several factors contributed to building defects includes external factor, biological agent and building material itself. External factors such as air, sunlight, moisture, gaseous contamination, soil and so on. Biological agencies contributed are fungi, bacteria, termite, insect and other agencies. Some building material composition such as calcium chloride is one of the factors contributed to the defects especially salt crystallisation (Pourzeynali and Jooei, 2013).

Bird damage

The damages that bird fouling causes to historic buildings can be extensive as been shown in Figure 1. Apart from the obvious unsightliness, the main problem is the acids released from their excrement. Studies have shown that the corrosive effects of the bird droppings can continue for a long time once the building fabric has been contaminated, even the fouling is removed or being washed away. The droppings from nesting materials can severely deteriorate the quality of virtually any roof. As time passes by, the acid contained in bird droppings will eat away the tar-based roofing materials and thus leading to leaks in asphalt roofs.

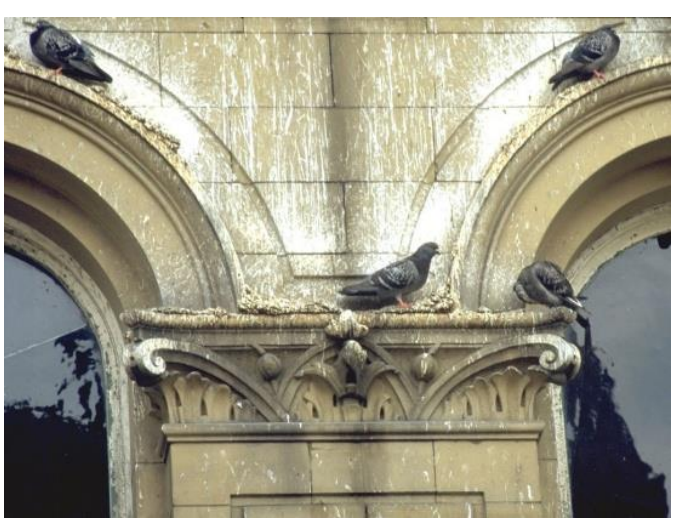

Figure 1. Bird damage on historical building

For those buildings especially historical building which is constructed of limestone or calciferous sandstone are most susceptible to the effects of the acids released from the bird excrements. The excrement from birds or any organisms is majority acidic nature (David, 2008). The method to reduce the building damage is to identify the location of the bird problems, treat and clean the affected area if any fouling found. Deterrents can be installed in order to avoid the bird from fouling in the same place. Another alternatives is, installing anti-perching devices such as anti-perching wire on the roof or the places where bird most likely to be fouling on.

Insect damage

Timber has been used widely in the past. It can be found in most of the elements in a building including floors, walls, windows, doors and roofs. Thus, many of the historic buildings are facing insect damage included termite damage. However, insecticides are not the wisest choice to kill the insect from damaging the building. This is due to insecticides might be killing the insect natural predator – spider at the same time. Figure 2 shows the termite damage on building structure. All of the organisms that damage timber in buildings are part of the natural process that takes dead wood to the forest floor, decomposes it into humus and recycle the nutrients released back into trees (Ernesto, 1999).

Figure 2. Termite damage on building structure

Salt crystallisation

Salt crystallisation is used to describe the damage caused by soluble salt crystallizing within the pores of masonry materials as can be seen in Figure 3. Salts are brought into the porous masonry in solution in water by a variety means included rising damp. During the dry period, when the moisture evaporates from the masonry wall, the salts will be left behind due to salts cannot be evaporated and the salt solution residue in the wall will become more and more concentrated as time goes by. More and more salt solution will be brought into the wall and accumulated, thus the wall become more and more concentrated. At some point where the solution is reaching a condition which is saturation, or super-saturation, crystals will begin to form in the wall. When the evaporation rate from the wall surface is low, the evaporative front may be at or very the surface, in this case salt crystal will grow as long thin needles, extruding from the wall surfaces (Graham, 2002).

Figure 3. Salt crystallisation on brick wall

i. Salts

Salts consist of a combination of positively and negatively charged ions known as cations and anions. The cations commonly encountered in wall are Sodium (Na^+), Potassium (K^+), Magnesium (Mg^{2+}) and Calcium (Ca^{2+}). The anions commonly in wall are Chloride (Cl^-), Sulphate (SO_4^{2-}), Nitrate (NO_3^{2-}) and Carbonate (CO_3^{2-}). Salts may consist of a combination of any cation with any anion, provided there is a balance of positive and negative charges. The combination of cation and anion which commonly can be found causing salt crystallisation in walls are sodium chloride, sodium sulphate and calcium sulphate. Calcium sulphate is also known as gypsum. When a salt is dissolved in water, it is dissociated into ions. For example,

$$NaCl + H_2O \rightarrow Na^+ + Cl^-$$

When the compounds formed by the crystallisation of a solution can be deriving from the reaction of an acid (eg. HCl) with a base (eg. NaOH).

$$HCl + NaOH \rightarrow H_2O + Na^+ + Cl^-$$

$$Na^+ + Cl^- H_2O - evaporation \rightarrow NaCl$$

The ions are making up into these salts may be of purely natural origin or may be sourced from other compounds deliberately applied to roads or walls. They may come from the pollutants in the air or water.

ii. Causes of salt crystallisation

The sources of salts in the walls are saline soils and groundwater, sea-spray for coastal sites, air-borne salts, air pollutants, inorganic garden fertilizers, biological sources such as pigeon droppings, salt naturally occurring in the stone, brick clay or mortar sand, salty water used for pudding brick clay or mixing mortar and cleaning compounds that contain or react to produce salts in wall. There are two types of salt contamination depending on the salt penetration. First one is the salt residue on the surface of the wall that will be shown as white powder on the plaster which is known as efflorescence. Efflorescence is considered harmless to the masonry wall this is due to the salt residue are inclined to come out from the wall apart from being unsightly. Figure 4 shows the causes and process of salt crystallisation

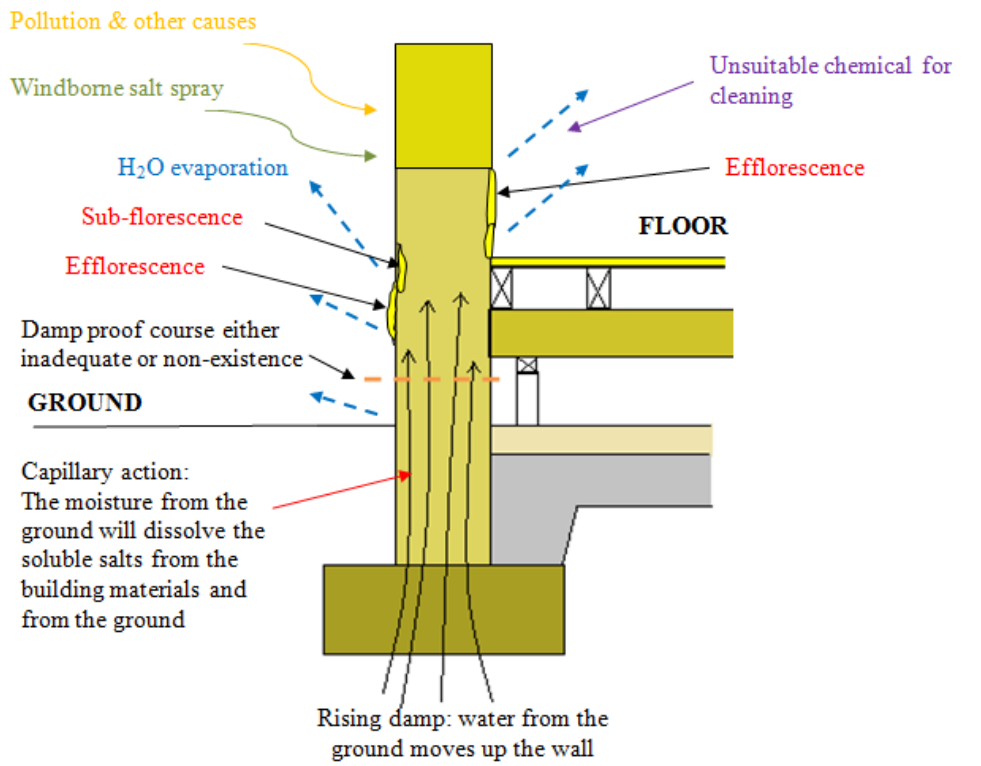

Figure 4. Causes and process of salt crystallisation (Harun, 2011)

iii. Effects of salt crystallisation

Salt crystallisation will lead to the destructive plastering work such as peeling, spalling and flaking of plastering works. The wall finishes such as paint will also be affected. Other than that, the salt contamination and rising damp area are susceptible to growth of fungi and mould. It would have unfavourable musty damp smell and the health of the occupant might be affected. Over the time, salts migrate into porous masonry materials and start to clog pore spaces. Cyclic of crystallisation and hydration has lead the pores become filled. This process will lead to the imposition of considerable stress on the surrounding pore walls (Harun, 2011).

Rising damp

Rising damp is one of the most common yet severe damage that leads to decay and deterioration of many buildings especially heritage buildings as been shown in Figure 5. Rising damp is the upward movement of moisture caused by the capillary action which draws the moisture from the ground or the soil through the network of pores in the permeable masonry material. Capillary suction becomes stronger as the pore size gets smaller.

Figure 5. Rising damp on masonry wall

i. Causes of rising damp

Rising damp refers to the moisture upward movement from the ground and soil. Thus, the common source of water that leads to rising damp problems in masonry wall is from the ground water and soil water itself. The severity of rising damp is depending on the water table underneath the soil. However, the water table is varied from one to another place depending on the geographic location and type of soil underneath. Despite of the geographic location, the defects of the surface drainage and ground drainage also leakage plumbing system underground can be the factor to the rising damp problem (Hassan et al., 2015).

ii. Effects of rising damp

The rising damp in a building can lead to several problems. The moisture content in the masonry can be reached to a level where the decay organisms may grow, or the materials themselves may be adversely affected (Kariya et al., 2016). Heritage buildings are susceptible to experience severe rising damp problem especially the timber structure which is widely use in the building structure include floor, roof, and wall and so on. This is due to moisture condition is an optimum condition for the growth of insects, fungi and mould. The rising damp affected wall allows the growth of the mould is aesthetically unacceptable. Moreover, the growth of mould can be a significant health hazard to the occupants. The finishes on the wall might be damaging. The plastering works and paints on the wall might be flaking and blistering. Where evaporation takes place, the precipitation of the soluble salts on the surface of the wall and within the pores of the building materials can cause aesthetic and structural damages (Mei and Othuman Mydin, 2015).

CASE STUDY

Shih Chung School

Figure 6. Shih Chung School

Figure 6 shows the Shih Chung School which is situated at No. 11, Jalan Sultan Ahamd Shah, 10050 Georgetown, Penang. It is built in year 1880 by Cheah Tek Soon. This building has been unoccupied since 1994. In early year, this building is functioning as a shelter for the family of Cheah Tek Soon. Then, it was once become as Chinese Consulate. Later, this building was function as a school which known as Shih Chung School until year 1994. After Shih Chung School, this building was left unoccupied until now. Now, this building is being fenced up and no entry is allowed as the building is deteriorated severely and might danger the visitor.

Boon San Tong Khoo Kongsi

Figure 7 shows the Boon San Tong Khoo Kongsi which is located at No. 117-A, Lebuh Victoria, 10300 Georgetown, Penang. It was built in year 1878. The building of Boon San Tong Khoo Kongsi itself does not occupied by any occupant. However, there are few houses along the two sides of the building. On the left is the side office of the Boon San Tong Khoo Kongsi. On the right is the house of a family. Back in year 1907, the Lebuh Victoria road previously was a sea before the creation of road. The current entrance of this building was changed into the newly created street in 1907. Currently, the building is under some renovation works included re-plastering, repainting, repair the traditional element in the building and so on.

Figure 7. Boon San Tong Khoo Kongsi

Doubled-storey Mansion at Jalan Dato Koyah

This double-storey building is located at No. 38, Jalan Dato Koyah 10050 Georgetown, Penang (Figure 8). It is built in early 19th century. It is a doubled-storey mansion which is used to be a shelter for a family. It has been unoccupied for more than 10 years. Currently the building is severely deteriorated and unable to accommodate occupants.

Figure 8. Doubled-storey Mansion at Jalan Dato Koyah

There are plenty of plants growing and even the roof of the building is no more. The condition of the building is not safe for use, thus it has been fencing up to prohibit any entry. This building did not undergo any repairing work before that. However, conservation work of this building will be begun soon by a conservator architect in Penang.

Double-storey old house at Lebuh Carnarvon

The case study is situated at No. 11-21, Lebuh Carnarvon, 10100 Georgetown, Penang (Figure 9). It was built in early 19th century. It is a doubled-storey old house. There is several building defects occurred in the building included decay of timber on the ceiling and staircase, peeling paints, dampness problem and salt attack problem. Thus, currently these houses are undergoing conservation and renovation work in order to repair the building defects in the building.

Figure 9. Double-storey old house at Lebuh Carnarvon

Double-storey house at Lorong Prangin

This case study is situated at No. 69, Lorong Prangin 10100 Georgetown, Penang has been shown in Figure 10. It is built in early 19th century as well. It is a doubled storey house which is previously occupied by a family. However, this house has been unoccupied since year 1996. There are many defects occurred in the house such as bird damage, salt attack, dampness, decay of timber and so on. Due to unoccupied, birds take this house as their own shelter and bird droppings can be found scattered everywhere in the house. The health of the occupants might be affected. Conservation work will be begun soon by a conservator architect in Penang.

Figure 10. Double-storey house at Lorong Prangin

DATA ANALYSIS

Shih Chung School

Moisture anomalies of the Shih Chung School

From the Table 1, it can be told that, rising dampness contributed to the dampness problem on the wall. Generally, moisture comes from the ground and travel up to the wall. As can be seen, the moisture content at the lower ground level has quite high percentage in moisture content. The capillary action is decelerating as the height is increasing, thus the moisture content is decreasing. However, in Shih Chung School, the dampness occurred not only contributed by rising damp but falling damp as well. Due to the deterioration of the roof of the building, rainwater is directly entered the building. This can be told by the reading of moisture content at the height of 2.0m. From Figure 11, it can be clearly seen that the temperature of the wall is low. Rising damp occurred in this building might be due to the location of the sa is near to this building which is less than 20 metres.

Table 1. Moisture content of Shih Chung School

Height from ground level (m)	Average moisture content (%)
0.5	4.6
1.0	3.6
1.5	3.2
2.0	>6.0 (out from scale)

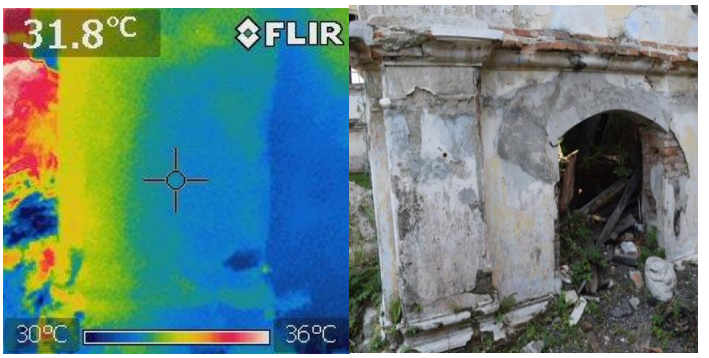

Figure 11. Infrared thermograph of Shih Chung School

X-Ray Fluorescence (XRF) test for Shih Chung School

From the Table 2 above, it depicts the salt concentration contained in the sample which collected from the case study. The elements of MgO, CaO, Na_2O and K_2O are added up due to salt are made up by the cations of Mg^{2+}, Ca^{2+}, Na^{+}, and K^{+}. This has proven that the wall is contaminated by salt. The salt content at 15mm depth is the highest which is 13.64% and the percentage of salt concentration is getting lower as the depth increasing. The salt contained in the sample at 30mm depth and 45mm depth are 10.74% and 8.22% respectively. This shows that the salts are inclined to come out from the wall along with the evaporation of moisture. The salt contaminated the wall are efflorescence but not sub-fluorescence. From the Table 2 above, Calcium (Ca) has the highest percentage for the salt content which is come from the source of limestone, gypsum and fluoride. This is followed by Potassium (K) which is from soils and electrolysis of chloride and hydroxide.

Table 2. Percentage of elements of the destructive salts in the sample of the Shih Chung School

Depth (mm)	MgO	CaO	Na_2O	K_2O	Total
15	0.23	12.06	0.15	1.20	13.64
30	0.49	8.63	0.16	1.46	10.74
45	0.53	5.89	0.15	1.55	8.12

Boon San Tong Khoo Kongsi

Moisture anomalies of the Boon San Tong Khoo Kongsi

From Table 3 above, the lower area of the affected column have very high moisture content until the reading is exceeding the scale. From Figure 12 above, the thermograph has captured that the temperature of the column is low. The moisture content in the wall is decreasing while further up to the column. However, the moisture content is still very high which is recorded as 5.0%. This shows the indications of rising damp. The possible cause of such high moisture content might be the location of the building which is previously a sea. Thus, the moisture of the ground is comparing high than others and the building is more susceptible to moisture.

Table 3. Moisture content of Boon San Tong Khoo Kongsi

Height from ground level (m)	Average moisture content (%)
0.5	>6.0 (out from scale)
1.0	5.8
1.5	5.0
2.0	5.0

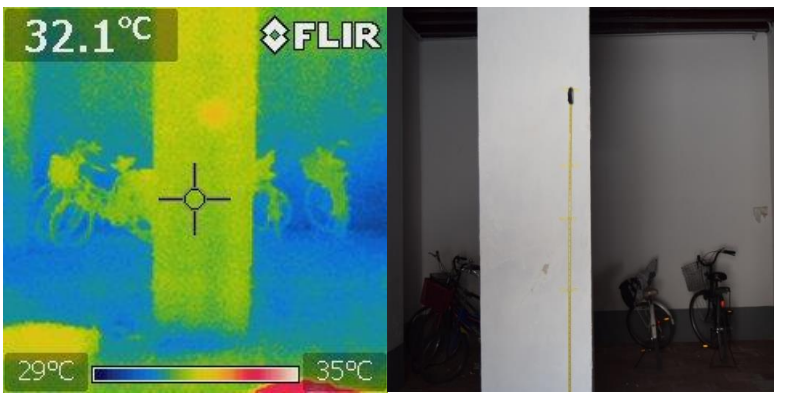

Figure 12. Infrared thermograph of Boon San Tong Khoo Kongsi

X-Ray Fluorescence (XRF) test for Boon San Tong Khoo Kongsi

From the Table 4 above, the highest salt content was recorded at the depth of 15mm of the wall. This is followed by 45mm and 30mm at 13.52% and 12.36% respectively. This portrays that the salt deposit is inclined to come out to the surface of the wall. Thus, it can be concluded that the salt contaminating the wall is efflorescence. Calcium (Ca) has occupied the highest percentage for the salt content which is come from the source of limestone, gypsum and fluoride. This is followed by Potassium (K) which is from soils and electrolysis of chloride and hydroxide. The source of Sodium (Na) basically is sea water and other natural water.

Table 4. Percentage of elements of the destructive salts in the sample of the Boon San Tong Khoo Kongsi

Depth (mm)	MgO	CaO	Na_2O	K_2O	Total
15	0.43	12.38	2.05	2.26	17.12
30	0.72	8.03	1.75	1.86	12.36
45	0.62	8.46	2.81	1.63	13.52

No. 38 Jalan Dato Koyah

Moisture anomalies of the No. 38 Jalan Dato Koyah

Table 5. Moisture content of No.38 Jalan Dato Koyah

Height from ground level (m)	Average moisture content (%)
0.5	2.8
1.0	2.2
1.5	1.6
2.0	2.0

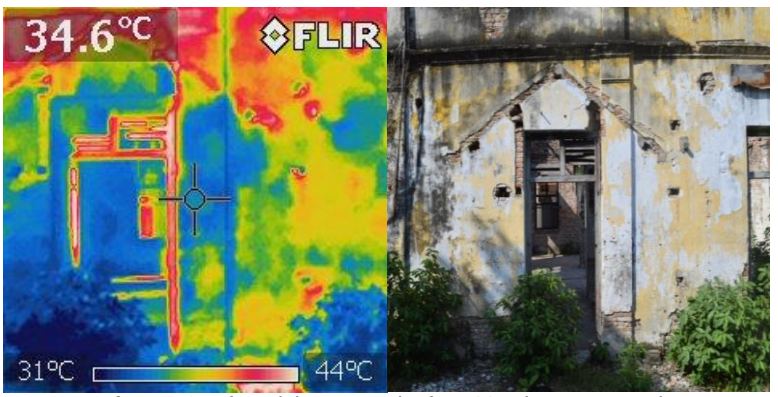

Figure 13. Infrared thermograph of No.38 Jalan Dato Koyah

From Table 5 above, the moisture content recorded has depicted the indication of rising damp problem. The moisture content recorded is increasing from 0.5m, 1.0m to 1.5m. From the Figure 13, the temperature captured on the wall is low at the lower area of the wall. The moisture content is recorded 2.0% at height of 2.0m. This might be caused by the rainwater enters the building because the roof of the building is deteriorated and currently the building is roofless and direct exposure to sunlight or rainwater.

X-Ray Fluorescence (XRF) test for No. 38 Jalan Dato Koyah

From Table 6 above, the percentage of elements of the destructive salts in the sample has proven that the building is contaminated by salt. Same as the other case studies, this case study has the highest salt content of 13.60% at the depth of 15mm then only followed by the depth of 30mm and 45mm at 9.09% and 8.86% respectively. This shows that the salt deposit is inclined to come out to the surface of the wall which can be concluded that the salt deposits are efflorescence. Calcium (Ca) is the largest composition portrays that the salt contaminated which is sourced from limestone, gypsum and fluoride. The composition of Potassium (K) is made up from soils.

Table 6. Percentage of elements of the destructive salts in the sample of the No.38 Jalan Dato Koyah

Depth (mm)	MgO	CaO	Na_2O	K_2O	Total
15	0.18	12.09	0.14	1.19	13.60
30	0.51	5.68	0.31	2.59	9.09
45	0.56	5.31	0.33	2.66	8.86

No. 11-21 Lebuh Carnarvon

Moisture anomalies of the No. 11-21 Lebuh Carnarvon

From the Table 7 and Figure 14 above, they depicts that the dampness problem in this case study is severe. The moisture content in the wall at the height of 0.5m, 1.0m and 1.5m are exceeding the scale of moisture metre. At the height of 2.0m, the moisture content has recorded at 5.6 %. The moisture content recorded portrays the indication of rising damp. The possible factor causing the rising damp problem might be the location of the building is close to the sea and the lack of exposure of sunlight on the wall. Thus, the evaporation rate is slower especially at the bottom part of the wall, it seems barely evaporates.

Table 7. Moisture content of No.11-21 Lebuh Carnarvon

Height from ground level (m)	Average moisture content (%)
0.5	>6.0 (out from scale)
1.0	>6.0 (out from scale)
1.5	>6.0 (out from scale)
2.0	5.6

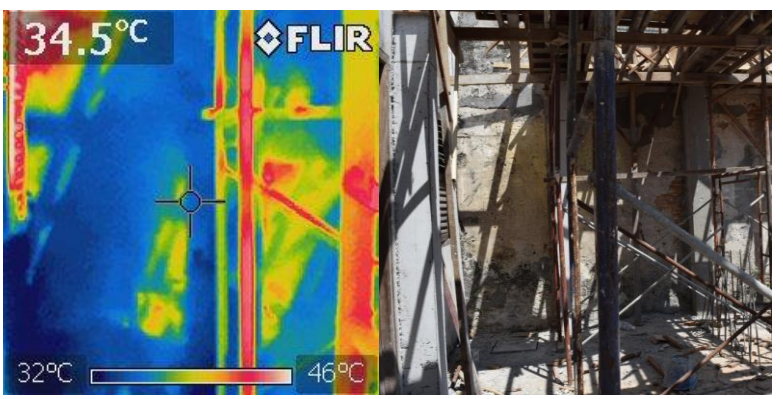

Figure 14. Infrared thermograph of No.11-21 Jalan Carnarvon

X-Ray Fluorescence (XRF) test for No. 11-21 Lebuh Carnarvon

From the Table 8 above, the percentage of elements of the destructive salts in the sample is gradually decreasing as it goes deeper into the wall. This implies that the salt deposits are tend to come out to the surface of wall and portrays that the salt deposits are efflorescence. The highest composition of salt identified is calcium (Ca) which is sourced from limestone, gypsum and fluoride. The second largest composition of sodium (Na) is come from the seawater and other natural water.

Table 8. Percentage of elements of the destructive salts in the sample of the No.11-21 Lebuh Carnarvon

Depth (mm)	MgO	CaO	Na_2O	K_2O	Total
15	0.60	13.77	0.42	0.99	15.78
30	0.78	5.36	0.43	1.18	7.75
45	0.82	3.83	0.38	1.14	6.17

No. 69 Lorong Prangin

Moisture anomalies of the No. 69 Lorong Prangin

Table 9: Moisture content of No.69 Lorong Prangin

Height from ground level (m)	Average moisture content (%)
0.5	4.6
1.0	4.0
1.5	4.4
2.0	2.6

From the Table 9 and Figure 15, the average moisture content recorded shows a gradual decrease as the height of the wall increases. This implies that the dampness occurred is rising dampness. However, as from the data obtained, the average moisture content increase and

reach to 4.4% at the height of 1.5m. This dramatically changes can be seen on the wall in the building as there is a severe and significant spalling paint at the height of 1.5m on the wall which can be vividly seen by naked eyes. The possible factor causing to the rising damp and salt contamination in this case study might be the location of the building close to the sea. This case study is located not far from the case study located at Lebuh Carnarvon. Moreover, less exposure to sunlight which lead to low evaporation rate of the moisture from the wall which has lead to accumulation of moisture and salt deposits on the wall.

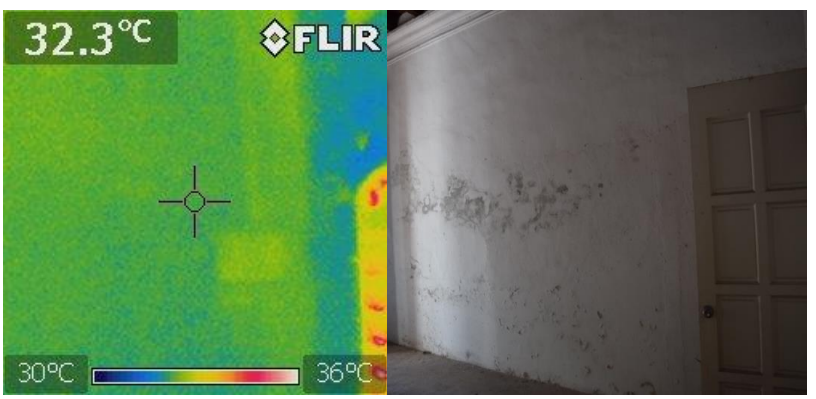

Figure 15. Infrared thermograph of No.69 Lorong Prangin

X-Ray Fluorescence (XRF) test for No. 69 Lorong Prangin

Table 10. Percentage of elements of the destructive salts in the sample of the No.69 Lorong Prangin

Depth (mm)	MgO	CaO	Na_2O	K_2O	Total
15	0.45	10.65	0.36	1.49	12.95
30	0.15	5.99	0.29	1.25	7.68
45	0.10	5.75	0.19	0.94	6.98

From Table 10 above, the percentage of elements of the destructive salts in the sample proves that the wall is destructed by salt. From the table above, it can be seen that the salt content is gradually reduce as goes into the wall. This implies that the salt deposits are efflorescence and the deposits are inclined to move out to the surface of the wall. In this case study, the major composition of the elements in the salt is Calcium (Ca) which is sourced from limestone, gypsum and fluoride. This is followed by Potassium (K) where it comes from soils and electrolysis of chloride and hydroxide.

CONCLUSION

Inheritance building are susceptible to salt contamination and rising damp this is due to lack of Damp Proof Course (DPC), the location of the building close to the sea and also some other factors. Salt contamination and rising damp can be a threat to the building deterioration if left untreated. It is very important to understand the factor and the source of the salt contamination and the type of contamination occurred in order to have an effective conservation works. A precise dilapidation survey and scientific analyses includes laboratory test is required in order to have a better understanding on the problem. From the five case studies in this research, basically the factors causing the salt contamination and rising damp to occur are the location of building and the lacking of Damp Proof Course (DPC). From the data analysed, the source

of salt mostly are come from the soils and limestone. Thus, a precise treatment and repair works can be taken with the reference from the data collected and laboratory result

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ASSESSMENT OF WATERPROOFING FAILURES IN CONCRETE BUILDINGS AND STRUCTURES

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Abstract
This paper focuses on waterproofing failures in concrete buildings and structures. The objectives of this paper are three folds; (1) to determine the main factors that contribute to waterproofing failures in concrete buildings and structures (2) to discover different types of present waterproofing system applied for concrete buildings and structures (3) to propose remedial waterproofing solutions of concrete buildings and structures. There are 4 case studies were carried out at Cyberjaya, Malacca, Kuala Lumpur and Seremban. Each of them consist of different type of building namely SOHO (small office), Commercial building, Hotel Building and shopping mall. The results obtained shows that the main factors that contribute to waterproofing failures in concrete buildings and structure are cracks, deteriorated waterproofing system, honeycombs in concrete and construction joint failure. At the moment there are few types of present waterproofing system applied for concrete buildings and structures such as cementitious system, sheet membrane system and liquid system. Remedial waterproofing solutions of concrete building structures includes cleaning, removing old sealant or joint, injecting appropriate epoxy or chemical grout and applying a new layer of waterproofing system.

Keywords: *waterproofing; building defects; cracks; swimming pool; capillary action; building*

INTRODUCTION

Water is a liquid form that comes from the sea, lakes, rivers and rain; where also known as the important fluids of living organisms but contrasted to the building. Water is the root of serious defects and continuing problems in building and building materials. Due to its natural physical which is watery and slippery, it can get into places where it should not be by flowing freely by the gravity force, by pressure, soakage, through capillary action or by vapor diffusion. Many of serious cases have been arising in constructed building due to the present of water in the building. It can basically affect the building material where it can lead us to unseen blemishes and progressive decomposition by the chemical reaction between the Water, Material and also the presence of Oxygen or Carbonate. Waterproofing was found during the century of Noah's Ark which is caused by 40 days of non-stop rainy weather that leads people to take effective action to prevent the water from entering the residence and habitats. During this era, then people used hay, leaves and other possible methods to curb the water from keep on flowing. Thus, it is impossible to stop the water, however, it does help to control the amount of water flowing.

Protecting a structure with a coat of waterproofing membrane is a crucial element of its design and construction. Water can infiltrate the concrete or masonry barrier of basement area via capillary action. Relying on the physical porosity of the cement and saturation of the exterior, it is possible that water can enter the basement at any location. Due to the negative effect of the presence of water in a building may cause, a proper attention is needed in selecting a quality and suitable waterproofing material based on its location. Living in the era of technology, there is various type of new materials being invented for waterproofing

treatment which is more effective to prevent the absorption of water by the concrete. For example, when it comes to the waterproofing of swimming pools, constant hydrostatic pressure are combined with the rigid and porous structure of concrete pose serious challenges for an effective and lasting job. A suitable preventative measure shall be taken to avoid future cracks of structure that will affect the performance of waterproofing membrane and, at last, can cause a leaking in water retaining structure.

Defects in building structure are a matter of great concern and should be given attention. When a building is not up to the expected standard and does not perform very well, many questions to be raised up by the house buyers and the occupants. The answer to the uncertainty consist of was it due to the poor quality of the material? Is it the contractor does not perform the quality assurance during the construction stage? Was it caused by poor workmanship during the installation? Does a proper maintenance have been correctly implemented? The most appropriate answer always related to the age of the affected building component, the presence or absence of human error or exact nature of the problem. Damage and defects issue in the building can cause a bad implication and brings up negative effects to all parties either directly or indirectly. It is not only threatening the occupant's safety, but it may worsen the aesthetic value of the building. The causes of the defects in construction world should be dug up till the tail in order to facilitate the earliest planning and preventative action ensuring minimal risk of damage and defects (Ali, 2016).

Defective waterproofing can be the root cause of defects that related to moisture. The purpose of installing a waterproofing membrane is to avoid water seepage problem by concrete. When there are an excessive amount of water absorbed by the concrete without any waterproofing system, not only the reinforcement bar will corrode but the structure will start to produce water and leads to leaking problem. From leaking problem the defects will expand to crack and spalling of concrete. In Malaysia, waterproofing a building is a must especially on the roof structure, toilet, basement area and any building façade that are exposed to water. Malaysia is a country that is prone to sun and rain, because of that, many waterproofing failures that occurred is related to roof structure area. Found in the Malay Mail Online, "New buildings could also have structural defects" stressed that not only a building of 10 years old are having structural defects but they found that almost all of the new building were constructed with a lot of defects during the inspection for vacant possession. Due to the shortcoming of workmanship, many minor defects has to be found and the most serious defects are the leaks in the electrical riser rooms. Furthermore, many new defects were found on a newly built Public School in Umbai, Melaka. Many parents are worried about their children's safety as many cracks in the structure of the building has been found (Ayob et al., 2017). Based on that matter, he also wondered how the new building that completed last 2 months has faced many cracks and leaks in the roof. He claims that the building defects might occur due to the apathy attitude of the contractor (Chang, 2015)

Undeniably, most of the problems faced by high-rise building owner are the inter-floor water leakage issue. Many of new invention in making a better high rise building has been invented and put into consideration, among them are built a building that can withstand an earthquake with seismic engineering, green buildings with energy and water efficient measures and fire resistant with comprehensive fire prevention measures. Despite all the new technologies, unfortunately, there are none of the provisions in building codes to look into an issue that bothers many building owners and occupants which the water leakage problem

(Habib and Rahman, 2007). Waterproofing usually costs a fraction of the overall project cost. Due to this problem, many of the contractors are trying to minimize the cost in waterproofing membrane. Price is the prime concern in choosing a product. Quality and workmanship are also important considerations. Timely delivery and stock availability are important as Malaysia construction projects depend on tight schedules. Seventy percent of waterproofing material sells directly through agents or distributors to end users who are architects, contractors, and developers. The highest investment when it comes to leaking is repairing the failure of the waterproofing membrane.

On the other side, based on The Star, our former Prime Minister has ordered an immediate inspection of all government buildings. Based on this statement, The Former Prime Minister ordered an immediate inspection of all government buildings for defects referring to a spate embarrassing defects in new government offices incident. The collapse of a ceiling due to a leaky sprinkler system at the Entrepreneur and Cooperative Development Ministry in Putrajaya (Online, 2011). Leakage, rising of dampness, water seepage syndrome is not only happening in the old building but also new building. There is various type of leakage category which is caused by different sources. Poor construction practices of the contractor like the use of damaged formwork and its early removal, failure to remove entrapped water and poor execution of waterproof membranes could cause defects in the completed building. Due to all the factors, water leakage will happen and caused dampness to the building. As we all aware, there is a case in Terengganu which involving the Batu Burok Aquatic Centre with RM18 Millions of construction cost is facing a problem of swimming pool leaking. Based on Bulletin Online, the aquatic stadium has just been open for 1 year and there are many problems has occurred mainly is the swimming pool. Many restaurant owner complaints that there is water seeped through the walls of their shop lot and causing a bad smell and also water ponding in their shop. The water is believed to be caused by the swimming pool leaking. This case has been reported to the contractor but there were none action was taken and the shop owner afraid if there is no any action being taken, the continuous damage will happen and bigger failure can occur to the aquatic stadium (Opalyn, 2013)

REVIEW OF RELATED LITERATURES

Definition of Waterproofing

Waterproofing is a coating or membrane applied to a surface, such as foundation wall, to prevent the intrusion of water under pressure; materials may include asphalt, felt, tar or various synthetic membranes. As to increase the reliability and durability of building it is a must to install a waterproofing membrane. The structural component and building need a protection from the penetration of water or either from the construction material itself that can harm the concrete through seepage of water or other corrosive fluids. Waterproofing is a relatively impervious membrane, coating or sealant used in concealed locations to prevent water from entering or passing through either the horizontal or vertical building material. Waterproofing is design to exclude water even when the water is under a hydrostatic head. Waterproofing prevents the entrance of water that is under pressure by forming a continuous membrane around walls, through concrete footings and under the concrete slab. There shall be no openings are present that allow leakage or passage of water and water vapor. Figure 1 shows the complete waterproofing solution for a building

Figure 3. Complete waterproofing solution for a building

Importance of Waterproofing

In design terms, the floor must be designed to endure upward thrust and wall must be designed or endure the lateral pressure, thus, waterproofing must be a design from the best and suitable materials to curb the entrance of water through any portion of the structure that are exposed to moisture. Waterproofing preserves the structure from the excessive amount of groundwater and rainwater. There are many possibilities that water can penetrate through the structure, among them are through cracks, expansion joints, opening in walls and roof and also it can seep through solid that are prone to porous characteristic. Water can cause costly damage to a building through the various way which is through heavy rain seeping through the exterior exposure, leaking from plumbing and cracking and etc. In order to prolong the life of a building, a serious action shall be taken in term of installing and designing waterproofing membrane to prevent the water from entering via the pores and voids in the structure.

In addition, exposure to weather condition like heavy rain and sunlight, especially in Malaysia, it could cause structural problems. For example, if wooden decks are used and not being waterproofed, a sign of discoloration, water stain, rotting and fungi growth can be seen. When walls are not properly waterproofed, it will result from a hydrostatic pressure creating cracks and leaks on the walls and floors. In achieving a healthier and sustainable environment, we must avoid any moulds and mildew growth. Mould and mildew breed easily in a place that is prone to humidity and moisture. The growth of this bacterium can cause respiratory problems like asthma and also prompt allergic reactions. There is no alternative to remove these fungi's spores inside the house; the only way that could remove such growth would be to control the moisture (Mailvaganam and Collins, 2004). By reducing humidity, preventing condensation and water seepage, it can decrease the growth of mould and mildew.

Causes of Waterproofing Failure

Shoddy Installation

With the rapid growth of the construction industry, workers are in short supply. In spite of the training programs conducted by several institution, there appears to be a general lack of labour, both skilled and unskilled workers. Most of the construction workers are foreign and there is no strict regulation of the qualification of tradesman job. Thus, the standard of workmanship become hard to control and the blame is being bare by the developer. Poor workmanship naturally leads to building defects. It is far more serious if the defects are unrecoverable, and permanent damage is done. The chemical composition and the installation way of a waterproofing membrane differ. The criticality and complexity of assembling each material on the site greatly influence the attitude of an individual. Although most membrane systems are installed by licensed applicators trained by the manufacturer, poor on-site practice and an indifference to quality control during the installation often produce a final product of dubious performance and durability. Any defects that occur during the installation of the membrane, it may require complete membrane removal. The poor workmanship during application of the materials and incorrect implementation of the design is the main reason for the failure of waterproofing system. In order to curb the workmanship issue, a good construction monitoring and quality assurance service shall be implemented to ensure the installation of waterproofing system is carried out correctly and in accordance with the specification. Contractor and construction managers are also contributing problems in the installation of waterproofing through their lacks of knowledge of the important of waterproofing performance.

Structural Deformation and Joints

Joints are the weakest link in any combination of the structure. When there is any leakage occur, the sources of leaking often close to the source of the failure in the building fabric. Thus, contractor and architects should exercise and observe the best practice in their detailing and sealing in order to prolong the waterproofing performance. In term of waterproofing the joint sealing system, there are differences in term of the mechanism and functionality, application area, preconditions for installation, required weather condition for incorporation, durability and long-term performance, sensitivity to improper handling. Expansion of joints has caused the membrane to tear or rip loose from edges or flooring thus it allows water to affect the structure. Expansion joint should be installed in the concrete to accommodate the thermal, seismic and settlement movement.

On top of that, during the construction stage, it is important to prevent the excessive moisture from being trapped between the reinforced concrete structure and membrane. Water can evaporate through wet cement screed and reinforce concrete. Once the waterproofing membrane is laid, any trapped moisture subjected to increased temperature from the weather will form a vapour which it will exert itself directly below the waterproofing membrane. If the trapped moisture is not released, the build-up pressure will begin to form a blister on the membrane itself and dampness is observed.

Design and Choices of Material

Waterproofing technique preserves a structure's integrity and usefulness through an understanding of natural forces and their life cycle process. Plus it also involves choosing the right design and materials to counter the damaging effects of these natural forces. The main purpose of waterproofing design is to prevent leakage. Once the purpose is being identifies, the design must incorporate an effective system to prevent and absorption of moisture. Roofing is a structure of a building that prevents water intrusion usually from gravitational forces in horizontal or slightly inclined elevations. Although waterproofing typically applied to the surface and exposed to the elements, roofing system also can be internal or sandwiched between other building components. Below grade waterproofing is to prevent water under hydrostatic pressure from entering into a structure or its components. These systems are not exposed to any weathering for example by ultraviolet rays or rain water. Above grade waterproofing, is a combination of materials or system that prevents water intrusion into exposed structure elements. These materials can be subject to hydrostatic pressure from the wind, exposed to weathering and pollutant attack. The building envelope is the combination of all roofing, waterproofing, damp proofing, flashing and diverter system (Christine, 1999).

These systems envelop a building or structure from top to bottom and from below grade up to the roof. Each item used or attached to the building envelope should be waterproof and appropriately connected to other envelope components to ensure that there is no opening or cracks in the envelope's integrity. The main reason of most waterproofing failure is due to improper waterproofing system and substrate design or installation.

Cracks

Crack is something that is inescapable in reinforced concrete structure (Edvardsen, 1999). Observation from many structural damages, most of the tensile cracks are the results of the restraint of imposed deformations, especially for water retaining structure. Since the structure is crack, it will become water permeable up to certain degree, depending on the crack width, length, and the hydraulic gradient. Cracks in the concrete surface are also a common source of leaks in waterproofing system. It is important to ensure that the concrete surface is free from any cracks before applying waterproofing system on it. For small crack with the size, less than 1/16 inches are usually can be treated by using the double thickness of waterproofing layer coat over the crack.

Meanwhile for crack that is more than 1/16, the crack shall be filled up with joint filler to fill up the crack area. Among all the option of waterproofing system either cementitious, membrane or natural clay, the ability to seal existing and future crack are limited. Another factor of cracking is due to the inadequate mixture, application, and curing process. These defects can lead to failure of waterproofing system and lack of protection that allows water to penetrate into the structure. Water seepage rate through cracks is depending on the crack geometry (Kubal, 2008). The seepage rate through horizontal cracks is larger than those through a vertical crack of the same width. Figure 2 shows the types of crack in building which will lead to water penetration.

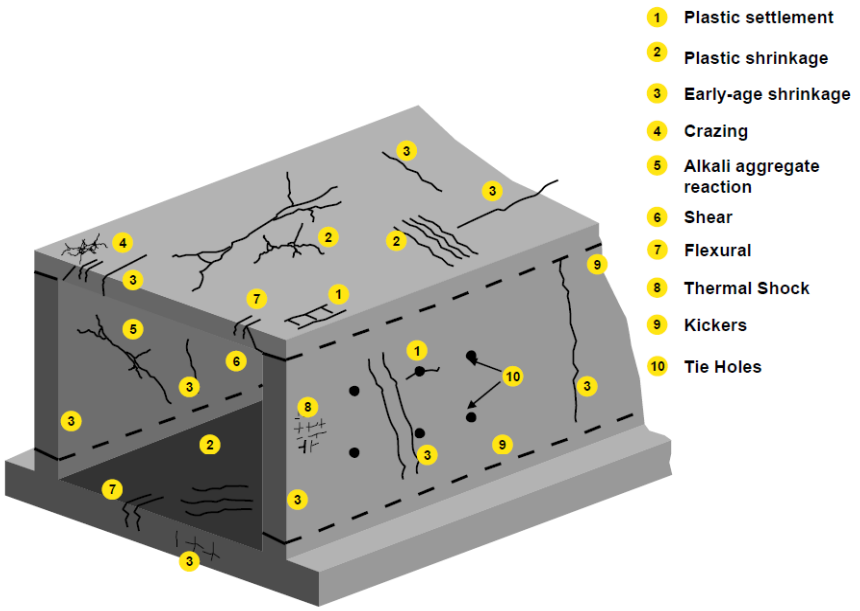

Figure 4. Types of crack building which will lead to water penetration

Types of waterproofing

Cementitious Waterproofing

Cementitious waterproofing is inexpensive and easy to apply but has no elasticity and cannot tolerate joint or crack movement. The bonding, durability, cohesion, tensile and flexural strength of substrate can be improved by using acrylic latex additives. Cementitious waterproofing can be used in below grade application where thermal expansion and contraction are accommodated by movement joints. The cementitious coating can be applied on both concrete and masonry surfaces and are often used in residential basement applications. The material used can seal active leaks, cracks, penetrations, cants, coves, and fillets. Cementitious waterproofing can be used in positive side or negative side applications. The chemical reaction between the materials penetrates or expands into the capillaries of porous concrete to reduce its permeability. In order to ensure the effectiveness of the waterproofing, it may require three to five coats of cementitious. These systems require high-quality workmanship and close field supervision to assure that proper mixing and application procedures are followed.

Liquid Waterproofing Membrane

In term of the membrane, there are only two types of waterproofing membranes; among them are sheet membranes and liquid applied membranes. Each of them has their own characteristic and specialties. The membrane has to achieve the waterproofing objective by being impermeable to prevent water entering or escaping. It has to be flexible and can cater normal building movement. The membrane has to be very durable and able to retain its integrity over a long period of time, and be able to blend itself to design details and specification of the building. Liquid applied membranes are usually applied on the site where the liquid being sprayed and allowed to set and form a water impermeable membrane.

It is known for its semi-flexibility, easy to apply, maintain and repair. The advantages of the liquid membrane are that they are fully bonded to the structure, can be UV stable and have the ability to breathe, cost effective systems and some are able to accommodate negative pressure. However, there are some disadvantages of the membrane where it is easily damaged, sensitive to humidity and weathering, poor bonding to substrates if not prepared correctly, short lifespan when it is left uncovered, influenced by building movement, and require careful supervision and control during the application to ensure proper curing of concrete, consistent thickness and uniform application. Figure xx shows an example of fixing bitumen membrane over building's expansion and movement joint. The liquid membrane is not very elastic so it does not bridge over cracks and gaps properly. The figure above shows the good practice to fix a lax bitumen membrane over building's movement and expansion of joints.

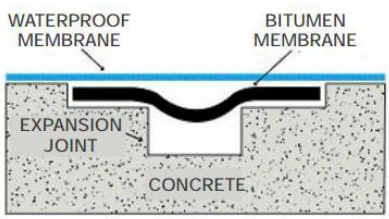

Figure 5. Example of fixing bitumen membrane over building's expansion and movement joint

Sheet based Waterproofing Membrane

Sheet membrane waterproofing includes thermoset and thermoplastic materials. Thermoset membranes may be vulcanized or non-vulcanized materials as well as performed rubberized sheets. Sheet waterproofing membrane is usually applied by heat or attached with an adhesive. Fully adhered system prevents migration of water under the membrane and is not as vulnerable to leaks caused by seam failures as other systems. It often comes in a roll where the asphaltic product is modified and bonded to a high strength fabric of polyester or fiberglass. Sheet membrane has the advantage of allowing protection board placement and backfilling operations to begin immediately after application. Plus, sheet membrane has elongation properties which make them suitable to protect a structure against any type of stress caused by the weather and normal structural expansion and contraction of a building. Water on adhesive field seams can result in leaks if even minor workmanship defects occur. It is very important that the workers read the instruction given by the manufacturer before any installation. The rubberized membrane is easy to install and have self-healing properties at small punctures. Seaming at lap splices does not require solvents or adhesive because the membrane sticks to itself to form a tight seal. Primers might be needed to assure good adhesion to concrete surfaces.

OBJECTIVES AND METHODOLOGIES

This paper focuses on waterproofing failures in concrete buildings and structures. The objectives of this paper are three folds; firstly to determine the main factors that contribute to waterproofing failures in concrete buildings and structures, secondly to discover different types of present waterproofing system applied for concrete buildings and structures and thirdly to propose remedial waterproofing solutions of concrete buildings and structures. Plenty of strategies are available to gather information and data for the research problem. In

this research, a case study strategy is used to achieve the research objectives in a qualitative nature. Case study is a form of qualitative descriptive research which the researcher conduct the study through observations, interviews, and tests. It is a research strategy that is based on the evaluation of the current and visible facts of the real world (Selvarajah and Johnston, 1995). In this study, a total of 4 sites are selected to achieve better coverage and collect more reliable data has been shown in Table 1. Building assessment is conducted to identify the leaking problem in the buildings. Records are done by using digital camera for further comparison during data analysis.

RESULTS AND DISCUSSION

Factors that contribute to waterproofing Failures in concrete buildings and structures

There are many factors that can contribute to the failure of waterproofing. Some of them have been discussed in chapter 2. "The 99% principle: Approximately 99 percent of waterproofing leaks are attributable to causes other than material or system failure" (Kubal, 2008). When to take into account of waterproofing system to be installed, both barrier and drainage systems, miles of sealant involved in building envelopes, it can be estimated that only 1 percent of envelope failures and resulting leakage is actually attributable to materials or systems actually failing.

Parking Multi-storey Car Park leakage (Case Study 1 at Mydin Giant Hypermarket)

The new Mydin giant hypermarket is built with multi-storey car park consists of several number of floors. The waterproofing failure can be detected on the ground floor and also along the ramp that acts as connecting routes to two different levels. Figure 4 shows the water stain that arises from the water below the structure. The stain can be seen along the wall. As discussed earlier, water can penetrate into the permeable building by capillary action. This moisture can dissolve soluble salts from the building materials such as calcium sulfate. From the figure above, we can see that there is a large evaporative surface where it allows the salt deposition to concentrated and forming thick crystalline deposits.

Figure 0. Imprint of water caused from rising damp

The sources of moisture penetration in the base of the walls are probably from the defective ground and defective design to protect the floor surface. Figure 5 shows the proper way layering involves in protecting the water from penetrating into the slab. The crack of the

concrete structure can be caused by many factors. One of them itself is from the presence of moisture in the concrete. Once a structure crack, automatically the waterproofing system of the structure is failed and it attracts more water to seeped through the structure. Figure 5(a) portrays the crack that can be seen on the surface of a ramp installed in the multi-storey car park. And Figure 6(b) is the picture of spalled concrete that can be found in the structure below the ramp. Figure 6 shows the way how spalling of concrete can happen.

(a) (b)

Figure 5. (a) Cracking on the floor (b) spalled concrete

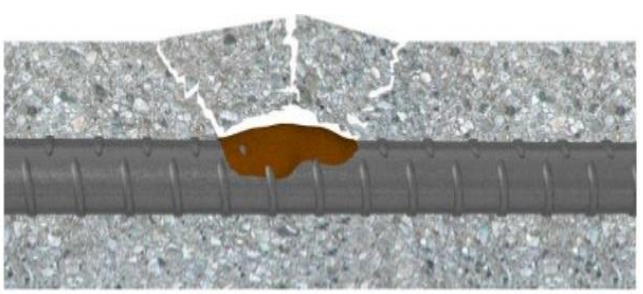

Figure 6. Occurrence of corrosion due to the presence of water in concrete structure

(a) (b)

Figure 7. (a) Expansion Joint on the Parking lot surface and (b) the effect on structure below

From Figure 7, we can observe that the sealant of the gap or joint is deteriorated. Off all factors that affecting sealant performance, installation and workmanship are the most critical and most often causes joint failures. No matter how expensive the sealant selected and how well the joint is designed, an improper installation will lead to failures. A proper installation of joint should consider a backer rod in the design stage. Leaking stain can be seen on the below structure of the car park. The stain produced is in brown color which probably the steel

inside the structure is corroded. Expansion joint that is exposed to wheatear and moisture are usually used the closed-cell rod as a way to add insulation and waterproofing.

Mechanical & Electrical Floor (Case Study 2 at Equatorial Hotel)

The equatorial hotel is located in Malacca. The building was probably aged around 18 to 20 years old. The area where leaking stain can be detected and the most critical area is at mechanical & electrical floor of the building. It accommodates the water tank that serves water to the guests and also electrical panel room of the building. Figure 8 show the water stain that can be seen from the outside of the building. From this picture, it can be said that the water has been penetrating for quite some time. Waterproofing layer has a maximum 10 years life span. As for this building, the waterproofing system installed has exceeded its timeframe and the effect of waterproofing failure can be detected through the emergence of whities along the wall. Figures 9 show the condition of structure inside the M&E room.

Figure 8. The exterior condition of M&E room

Figure 9. The condition of structure inside the M&E room

Due to the age of Equatorial Hotel has been more than a decade, many of defects can be found in the structure. The emergence of mold, stalactite, and spalled concrete can be proved that damaged of insulation, waterproofing system. Deterioration of waterproofing will not only allow leaks but it also allows rain to be absorbed into the various concrete layers. Depending on types and technology of waterproofed used, some of the waterproofing company claims 30 years of life span guarantees.

Swimming Pool Leakage (Case Study at the Face Platinum Suites)

The swimming pool of The Face Platinum Suites was installed on the rooftop of the building. It is a newly built building which the old is less than a year. They are using

suspended type of pool where it incorporates beams and columns to support the weight of the swimming pool.

Figure 10. Leaking that can be found on the swimming pool wall

The newly built swimming pool is facing a critical leaking problem on the structure. It has been rectified for a few times and yet there is still a watermark can be seen on the surface structure. This is probably due to highly porous or the presence of honeycomb inside the concrete. It is usually caused by using concrete that is too stiff or by not vibrating it sufficiently after the concrete has been poured. In addition, the most serious kind of leaks often entangles error in structural design. As seen in Figure 10, the remedial work has been done wrongly as they only applied a layer of plaster cement to prevent the pool structure from leaking. In addition, many construction techniques of swimming pool nowadays are not incorporating the used of water stop as they only connecting the structure directly.

Open Hard Landscape (Cyberjaya Commercial Office)

What we can interpret from Figures 11, it is proven that the waterproofing for the planter box of the hard landscape is deteriorated. This is mainly due to the aging factor of the structure. Cyberjaya Commercial Office has been built roughly for more than 10 years. Thus, it is common where the waterproofing system of the deck is deteriorated and some cracks can be observed. There is sign of blistering of concrete at the drain pipe of the planter box. This is due to the continuous moisture content in the structure. Below figure shows the construction layer of the planter box.

Figure 11. Cracking on the edge of planter box and deterioration of waterproofing on slab surface

Remedial waterproofing solutions of concrete buildings and structures

Rising Dampness

Rising damp may be defined as the vertical flow of water up through a wall structure where the water was derived from underground water. The water rises through the pores by the process of capillary action. Ground water contains an amount of soluble salt namely known as chlorides, nitrates, and sulfate. Thus, when any arises of damp, the first thing that may pop out is white dust where the salts accumulate within the surface structure. In order to avoid this situation to happen, the insertion of damp proof course is needed. For the remedial action that should be taken is by replacing the damp proof materials. Drilling method should be applied in order to achieve a fully effective treatment.

Crack

Cracks often develop that allow water and pollutants to enter a substrate. Crack is repaired through injection of epoxy. The epoxy seals the cracks and restores the structural nature of the substrate. Epoxies can fill the gaps by not increasing the load bearing capability. It has a high number in compressive strengths. If there is any future expansion or movement of crack, expansion and control joints must be installed or else the treated crack maybe allows for movement. Epoxy injection does not only restore the cracks but it also as well restores the waterproofing system. It can restore substrates to a safe condition before waterproofing application to be used as waterproofing itself by stopping leakage through a crack. Epoxy injection is often used for any cracks that are more than 3mm diameter. For any crack which is less than 0.3 mm, the repairing work shall be done by using chemical grout application.

Expansion of joint

Keeping the joint watertight will prevent moisture from seeping under concrete pads and causing them to heave or sink. Expansion joints are important for a driveway. Expansion joint was built to allow the pads to expand and contract with surrounding temperature and humidity percentages. Below is the detail drawing of expansion joint treatment.

Deteriorated Waterproofing

The purpose of waterproofing application is to prevent the water from penetrating into any concrete members. When the water penetrates into the subgrade or substrate for example concrete wall or foundation, the steel reinforcement that embedded in the concrete would corrode due to the chemical reaction caused by water and in addition, it will eventually fail the structure. Thus, a proper repair method is needed.

CONCLUSION

This paper focuses on waterproofing failures in concrete buildings and structures. Crack are the major factor that contributes to waterproofing failure followed by deteriorated WP, honeycombs concrete and problem at construction jointing. The life spans of most of the waterproofing applied on case study site are not more than 15 years old. A proper installation and maintenance is the main key factor of long life cycle process of waterproofing system.

Construction jointing plays an important role in preventing water seepage into the concrete structure. Sheet membrane system is the most system used in all site and location as it is the most durable and flexible waterproofing system.

ACKNOWLEDGEMENT

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EXPERIMENTAL VALIDATION ON THE DESIGN OF STRAIN GAGE BASED SENSOR FOR SOIL COMPACTION

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Abstract
This paper describes the design and development of a sensor equipped with strain gage for soil compaction measurement during earthwork construction. The aim of this research was to perform analysis and experimental validation on the strain gage based sensor in controlled laboratory conditions. The sensor that is developed must be simple to conduct and able to detect the changes and differences of pressure with soil depth. A cylindrical metal sensor block had been designed in two different diameters (50 mm and 100 mm) and with different metal ceiling thickness labeled as Sensor 1 (2.5 mm), Sensor 2 (5.0 mm), and Sensor 3 (7.5 mm). The strain gage was attached inside the sensor block on the metal ceiling. The effect of the loading applied on the metal block was analyzed as the strain gage that was deployed in the metal ceiling would give readings upon forces acting on it. Layers of rubber mat with different dimensions (150 mm x 150 mm for 100 mm diameter sensors and 100 mm x 100 mm for 50 mm diameter sensors) were placed on top of the sensor as laboratory simulation of field compaction and soil thickness. Equation of regression line (y=ax+b) was obtained and the analytical method validation parameter of linearity was used to identify the most reliable sensor design by using the coefficient of determination (R^2). The correlation R^2 resulted for 100 mm diameter sensors were Sensor 1, 0.977; Sensor 2, 0.990; Sensor 3, 0.958; and for 50 mm diameter sensors were Sensor 1, 0.974; Sensor 2, 0,954; Sensor 3, 0.920. It can be concluded that the sensor with 100 mm diameter and ceiling thickness of 5.0 mm (Sensor 2) was the most suitable sensor to be used in actual field soil compaction measurement.

Keywords: *sensor, soil compaction, strain gage*

INTRODUCTION

In the current state of practices for ensuring adequate compaction and proper moisture control relies primarily on the process control which is by means of controlled compaction monitoring (White, 2006). The conventional methods for soil compaction use devices that sense the soil either vertically or horizontally. According to previous works conducted by other researchers, there are methods to identify soil compaction such as by digging soil pits, measuring bulk density and porosity, vertical cone penetrometer, horizontal cone penetrometer, horizontal prismatic penetrometer, ground penetrating radar, air permeability of soil, and the level of the sound produced by a tine pulled through soil (Sharifi et al., 2007).

Soil compaction devices that sense the soil are often expensive when ported to real case scenarios that require large deployments. Besides the inherent cost, the devices also require high maintenance cost and there is always issue regarding on the maintenance such as network failure due to node malfunction somewhere in the device structure (Turkman, 2012). Thus, a simple low cost method which can be used to identify the soil mechanisms in real time is a crucial requirement (Sharifi et al., 2007). The above indicated the problems are in one way or another connected with the

devices that are used for the soil compaction control and monitoring. In this research, a sensor that is simple to conduct and low-cost is developed using strain gage as the main sensing component. The strain gage is a very thin and typically composed of a thin metal on a plastic substrate which has unique advantages of being very compliant to the surface material which they are measuring. The strain gage may also be made from a number of different materials, enabling a good coefficient of movement or expansion detection that match with the measurement surface (Myers, 2010). The strain gage based sensors that has been developed in this study were tested for its application and sensitivity in laboratory simulation of field compaction.

LITERATURE REVIEW

Soil Compaction

Soil compaction is usually defined as the densification of soils by the application of mechanical energy and is conducted by reducing the air volume from the pore space. When the pore space is decreased within a soil, the bulk density is increased. Most construction projects that involve with the works on foundation, slope stability, dams, highways and railway fills or landfills barriers require soils with a minimum engineering properties. These improvements are able to ensure the soil to sufficiently support the man made structure which is going to be built on top of it later on. The improvement that can be carried out on the soil may consist of mechanical, chemical, thermal or electrical stabilization. However, the most widely used methods to improve the engineering properties of the soil is by increasing the soil density by mechanical compaction (Holtz, (1990). Radzi et al. (2017) and Ghani et al. (2016) described the crucial need for satisfactory compaction in relation to road subgrade capacity to support pavement. In the past years, engineers have developed various laboratory soil compaction tests which are able to evaluate field compaction as a metric to effectively monitor the degree of soil compaction that is occurred in the field. However, a quick and reliable field monitoring technique is urgently required for the efficient verification of compliance to specifications.

Strain Gage

A strain gage is a device that is used to measure or to indicate the strains that are produced on the surface of a structural member or to measure the surface deformation (Perry, 1984). The importance of experimental stress analysis and the techniques for measuring strain have contributed in the application of strain measurements using bonded resistance strain gages.

Properties and principles of strain gage

There are many different types of strain gages. The types of strain gage include foil strain gage, wire strain gage and semiconductor strain gage. One of the types is the

universal strain gage that has a structure of a grid shaped sensing element of a thin metallic resistive foil with 3 to 6 μm thick and is laminated with a thin film. The strain gage consists of a small diameter wire that is attached to the backing material. The wire of the strain gage is looped back and forth several times to create an effectively longer wires as the longer the wire, the larger the resistance and the larger the change in resistance with strain. Figure 1 and 2 illustrate the typical strain gage components (KYOWA, 2017).

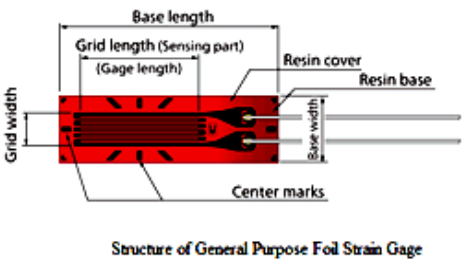

Figure 1. Structure of a Foil Strain Gage

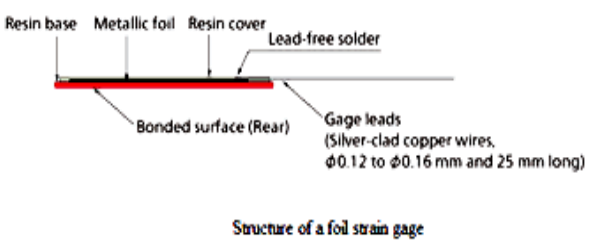

Figure 2. Structure of General Purpose Foil Strain Gage

The foil strain gage has metal foil photo-etched in a grid pattern on the electric insulator of the thin resin and gage leads attached onto it. The conventional fabrication of metal foil strain gage employs both photolithographic and photo-etching techniques to realize the strain sensor geometry (Murray and Miller, 1992). Within the grid pattern, four loops of metal foil can be found that provides an effective total foil length (L) that is eight times greater than if a single wire looping pattern. The grid pattern which covers the area of the material to be monitored for strain is known as the sensing area. The sensing direction is always parallel to the grid lines. The strain gage tends to average the strain covered by the grid lines and therefore the strain gage footprint size is critical when measuring strain over a small surface area. When the sensing area is larger than the maximum strain area, the measured strain magnitude is lower than the actual strain (Lee et al., 2012). Hence a smaller area strain gage is required to obtain an accurate strain measurement of point surface areas. The strain gage physical size is called the gage length.

The principle of the strain gage is based on the electrical resistance change with strain applied. The specific resistance for each metal is different and therefore when

an external tensile force is exerted then the resistance would increase by the elongation. Same goes for when external compressive force is exerted; the resistance would decreases by the contraction. When a strain gage is firmly attached or glued onto a material to be tested, the assumption is made that the glue material has the same deformation as the material itself.

Strain gage based sensor

Strain gage based sensors are used extensively in industrial machines, testing equipment, and weighing indicators (Zorob, 2010). It is popular whereby strain gage are to be used to measure mechanical movement in micro components. They are employed and be used in acceleration sensor, vibration sensor, acoustic sensor and especially pressure sensor (Middelhoek and Audet, 1994). Sensor that converts physical phenomenon or quantity into an electrical signal can be further used to indicate or control the measured variable.

Linearity of Calibration Curve

Linearity of an analytical method refers to the ability to obtain results either directly, or after a mathematical transformation proportional to the concentration of the analyzed data in the sample within a given range (Shabir, 2003; Chandran and Singh, 2007) Linearity is established by a measurement of the instrument response of a sufficient number of standard data in the expected range and it is estimated by the equation of regression line (y=ax+b). The regression line can be plotted in correspond with the concentrations (x) versus the response (y) (Caldas et al., 2009) There will be some expected distributed errors in connection with the regression line plotted. Usually, the correlation coefficient (r) is used to express the acceptability of the linearity of the regression line (Chandra and Singh, 2007). The correlation refers to a technique used to measure the relationship between two or more variables. Correlation coefficient can differ numerically between 0.0 and 1.0. The more closely the correlation values to 1.0, the stronger the relationship between the two variables. If there is a correlation of 0.0, this would indicates that there is an absence of a relationship. In the case of a straight line graph, the coefficient of determination (R^2) is calculated from the regression line of the calibration curve as a decimal value by Microsoft Excel or is given as percentages if multiplied by 100 (Miller and Miller, 2005). As the coefficient of determination (R^2) explains the variation from the regression line, thus the total variability is expressed by the variability that can explained from the regression line and the remaining variability is due to the other unexplained factor. For an example stated by Nidhal Meena (2012), if R^2 is known to be 89% or 0.89, it means that 89% of the variability of the response of y from the regression line can be explained while the remaining 11% of the variability is unexplained. Earlier, Green (1996) concluded that the assessment of the linearity of the calibration curve is recommended to prove the acceptability of any analytical method.

METHODOLOGY

The developed methodology states the sequential procedure of the entire research work and the workflow was illustrated. The workflow of experimental works began with the preparation of tools and equipment and the designing stage of the metal sensor block such as the material of the sensor block, shape, dimension and the ceiling thickness of the sensor. After that, the attachment of strain gage onto the metal block was carried out and the setting up of the experimental works was done for data collection process.

Preparation of materials, equipment and tools

The materials, instrumentation and tools used to conduct the experiments include metal block, strain gage attachment tools and equipment's, compaction equipment, loading interface surfaces, and data acquisition systems.

Metal block

The metal blocks, as shown in Figure 3, are designed and made with mild steel. The dimensions are set to have a circular diameter of 100mm and 50 mm. There are three different inner ceiling thicknesses which are 2.5 mm, 5 mm, and 7.5 mm. The side wall thicknesses (5 mm) and the height of metal block (25 mm) are equally the same for each and all three metal blocks.

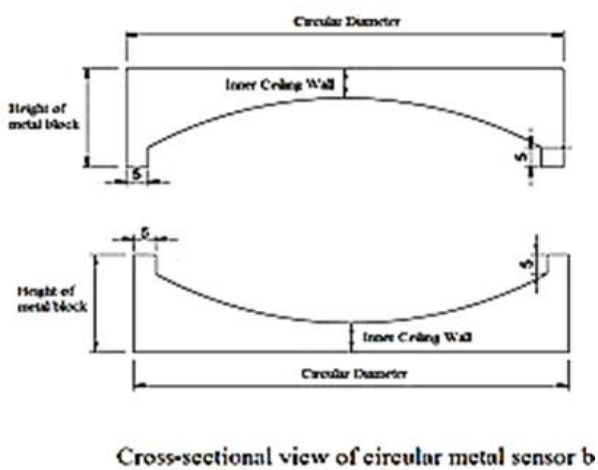

Figure 3. Cross-Sectional View of Circular Metal

Strain gage attachment equipment and tools

The equipment and tools that were required for the attachment of strain gage onto the mental block are alcohol, cotton buds, scissors, tweezers, sand paper, UHU all purposes adhesive as bonding material, cellophane tape as adhesive material of lead

wire, automatic passive component analyzer, and KFG series of General-purpose Foil Strain Gages. These are shown below in Figure 4.

Figure 4. Strain Gage Attachment Equipment and Tools

Compaction equipment

The compaction equipment that has been used in this experiment is the California Bearing Ratio (CBR) test which was a relatively simple test that is used as an indicator to indicate the strength of a subgrade soil, sub base, and base course materials from laboratory compacted specimens. The test is described in the ASTM D1833-07 standards.

Loading interface surface

The loading surfaces that were used to apply pressure on the sensor are metal plates and rubber mats. The rubber mat that was used on the 100mm diameter sensors had the surface area of 150 mm x 150 mm with thickness of 10 mm while the rubber mats used on the 50mm diameter sensors had the surface area of 100mm x 100mm with thickness of 10mm (Figure 5). The number of rubber mat layers placed on top of the sensor represents as a lab simulation of depth of soil where the sensor is placed for soil compaction. The metal plate had a surface area of 150mm x 150mm which is able to cover up the whole rubber mat so as to maintain the same pressure when loading is applied on top of the rubber mat. The plates were manufactured to have a 10 mm thickness.

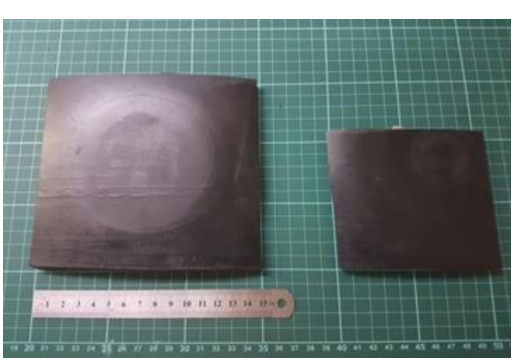

Figure 4. (150mm x 150mm) and (100mm x 100mm) rubber mat

Data acquisition system

The data acquisition is the process of measuring an electrical or physical phenomenon such as voltage, current, temperature, pressure or sound with a computer. The data acquisition systems consisted of a sensor, the data acquisition device measurement hardware, and a computer with programmable software. These devices were used for the measurement of the strain value that will be detected by the strain gage when loading was applied.

Experimental works

Attachment of strain gage to metal block

According to Strain Gage Bonding Manual by KYOWA (2017), the procedures for strain gage bonding are stated as below:

1. Strain gage selection: KFG Series General Purpose Foil Strain Gage of uniaxial with 2-wire cable is selected.
2. Dust removal and surface smoothen: Using sandpaper for the cleaning and smoothening out of bonding site.
3. Grease removal and cleaning of bonding surface: Cotton buds dipped in alcohol used.
4. Bonding position determination: A marker or pencil used to mark the position of attachment of strain gage.
5. Application of adhesive material: A drop of adhesive applied to the back of the strain gage.
6. Strain gage bonding: Placed strain gage with adhesive onto the marked location.
7. Application of pressure onto strain gage: Apply pressure onto polyethylene sheet over the strain gage.
8. Confirmation of bonding work: Removal of polyethylene sheet after one minute or so.
9. Cleaning of bonding site: Carefully remove excessive adhesive outside of bonding site.
10. Adhesion of lead wire: Adhesion material (cellophane tape) used to secure the lead wire.

The process of attaching the gage onto the housing is shown in Figure 6 below.

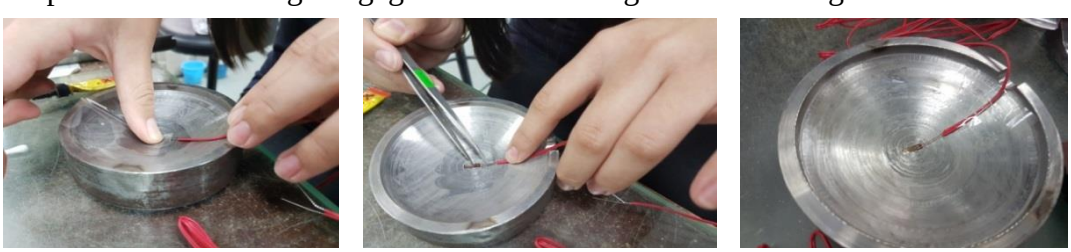

Figure 6. Attachment of Strain Gage to Metal Block

Experimental testing works set up

After the attachment of the strain gage onto the metal block, the setting up of the experimental testing works was carried out. The setting up of the experimental testing works takes place in two parts. The setting up of the load cell as the first part and continued with the second part of setting up of the laptop and data logger.

Load cell set up

The plunger attached with a load cell were set up and secured on the CBR testing machine. The strain gage based sensor was placed on the lower plate of the testing machine and one piece of rubber mat was placed on top of sensor. The metal plate was placed on the rubber mat prior to seating of the plunger after which the loading will be exerted onto it.

Laptop and data logger set up

The laptop was connected to the data logger with a USB cable and the strain gage was connected to the channel 1 and load cell was connected to the channel 2. All the cable connections were to be confirmed to be connected successfully before the monitoring and recording of the experimental works took place. The strain gage and load cell were set and balance to zero in the software before the experiment was being carried out by switching on the compression testing machine. The loading exerted will be monitored and recorded through the dynamic data acquisition software DCS 100A series in the computer.

Carrying out the experiment testing works

Once the compression testing machine was being switched on, the lower plate of the testing machine will be slowly lifted until the load cell detected to a maximum loading of 20kN. The testing machine will then be stopped when the exerted load reached 20kN and the testing machine will be switched back on to remove the loading that was applied until 0kN. The changes in the strain value starting from the sensor was being loaded in increment from 0kN to a maximum of 20kN and unloaded in decrement from 20kN to 0kN were been monitored and recorded for further analysis of results (Figure 7 and 8).

The experiment was repeated by increasing the number of layers of rubber mat to the maximum of 6 layers. The procedure of setting up and carrying out the experiment were being repeated and the changes in the value of the strain gage for all different number of layers of rubber mat were recorded and monitored. The analysis of the results will then be carried out in tabulation and graphical form.

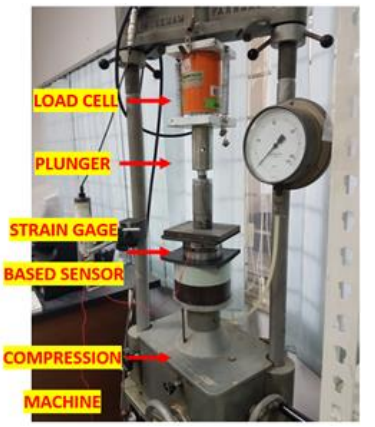

Figure 7. Setting Up of Experimental Works

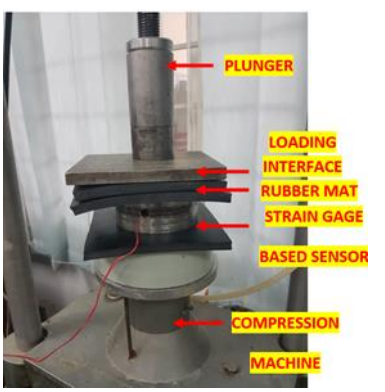

Figure 8. Carrying out of Experimental Works where loading is exerted onto the rubber mat and the sensor

RESULT AND DISCUSSION

The results analysis was carried out in two separate sections. The first section is the analysis of results obtained from the compression test on the sensor with different number of layers of rubber mat. The second section is the analysis of the results from the first section for the plotting of the calibration curve for all the sensors of diameter 100mm and 50mm.

Compression test results

The compression test results were obtained when the plunger that was attached to the compression machine exerted force onto the sensor with different number of layers of rubber mat from 1 layer to 6 layers placed on top of it. The results gathered were of 3 sets of sensors with 100 mm diameter which are, Sensor 1 (100mm diameter 2.5mm thickness), Sensor 2 (100mm diameter 5.0mm thickness), and Sensor 3(100mm diameter 7.5mm thickness). As for the other 3 sets of sensors, they are of 50 mm diameter sensor which are Sensor 1(50mm diameter 2.5mm thickness), Sensor 2(50mm diameter 5.0mm thickness), and Sensor 3(50mm diameter 7.5mm thickness).

The results of the compression test for sensor are presented graphically as shown in Figure 9 and 10 below:

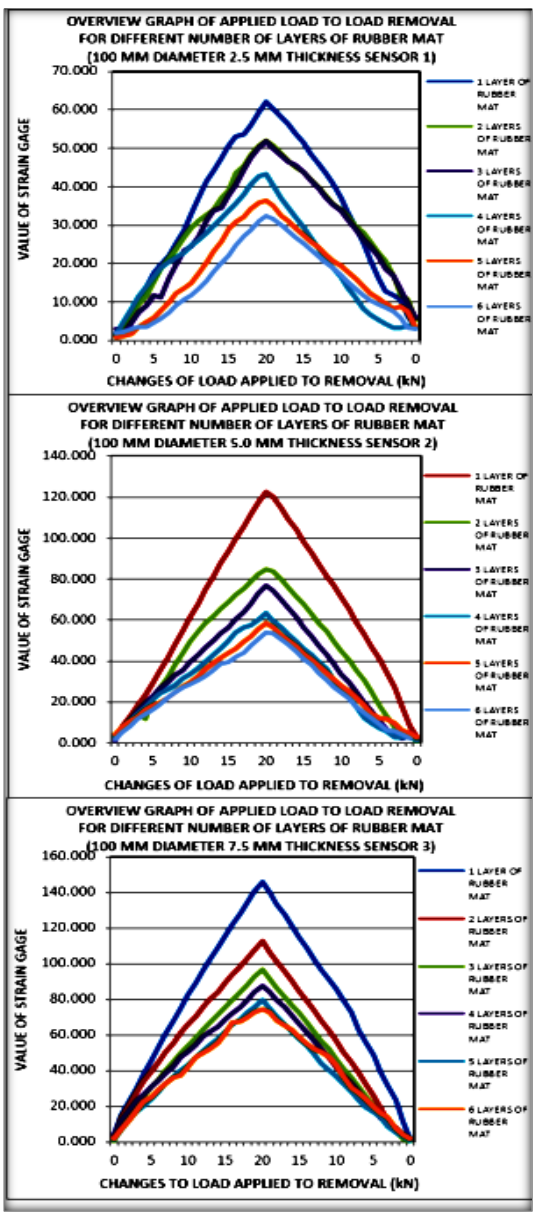

Figure 9. Strain vs. Load for 100mm diameter Sensor 1 (2.5mm thickness), 100mm diameter Sensor 2 (5.0mm thickness), and 100mm diameter Sensor 3 (7.5mm thickness)

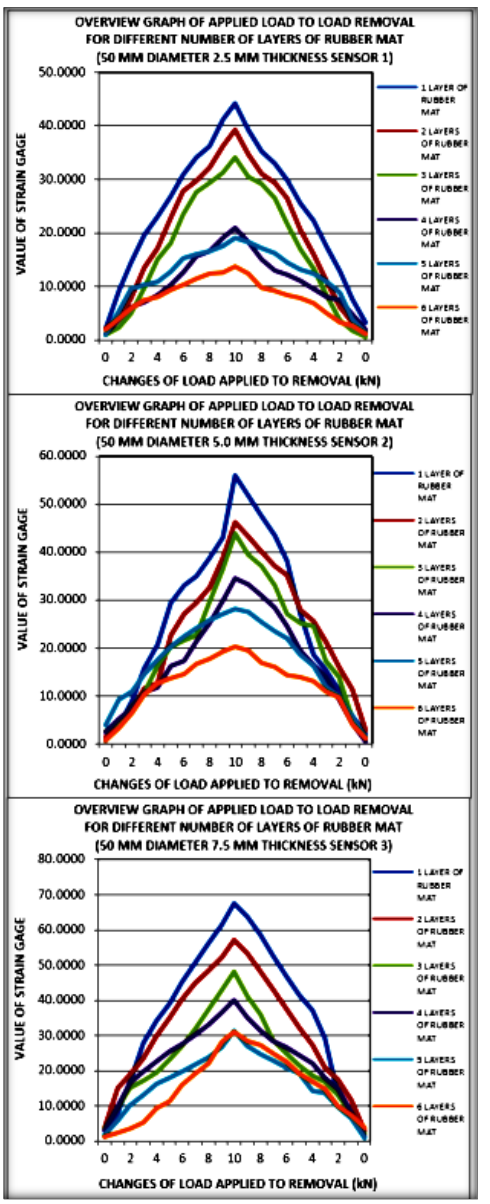

Figure 10. Strain vs. Load for 50mm diameter Sensor 1 (2.5mm thickness), 50mm diameter Sensor 2 (5.0mm thickness), and 50mm diameter Sensor 3 (7.5mm thickness)

Calibration results

The calibration curve was constructed by plotting the intersection points of y-axis, the value of strain gage for each selected loading (5kN, 10kN, 15kN, and 20kN) at assumption when no layers of rubber mat was placed against the corresponding selected loading. The four points of the regression line offered a good linear behaviour as the value of strain gage increases slowly with the loading. The coefficient of determination (R^2) values was obtained for 100mm diameter sensors and 50mm diameter sensors from the calibration graph plotted below (Figure 11 and 12). The

equation of regression line, y=ax+b where y represented the value of strain gage (dimensionless) and x represented the load (kN) was also stated in each graph.

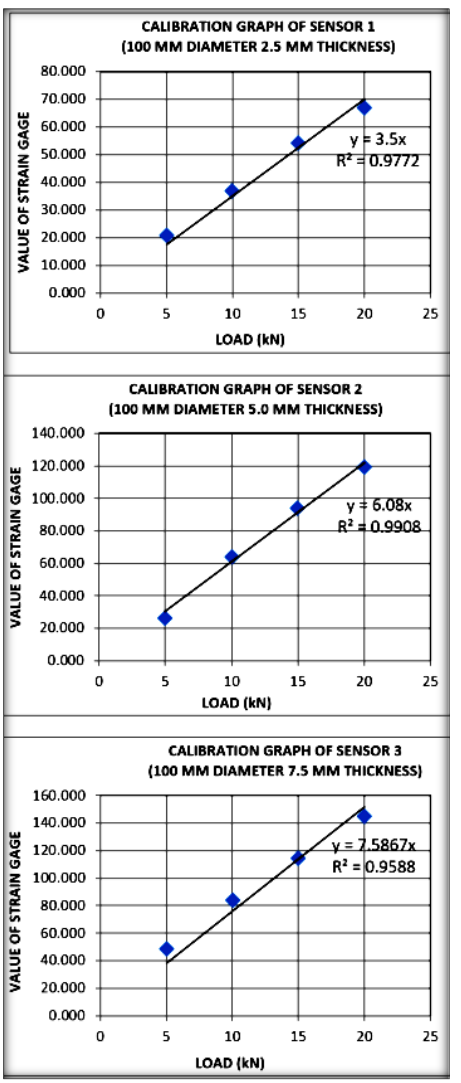

Figure 11. Calibration graph for 100mm diameter Sensor 1 (2.5mm thk.), 100mm diameter Sensor 2 (5.0mm thk.), and 100mm diameter Sensor 3 (7.5mm thk.)

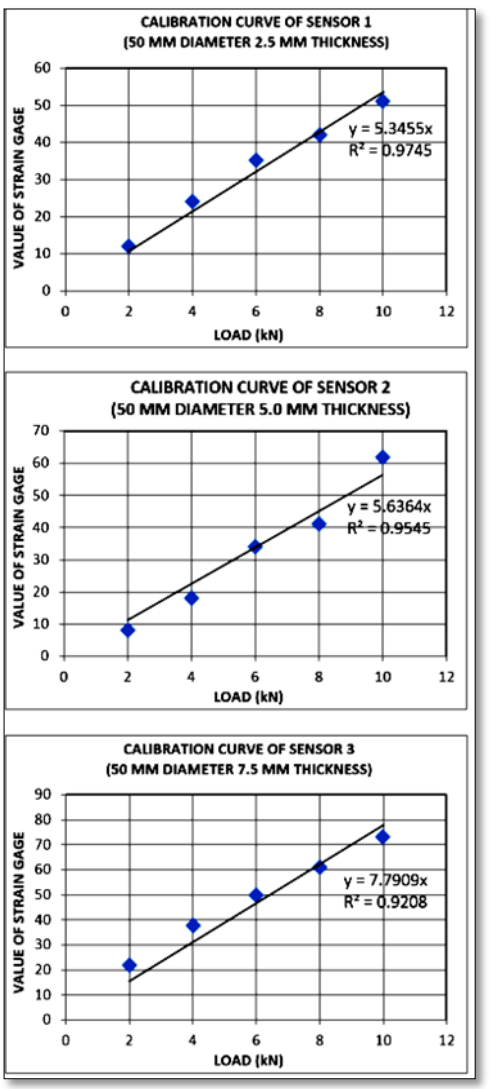

Figure 12. Calibration graph for 50mm diameter Sensor 1 (2.5mm thk.), 50mm diameter Sensor 2 (5.0mm thk.), and 50mm diameter Sensor 3 (7.5mm thk.)

Discussion

Sensitivity of the strain gage based sensor

In this research, the rubber mat that was placed on top of the sensor when compression took place represented as a lab simulation of field soil compaction. The number of layers of rubber mat would reflect as the depth of soil the sensor is deployed

in the field later on. This can be explained as the more the number of layers placed on the sensor; the deeper the sensor was placed in the soil in actual field test. The rubber mat used in this research had two different dimensions of 150mm (length) x 150mm (width) x 10mm (thick) which was being used for the testing of 100mm diameter sensors and another dimensions of 100mm (length) x 100mm (width) x 10mm (thick) which was being used for the testing experimental works on 50mm diameter sensors. The total of 6 layers of rubber mat was representing 60mm depth of soil or also known as a depth range of 0 - 60mm. There were 3 sensors each for both 100mm diameter sensor and 50mm diameter sensor which were of different ceiling thickness of 2.5mm, 5.0mm, and 7.5mm; namely 100mm diameter Sensor 1 (2.5mm thickness), 100mm Sensor 2 (5.0mm thickness), 100mm Sensor 3 (7.5mm thickness), 50mm Sensor 1 (2.5mm thickness), 50mm Sensor 2 (5.0mm thickness), and 50mm Sensor 3 (7.5mm thickness). From the data collected and analyzed, the graph of applied load to load removal against different number of layers of rubber mat placed for all 6 sensors had the same trend of line curve graph. The trend of the line graphs were all in an inverted "v" shape as shown in Figure 13.

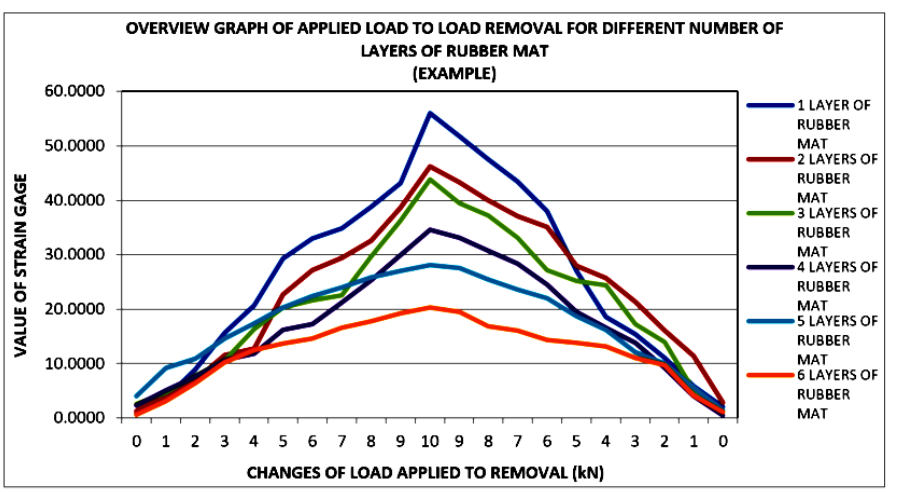

Figure 13. Strain vs. Load applied for all sensors

Figure 13 shows that with the increase in the number of layers of rubber mat, the value of strain gage decreases, therefore, with 1 layer of rubber mat, the value of strain gage is the highest and then the value decreased for 2 layers followed by 3 layers, 4 layers, 5 layers, and lastly the final 6 layers with the lowest value. The trend was the same for all 6 sensors and this means that all 6 sensors were sensitive towards the changes in the number of layers of rubber mat or also to when deployed in different depth of soil.

The 3 sets of 100mm diameter sensors had been tested with the applied loading from 0kN to a maximum of 20kN. The other 3 sets of sensor of 50mm diameter had been tested with the applied load of 0kN to 10kN only, which is half of the maximum load that was being tested for the 100mm diameter sensors. The reason for not

carrying out the experiment loading to 20kN for the 50mm diameters sensors was due to the rubber mat that had shown primary stages of rupture whenever the loading exceeded 10kN.

According to Green (1996), precision can be characterized into four types of repeatability. In this research, the repeatability used is in intra-assay precision which is assessed by repeating the sample analysis in one laboratory by one analyst using the same conditions. Thus, the experiment has been carried out three times to obtain the average value for each layer of rubber mat placed on both 100mm diameter sensors and 50mm diameter sensors.

Validation and calibration of the strain gage based sensor

Table 1 below is the tabulation data of all the coefficient of determination (R^2) and equation of regression line (y+ax+b) for all 6 sensors of both 100mm diameter and 50mm diameter. According to Nidhal Meena (2012), the coefficient of determination (R^2) explains the variation from the regression line, thus the total variability is expressed by the variability that can explained from the regression line and the remaining variability is due to the other unexplained factor. The calibration graph of R^2 value that is closest to 1.00 is known as the calibration curve with the least unexplained variable in its calibration curve.

Table 1. Tabulation of overall equation of regression line and coefficient of determination (R^2) of all sensors

SENSOR	100 MM DIAMETER			50 MM DIAMETER		
	SENSOR 1	SENSOR 2	SENSOR 3	SENSOR 1	SENSOR 2	SENSOR 3
THICKNESS (MM)	2.5	5.0	7.5	2.5	5.0	7.5
EQUATION OF REGRESSION LINE (y=ax+b)	y=3.5x	y=6.08x	y=7.586x	y=5.345x	y=5.636x	y=7.790x
COEFFICIENT OF DETERMINATION (R^2)	0.977	0.990	0.958	0.974	0.954	0.920

From the data tabulated, the coefficient of determination (R^2) for all 6 sensors were compared and hence, the sensor with the highest R^2 value was chosen as the best sensor among all 6 sensors for field soil compaction as its calibration curve could explain most of its variability in response to the y-axis, value of strain gage.

The best sensor that was chosen among all 6 sensors was the 100mm diameter Sensor 2 of thickness 5.0mm with the highest R^2 value (0.990) among all other R^2 values. The 100mm diameter Sensor 2 is known as the best sensor among all 6 sensors as it had the highest value of R^2.

CONCLUSION

The purpose of this research is to design and developed a strain gage based sensor for soil compaction. Analysis and experimental validation on the performance of the sensor when loading is applied to it has also been carried out. Based on the results, the following conclusions can be drawn.

1. The material of high tensile steel metal sensor block with cylinder dimensions of 100mm diameter and 50mm diameter; each designed and developed with three sets of different ceiling thickness of 2.5mm, 5.0mm and 7.5mm were practicable.
2. The rubber mat placed on the sensor was able to simulate the realistic situation of field soil compaction in soil laboratory.
3. The metal sensor block was deployed with strain gage as a strain gage based sensor which act as a soil pressure sensor was successfully developed and the design details were all shown in this research paper.
4. The sensors were all sensitive towards the changes in the number of layers of rubber mat placed on top of the sensors. Experimental validation on the performance of the sensor was carried out and a calibration curve was plotted for all six sensors.
5. The analysis of regression whereby the coefficient of determination (R^2) was determined from the calibration curve that has been plotted. The sensor with the highest value of coefficient of determination (R^2) was considered as the best sensor among all 6 sensors.
6. The coefficient of determination (R^2) for 100mm diameter Sensor 1 (2.5mm thickness) is 0.977, 100mm diameter Sensor 2 (5.0mm thickness) is 0.990, 100mm diameter Sensor 3 (7.5mm thickness) is 0.958, 50mm diameter Sensor 1 (2.5mm thickness) is 0.974, 50mm diameter Sensor 2 (5.0mm thickness) is 0.954 and 50mm diameter Sensor 3 (7.5mm thickness) is 0.920.
7. Based on the coefficient of determination (R^2), it had been concluded that the 100mm diameter Sensor 2 of 5.0mm thickness is the best sensor to be used in the actual field soil compaction among all six sensors with the R^2 value of 0.990.

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THE LEVEL OF TECHNOLOGY ACCEPTANCE OF FOREIGN WORKER TOWARDS POWERPOINT (PPT) IN SAFETY AND HEALTH INDUCTION COURSE (SHIC)

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Abstract
Attending Safety and Health Induction Course (SHIC) is compulsory for construction workers before they can enter and work in this site. After attending this training, they will get the Green Card which allows them to start working on the sites. However, the PowerPoint (PPT) still be used as an existing medium which has been used to disseminate the safety information in SHIC using the Malay language and English as a mediator. Thus, this study examines the level of technology acceptance of foreign worker towards PPT after attending the training, which assessed using the Technology Acceptance Model (TAM) in order to seek their response. It is important to seek the foreign workers' response towards PPT which providing empirical evidence to the CIDB, trainer and employers' management for future improvement. So, TAM has been used to study the factors which impact the foreign workers' acceptance level towards PPT. The factors contained perceive usefulness (PU), perceive ease of use (PEOU), attitudes towards using (A) and behavioural intention to use (BI). Thereby to seek the foreign workers acceptance level towards PPT in SHIC, convenient sampling has been chosen in this study. The area covered in this study was Kedah and Perlis and it is limited to 64 foreign workers due to the constraint and limitation. The analyzed results reveal that the foreign workers perceived usefulness and perceived ease of use shows the moderate positive relationship towards the PPT. While, foreign workers attitude and behaviour intention to use shows low correlation with no significant impact towards the PPT. The finding suggests that PPT still useful to be used as a learning medium, but needs to be upgraded and improve regarding the content, text, video, language usage, functions, interfaces and others. As a future result for this improvement, it will lead to a better learning medium, encourages them to stay motivated and focus while increasing the construction performance and decreasing the accidents.

Keywords:*power point, technology acceptance level, foreign worker, safety and health induction course, construction industry*

INTRODUCTION

The construction industry is one of the critical sectors which plays an important role in the national economy and social development (Ofori, 2015). It plays a crucial part to fulfill the global community's desires in the form of physical development, such as infrastructure development, housing, business, education centers and so on (Salleh, 2014). In most developing and Industrialised countries, the construction industry becomes one of the significant industries that represents a large contribution towards the Gross Domestic Product (GDP). Rapid growth and development in the construction industry increases the yearly labour force demand, attracting more local and foreign workers to work in the construction sector (Hamid et al., 2013). However, there exists a labour force deficiency phenomenon in this industry, which causes Malaysia to rely on foreign workers.

The recruitment of foreign workers is not a new issue in Malaysia (Shafii et al., 2009; Rahman et al., 2012). The first wave of recruitment occurs illegally in the 1970's and started to receive attention in the mid 1980's (Kanapathy, 2001) when the Malaysian government started to use foreign workers legally in various sectors (Rahman et al., 2012) including the

construction sector. Most of the foreign workers in Malaysia came from various countries such as Indonesia, Bangladesh, Myanmar, Pakistan and Nepal. However, the numbers of foreign workers entry in Malaysia have created an influx of foreign workers in the Malaysian employment sectors, including the construction sector which created a language diversity effect.

As such, there exists a communication problem among the foreign workers. Valitherm (2014), states that communication problems, also known as language barriers in the Malaysian construction industry are the greatest concern for supervisors or contractors when giving instructions to foreign workers who are unable to understand or speak in the local language which creates a safety issue, delays, accidents. Most of the cause of an accident at construction sites is the worker's attitude while working (Ghani et al., 2008). Most of the workers did not properly wear the personal protective equipment (PPE) because of negligence, ignorance, over-confidence (Krishnamurthy, 2006) and having a low level of safety awareness on-site (Mahalingam and Levitt, 2007).

Malaysian Construction Industry Development Board (CIDB) realized the important role of safety awareness among construction workers and have issued the Green Card Program which require all the construction workers to attend Safety and Health Induction Course (Bakri et al., 2006). All the participant will be registered with the CIDB and the Green Card, which act as personnel identified areas card to enter the construction sites. Without the card, they are not allowed to enter the site. Referring to the existing information delivery medium in SHIC, there are several weaknesses found when it was used for foreign workers (Salleh et al., 2014) such as the language, contents and the medium itself. A preliminary study by Salleh et al. (2012) found that PPT used in SHIC is less interactive for disseminating the information to the foreign workers due to most of the text was written in the Malay language.

Previous studies have proven that this problem exists. A study of 102 Myanmar construction workers who attended a safety course that used PPT found that for verbally conveyed information, only 13.7% (14) understood the content while 43.1% (44) were unable to understand it at all (Salleh, 2014). Meanwhile, for written information, only 6.9% (7) understood it while 55.88% (57) did not. Another preliminary study was on 96 instructors, showed that 43.75% (42) of them, agreed that a verbal language problem exists and 77.1% (74) agreed that a writing problem occurs among Myanmar workers in a safety course (Salleh, 2014). Around 85.4% (82) of the instructor believed that the problem arises when the instructors or trainers exclusively used the written Malay language for conveying information in the safety courses.

Therefore, the purpose of this study was to conduct a reassessment on the existing medium in terms of foreign worker acceptance levels towards PPT and to seek their response of the PPT in SHIC. For the PPT reassessment, Technology Acceptance Model (TAM) has been used in this study. According to Hsu and Chang (2013), TAM specifically used to examine the impact of technology on user behaviour, perceived usefulness and perceived ease of use as a key factor which affects individual attitudes when they use specific technology. In simpler words, TAM has been used to explain the user or individual's acceptance behaviour towards the technology (Surendran, 2012).

TAM became one of the most popular models linked to technology acceptance and prediction of user acceptance of technology (Davis, 1989). According to Ducey (2013), TAM is linked from attitude toward using (A) to behavioral intention to use (BI) and to actual system use based on the Theory Reasoned Action (TRA). For example, a user who has more positive attitude towards using (A) the actual system, will cause the system to develop stronger behavioral intention to use (BI) the actual system and vice versa. In other words, when users start to believe that specific technology make their work performance better than before, they will develop stronger behavior intention to use (BI) the system.

While, Hamid and Ismail (2014), ex plained that two variables in TAM which are the usefulness and ease of use, are supported by external variables, attitude towards using, behavioral intention to use and actual system use in order to seek the technology acceptance by users. Moreover, it is important to seek the foreign workers acceptance level towards the PPT which can provide empirical evidence for the future improvement in the SHIC.

MATERIALS AND METHODS

Questionnaire

The questionnaires were adopted from Lorenzo-Romero et al., (2014) and modified for the purposes of this study where they were used to evaluate the level of technology acceptance of foreign workers towards PPT in SHIC. Furthermore, the questionnaires can collect certain or specific data, easy to manage and coordinate while being cost-effective (Dyer, 2006). Data and statistics are raw data that have been analyzed before they were used to test the theory and the research results, and it was important in supporting the objectives set. This is known as primary data. The questionnaires in this study consist of five components, such as perceived usefulness (PU), perceived ease of use (PEOU), attitude towards using (A), behavioural intention to use (BI) and acceptance level (AL).

In this study, self-administered questionnaires were used because they have high response rates and allows data to be collected quickly. Self-administered questionnaires means the respondents need to read and answer the questions by themselves (Zikmund et al., 2010). In the present study, the questionnaires were written in English and Malay. It was designed carefully and orderly to help respondents answer the question easily. The questionnaires are divided into two parts:

i) Section A

Containing demographic questions on the respondent, namely age, gender, work experience, daily income and education level.

ii) Section B

This section consists of technology acceptance element which consist of perceived usefulness (PU), perceived ease of use (PEOU), attitudes towards using (A), behavioural intention to use (BI) and acceptance level (AL). For assessment, the Likert scale was used in the questionnaire because respondents can express their responses from value 1 (strongly

disagree) until 5 (strongly agree) based on a specific range of statements that has been chosen by the researcher (Likert, 1932) as shown in Table 1.

Table 1. Likert Scale to Identify the Level of Technology Acceptance of Foreign Workers towards PPT in SHIC.

Scale	Score
Strongly Agree	5
Agree	4
Moderately Agree	3
Not agree	2
Strongly Not Agree	1

(Source: Likert, 1932)

Participant

In this study, the total of the sample size is 64. Roscoe (1975) stated that sample sizes that are larger than 30 and less than 500 are appropriate for most researchers. Thus, 64 sample size in this study was sufficient to get a good result. The sampling method chosen for this study was convenient sampling. Convenient sampling were useful because samples can be easily obtained and accessed from an expected place to provide the information (Saunders et al., 2012) without knowing the exact amount of the population. Moreover, it is the most basic and non-probabilistic sampling type based on existing subject or any location with the characteristic of the sample that need to be studied. The characteristic of the sample that often change following the location of the construction site, making it difficult to track the status of their position for the purpose of data acquisition. Thus, every foreign worker that has been found will be counted as a sample of the study.

The sample selection is intended to provide more relevant information and data (Ramsay and Silverman, 2002). For this selection method, the researcher used the time available, opportunity, knowledge, common sense, research objective and research question as a benchmark to select the respondents. There are several criteria that have been taken into consideration to select the suitable respondents. Firstly, the respondent must be a foreign worker who works on construction sites. Secondly, these foreign workers must have completed the SHIC and have a Green Card from CIDB. It is important to ensure the respondent have gone through the SHIC learning process that used PPT containing words, images, audio, video and oral explanation from the trainer.

Based on the Ministry of Human Resource (2015) list, Table 2 shows the number of foreign worker statistics based on nationality in the Malaysian construction industry in 2014.

Table 1. List of Foreign Workers based on Nationality in Malaysian Construction Industry (2014)

Nationality	Construction
Bangladesh	111, 262
Cambodia	280
China	4, 204
India	6, 136
Indonesia	222, 501

Nationality	Construction
Laos	3
Myanmar	21, 430
Nepal	16, 263
Pakistan	18, 693
Philippines	3, 993
Sri Lanka	179
Thailand	535
Vietnam	5, 427
Others	913
Total	**411, 819**

(Source: Ministry of Human Resource, 2015)

Data Collection

Data were collected for three months, using a questionnaire on the foreign workers, which have finished their SHIC training and obtained Green Card. The surveys were self-administered means the respondents need to read and answer the questions by themselves (Zikmund et al., 2010). The questionnaires were written in English and Malay. It was designed carefully and orderly to help respondents answer the question easily. The questionnaires are divided into two parts which are section A and section B. For section A, it contains demographic questions on the respondent, namely age, gender, work experience, daily income and education level. While, section B consists of technology acceptance element which consist of perceived usefulness (PU), perceived ease of use (PEOU), attitudes towards using (A), behavioural intention to use (BI) and acceptance level (AL). For assessment, the Likert scale was used in the questionnaire because respondents can express their responses from value 1 (strongly disagree) until 5 (strongly agree) based on a specific range of statements that has been chosen by the researcher (Likert, 1932). It took about 30 minutes for the respondent to complete the questionnaire with 32 questions in total. To examine the reliability of the questions for each independent variable, Cronbach α coefficients was calculated. The Cronbach α coefficients for the variables of this study is more than 0.60, which means the questions were good and the respondents understood the meaning of the questions (Konting, 1993).

Data Screening

Before starting to perform the statistical analysis, the data were screened in order to confirm the validity and completeness (Hair et al., 2006) and to detect any outliers. It is important to screen the data in this stage because the results in this initial step can influence the next steps in the study.

Detecting Outliers

After the data screening process, the process of detecting outliers is important in order to identify the patterns or abnormality in the data which do not comply with the expected pattern (Singh and Upahdhyay, 2012). Outliers data that need to be disposed involve data entry error, which are unusable in the study (Tabachnick and Fidell, 2007). However, there are no outliers discovered in the data of the present study.

Normality Test

After data screening have been conducted, normality tests were carried out by examining the skewness, kurtosis and Kolmogorov-Smirnov values of the survey data. The value of skewness can be determined as positive normal graph (skewness to the right) or negative normal (skewness to the left) within the range +2 to -2. Kurtosis values refer to low or high for data distribution; high peak (negative) and flattened or horizontal graph (positive) (Darusalam and Hussin, 2016). Another previous study also suggests that data distribution is normal for skewness and kurtosis values if the values are around +/- 1.7 or +/-2 (Darussalam and Hussin, 2016). Table 3 shows the values of skewness and kurtosis for this study.

Table 3. Normality Test: Skewness and Kurtosis Statistics (n=64)

Variable	Skewness	Kurtosis	Description of Distribution
Perceived Usefulness	-0.564	10.644	Non Normal Distribution
Perceived Ease of Use	0.097	-0.748	Normal Distribution
Attitude	-0.093	-0.479	Normal Distribution
Behavioral Intention	-0.040	-0.804	Normal Distribution
Acceptance Level	-0.215	0.317	Normal Distribution

(Source: Darussalam and Hussin, 2016)

From the Table 3, the values of the skewness and kurtosis more than +/-2, means the data distribution is non-normal. After the skewness and kurtosis tests, the Kolmogorov-Smornov test was used to calculate the level of significance of the differences from a non-normal distribution (Hair et al., 2010) due to the sample of the study having more than 50 samples of study (n = 64). Data distribution is considered normal if the significant value is more than 0.05 (sig>0.05) (Pallant, 2011). However, in this study, the variable data showed the violation of the assumption of normality since the values of Kolmogorov-Smirnov were less than 0.05 ($p<0.05$) as presented in Table 4.

Table 3. Kolmogorov-Smirnov values

Variable	Kolmogorov-Smirnov		Result
	Z	sig.	
Perceived Usefulness	0.475	0.000	Not Normal
Perceived Ease Of Use	0.370	0.000	Not Normal
Attitude	0.343	0.000	Not Normal
Behavioural Intention	0.362	0.000	Not Normal
Acceptance Level	0.395	0.000	Not Normal

(Source: Hair et al., 2010)

Based on Table 4, the perceived usefulness, perceived ease of use, attitude, behavioural intention and acceptance level has significant values lower than 0.05 ($p<0.05$), implying that the distribution of the data was not normal. Since the data is not normal, non-parametric test have been used for further analysis.

Data Analysis

Correlation analysis were used to describe the strength, direction, (Pallant, 2005) and significance of the relationship among variables (Sekaran and Bougie, 2009). In this study, the objectives of this study were to identify the level of technology acceptance of foreign

worker towards PowerPoint (PPT) in Safety and Health Induction Course (SHIC). According to the objectives and the research question, the researcher used Spearman's Rank Order Correlation (rho) which is the most frequently used correlation coefficient (Udovicic et al., 2007) in order to test the hypothesis and to accomplish the research objectives. Data analysis were conducted using Statistical Packages for Social Science (SPSS) version 22 software program.

RESULTS AND DISCUSSIONS

To investigate the impact of perceived usefulness towards acceptance level of using PPT among foreign workers.

Perceived usefulness is an individual perception while using a specific technology, which can improve their job performance (Davis, 1989). Based on the first finding in this study, in response towards the first objective which is to investigate the impact of perceived usefulness towards the acceptance level of using PPT among the foreign workers. It referred to how the respondents perceive the learning medium and their acceptance level towards the PPT which can improve their performance on daily tasks.

The finding showed that there is a significant impact on the technology acceptance level of foreign workers towards PPT. The significant value showed that $r = 0.001$ is less than $p<0.05$ and rho value stated 0.441 that indicate a moderate relationship. It showed that respondent getting better control on the job performance, work quality, productivity and job efficiency after attending the SHIC. They become knowledgeable about their works need such as using a safety equipment such as safety helmet, safety boot, safety jacket and etc., know how to work accordingly and organized, which led to a safe working environment.

Moreover, the respondents also acknowledged PPT as an interested and useful technology, which improving their job performance and safety awareness while working on the construction sites. This is consistent with the previous study by Fathema et al. (2015) which stated that the useful technology can develop a positive attitude and intention to use the technology which influencing their motivation and focus point. While, Park (2009) also highlighted that the management must take a necessary action to help the users increasing their perception positively through information technology which can bring out more satisfaction to the users. While, Aypay et al. (2012) shows that users tend to utilize the technology when the technological product or medium becomes simpler to use and operates. The result of this study has signified that trainers and CIDB need to come out with the new method or creating suitable training method, which can increase the respondent understanding of the safety information in order to decrease the accident in the construction industry.

To investigate the impact of perceive ease of use towards acceptance level of using PPT among foreign workers.

Perceived ease of use referred to a degree of users' beliefs that using specific technology would be free of effort (Davis, 1989). On the other hand, the results of the study showed that there is a positive relationship of perceive ease of use towards PPT acceptance level, which was moderate ($r=0.331$) and significant (0.008), $p>0.05$). It is showing a moderate positive relationship towards user acceptance level towards the PPT. In this study, the respondents considered the PPT was an easy way to understand, learning, become skillful, remember how

to perform tasks safely and makes learning platform becomes better and simpler. Moreover, the respondent attracted to the media content such as the video and the pictures which is easy to understand and giving them a virtual experience. Unfortunately, they are less interested during the speech and talk by the trainer due to their preferred native language was not English and Malay.

The findings of this study were supported by Thompson et al. (2006), user involvement or exposure to a specific system can make users to experience virtually and accumulate the users' skill knowledge after using the system. It has been proven that when the users perceived ease of use towards the technology increases, users developed a positive attitude towards the technology utilization (Alharbi and Drew, 2014). The results indicated that this study should be further investigated for better understanding on the PPT usage in SHIC. The findings of this study suggested that the study between two groups of age (older and younger) in order to seek the significant differences on the PPT technology acceptance between groups. Moreover, there are differences understanding between old and young users when they use an information system (Wallen and Mulloy, 2006).

To investigate the impact of attitude towards acceptance level of using PPT among foreign workers.

Attitude can be referred as an individual positive and negative evaluation about to perform a specific behaviour (Ajzen, 1991). In this study, based on the third research objective which focused on the impact of attitude towards foreign workers' acceptance level towards the PPT. The results showed that there is no significant impact with low correlation between attitude with the foreign workers' acceptance level, as $r=0.838$ ($p>0.05$). The researcher found out that respondent has no intention to use the PPT in the future. Respondent explained that the language used that has been used by the trainer using text in Malay and English make it difficult to be understood, become unattractive, and teacher-centered learning generates low on focus and motivation to learn. This result has been supported by Salleh et al. (2012) study, which shows that PPT is less interactive due to the text was written in Malay language. However, the result of this study is not in line with Susskind (2005) study, which is there is a positive effect on the users' attitude towards the training when the college instructor and lecturers using a computer-mediated PPT presentation or PPT as a teaching tool.

Ajzen (1991) highlighted that an individual with positive and negative attitudes probably will develop an intention to perform the behaviour while using the technology or system. This statement supported this result of the study, that foreign workers negative attitude are not developing any intention to perform the behaviour and no motivation to learn more using the PPT. Meanwhile, Davies, Lavin and Korte (2009) mentioned that the respondents may have reached the point where they view the specific technology use is expected, common and no longer seen as a medium which promote the learning. This result suggests that the PPT has a negative impact which it is not appropriate for the respondents use in this study. Nevertheless, further study need to be conduct to consider, whether certain demographic of the respondents such as age, academic background, class type (lecture oriented, quantitative, etc.) or other differences perceive the technology use differently in SHIC.

To investigate the impact of behavior intention towards acceptance level of using PPT among foreign workers.

Behavioural intention to use referred as a manifestation of people's effort which are willing and planning to give a try in order to perform the behaviour (Ajzen, 1991). The correlation Spearman's rho results showed that behaviour intention toward foreign worker acceptance level has low relationship with no significant value. The significant value shows value of 0.761 ($p>0.05$) and $r=0.039$. The results of this study also found out that the foreign workers do not show any behavioural intention to use the PPT¸which they does not want to continually use and learn using the PPT in the future. It explained that attitude towards use and behavioural intention to use the PPT is significantly related to each other, which is the respondent have no positive behavior intention to use the PPT. This result contradicts with the study performed by Davis (1989), it stated that positive perceived usefulness and positive perceived ease of use have a positive impacts on behaviour intention to use the technology. Eventhough, the perceived usefulness and perceived ease of use have a positive impact on the PPT acceptance level, but there is no positive behaviour intention to use in this study.

Likewise, a previous study also found out that the behavior intention positively impacted intention to use the system or technology (Harrison et al., 1997; Nor and Pearson, 2008; Lu and Ling, 2009). While, Bhatti (1970) also supported that behavior intention has a significant relationship with intention to use the system or technology. This result suggests that CIDB and trainer must realize that the PPT should be designed, programmed and carefully selected according to respondent demographics and abilities.

CONCLUSION

The study has contributed towards the body of knowledge by providing empirical evidence on the impact of technology acceptance between PPT and foreign workers in SHIC. Without being affected by limitation, this study has successfully examined the hypothesis, objectives and revealed how PPT affecting the foreign worker acceptance.

The purpose of this study was to examine the level of technology acceptance of foreign workers towards PPT in SHIC in construction sites at northern region which are Kedah and Perlis. It focused on foreign workers who was finished their SHIC and get their Green Card which automatically selected as a respondent. In addition, there are four main independent variable that have been used in this study, which is perceived usefulness, perceived ease of use, attitude and behavioural intention. According to the result which explained in the result and discussion, perceive usefulness has become an important factor which giving an impact towards the use of PPT. The study found out that PPT is useful, simple and understandable for the respondents, which has a positive relationship between foreign workers and PPT. By using this learning medium, they can easily understand the safety information, objectives and improves their work performance.

While, perceived ease of use also showed a positive relationship in this study. The respondent mentioned that PPT is easy to use, easy to understand and simple to be use. Furthermore, the PPT was good to them and still can be improved such as the contents and the language usage. Thus, it can be stated that users factor and technology factor played a crucial role on foreign workers towards perceived usefulness and perceived ease of use of the

PPT which makes them interested and becomes productive in their works. While, attitudes towards using and behavioural intention to use showed no relationship with the foreign workers' acceptance level towards PPT.

Based on the findings, it is clear that the safety training in the Malaysian construction industry needs to transform from maintaining the existing content of PPT into a new, suitable or an improvement, which are being designed, programmed and selected based on the ability of the respondent. Utilizing a combination of pictures, videos and audio narration may facilitate this transform and enhance the whole industry's performance. In addition, CIDB can identify the weaknesses of the PPT based on the feedback from foreign workers and try to come out with new or alternative approaches to improve the training and workplace operation. Furthermore, it provides valuable input or data for the trainer to improve their teaching method and the training operation. Also, it can help the trainer to identify the weaknesses in the existing delivery medium to construct a better and more suitable medium. Not only that, it can help the employer to plan systematically, organize activities or use a medium that is suitable for foreign workers and controlling the activities carefully in SHIC. This three aspect can influence the workers' attitude in their work and improve their performance while conducting the site operation as well as reducing the accident rates.

As a conclusion, it is hoped that this study will be a route for future PPT researches, especially related to limited studies on PPT in SHIC and technology acceptance of foreign workers. Realizing the importance of the construction industry for Malaysian development, it is hoped that this research has contributed to the understanding of current knowledge of PPT and foreign workers acceptance.

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SMART HOME USERS' INFORMATION IN CLOUD SYSTEM: A COMPARISON BETWEEN MALAYSIAN PERSONAL DATA PROTECTION ACT 2010 AND EU GENERAL DATA PROTECTION REGULATION

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Abstract
Security of data in cloud system plays a significant role in ensuring trust from the users. It is also a method of warranting well working system in a smart concept of house by offering numbers of services to the home owner especially in data management and data storage. However, immense of benefits offered by the cloud system are associated with numbers of uncertainties which has created the issue of confidentiality and data safety. This article adopts doctrinal legal study that analyses the Personal Data Protection Act 2010 on the aspect of protection conferred to the cloud users and with reference to additional point that is well addressed in European Union General Data Protection Regulation. The overall finding shows that there is still loopholes in the Act which need to be looked into for the purpose of improving as well as to cater the needs of legal policy in protecting personal data of smart home users in cloud.

Keywords: *component; cloud system; Smart Home; Personal Data Protection Act 2010; European Union General Data Protection Regulation*.

INTRODUCTION

Over the years, we have experienced phases of technology evolution which has a significant contribution in our life. The trend of technology application is not restricted to the usage of telecommunication alone, but has extended to the concept of housing development. Malaysia has introduced smart living concept that requires technology assistance in all aspect of daily routine from preparing meals, music entertainment, and healthy lifestyle until the alertness of safety of the house. Installation of interconnecting devices in a house demand big data storage to enable massive amount of data information to be stored. Thus, the traditional of physical storage system is incapable of keeping such information for longer time and being managed in effective way due to its finite capacity. As an alternative, cloud storage system has been introduced to cater for the technology demand and needs in improving a great working system in a smart home. Nevertheless, cloud computing which is accessible through virtual system exposed to various types of cyber threat.

Keeping eyes on the technology per se may bring great disaster without taking precaution of the vulnerabilities of application deals on the internet. Cloud system is basically accessible through virtual system which may expose to various types of cyber threat. Network communication in a smart home is prone to hack due to its open system may expose to eavesdropping, Distributed Denial of Service (DDoS) attack, privacy intrusion, and attack against authentication (Li et al., 2016), hacking activity, data stolen and data manipulation. It is among the big concern of smart home users when deal with technology devices due to numbers of personal data collected might leak out without their consent.

In addition to that, the implementation of cloud technology system raises several legal issues such as the sovereignty of law to govern the diverging function and responsibility of local ownership and management to third-party service provider and the data protection of users.

Issue of data protection over the cloud falls under the purview of Personal Data Protection Act 2010 (hereafter known as PDPA 2010) which is possible to provide protection for the smart home users. Nevertheless, it has created a question whether the protection of personal data information and data stored in cloud will be treated the same way it is kept using the traditional physical storage system, and whether the PDPA 2010 adequately address matters relates to cloud system storage.

Thus, for the purpose of this writing, Malaysian Personal Data Protection Act 2010 which provide protection to the smart home users' information in cloud will be analysed to look into the loopholes that requires room for improvement. Reference also be made to the European Union General Data Protection Regulation (hereafter known as GDPR) on several related sections specifically on the issue of the coverage of personal data, agreement on consent required in processing data subject, and the issue of protection conferred to data which is processed outside the original source of data.

RESEARCH METHODOLOGY

This writing adopts a doctrinal research concept by analysing laws and regulations related to the issue of protection of security and personal data information of the smart home users in the cloud. An analytical and critical approach will be implemented to specifically analyse the relevant provisions contain in Malaysian Personal Data Protection Act 2010 and The European Union General Data Protection Regulation to come with possible conclusion in protecting personal data information of the smart home user in cloud.

TECHNOLOGY IN SMART HOME

Malaysian housing development has introduced a profound concept of a house equipped with technology devices to leave the best living experience of the owner which is known as 'smart home'. Smart home is a pattern of a house installed with advanced devices exists in a form of communications network, sensors, electronic and electrical devices as well as few appliances which are controllable, accessible and remotely monitored using a smart phone or tab as illustrated in Figure 1. The fundamental concept of smart home is referring to the ability of technological devices in linking with the existing network to ensure the good working system of a house. Smart home is distinguishable from a home that equipped with standalone technological devices operated via network connection in the house. A smart home may comprise of various devices that link to each other which can be accessed either from the central hub or outside the home (Balta-Ozkan et al., 2013).

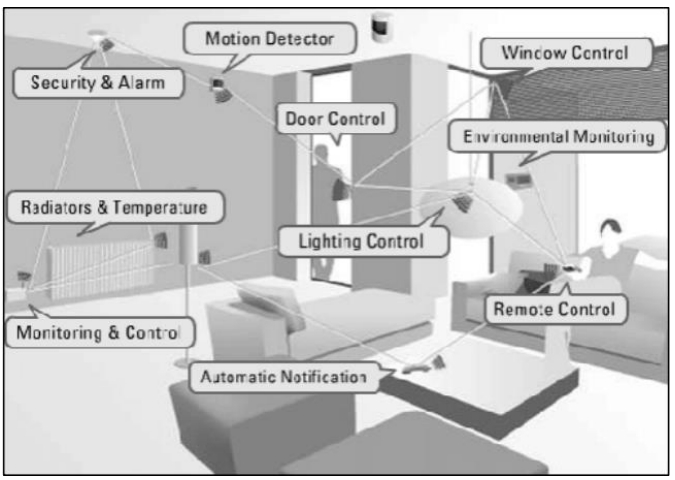

Figure 1. Smart Home Technology Automation

The systems and tools installed within the house will give full enjoyment and peace. The security system is regarded as the most important function in establishing a smart home. It holds a monitoring function to ensure the safety of people living in the house and the surroundings. Apart from that, smart home has potential in saving the energy efficiently. The system function as a medium for energy reduction which is able to automatically on or off based on the commands given through actuator or detector. Energy saving appliances may help in reducing the cost of electricity bills estimated one third lesser than the actual cost in the same size of a normal house by tracking the energy used and command it to use less. Smart home may also provide benefits for an elderly person who needs care and observation especially on medical rehabilitation. In an emergency, appliances within a smart home may alert the hospital directly to always ensure the safe condition of the residents (Robles et al., 2010).

The full function of devices in a smart home requires a complex embedded system to take in place which includes the communications network that allow the integration of devices, reliable sensors, intelligent system control management to collect and deliver the information, and smart features of the devices itself (Robles et al., 2010). In ensuring well working system in a smart home, central server that host the application must respond instantaneously without any interruption. Thus, cloud computing system comes into place to enable the auto-transformation and auto-switching of the tasks.

Smart home devices demand a reliability network to integrate among them to function according to what it should be. Due to that, Shaw in his opinion states, the most vital function of the devices require higher speed connections as it fails to integrate, devices might work in a degraded manner which may lead to inconvenience of life of the owner (Shaw, 2015). However, immense of fascinated benefits come along with the question of security. Security is the vital role in establishing a smart home due to its dependability on trusted network connection and massive personal data information collected and stored over the system. Security is a method of protection against any attacks on the system. In this aspect, security includes wide coverage of scope from confidentiality, information reliability, privacy protection and others. Network communication and cloud computing environment in a smart home is prone to hack due to its open system which may expose to wrongful activity such as

unauthorized access, data leaks, eavesdropping, Dos attack, privacy intrusion, and attack against authentication. As the usage of cloud system and Internet of Things (IoT) are getting more compatible to cater the needs of network consistency, methods to mitigate the risk associated with cloud and IoT are important to ensure the system employed will run legally, ethically and in acceptable way (Li, 2016) as failure to address the implications attending these systems are potentially toxic (Lillard, 2010).

CHALLENGES OCCASIONED BY THE CLOUD SYSTEM

The arising of cloud application together with the Internet of Things in today's life has created changes in the cyber threat landscape. The massive scale of data exchanged over the internet has directed to a number of attacks and has introduced to an exponential exposure to security risks (Anantwar et al., 2012) happened especially in virtual form. Among the issues that has caused concern of the cloud users includes data confidentiality, data integrity [8], data management by the cloud provider, and the tracing of criminal activity over the transferring of data. Cloud and IoT faced external and internal attacks that may obstruct the functions and its benefits. Internal attacks will give more effect compared to external attacks because it might involve with valuable and secret information, and also encompass of privileged access rights.

Data confidentiality is referring to the accessibility of authenticated and authorized information over the cloud from leak to the outsiders. The protected information includes personal data of individual in a smart home either the home owner itself or any visitors may also include sensitive information which should not be revealed regardless of request from parties that have interest over the data. In most of the situation confidentiality of data will be questioned whenever various integrating devices and applications are being placed together involved process of data management, data exchange or updating phase may open up to risks.

While on the issue of data integrity (Personal Data Protection Act, Sec 11), it is upon cloud service provider to ensure data received will not be modified, fabricated or deleted. Smart home users relied wholly on the service provider to ensure their data is properly managed and protected from unauthorized access because data has been kept in centre miles away from the original place of data sources (Jaiswal et al., 2015). However, attack on data might also occurs during the process of data transfer which is known as eavesdropping attacks. In this situation, attacker may intercept the network and falsify the data before it reaches the recipient. It is more dangerous if attackers have control over the system which made the integrity of important information is no longer secured (Ryu & Kwak, 2015).

Due to changing nature of technology, criminals now are able to commit more high-tech crimes and such nature seems to be more complex as it increases created challenges in tracing the attackers and the evidence (Ravin, 2006). Criminal activity perpetrated over the internet is difficult to be tracked even if the criminals are able to be identified, the evidence will no longer be found with them which make the enforcement of law is getting complicated. Furthermore, on the matter of checking on the accuracy of data seems difficult because the cloud datacentre that receive bulk of information in every second is not being able to be audited at all time to trace its correctness as well as the possession of the data storage is no longer with the users has made the verification of correctness of outsourced cloud data becomes a big challenge (Shrinivas, 2011). The concept of "data sovereignty" which refers to

the specific data sovereignty laws limiting cross-border data transmission (Vogel, 2014) has to be determined due to the difficulties in acquiring information and evidence from cloud service providers caused by geographical nature of datacentre that placed outside the country of origin creates uncertainty on the applicable jurisdiction.

As the reliance of technology in managing today's life is continuing to grow, an upsurge of security legal protection is also significant to be considered (Ravin, 2006). Security is a framework consists of several components such as principles, policies, procedures, concepts, beliefs, and techniques necessary to protect system and data of the users against any threat. It is the vital role in establishing a smart home due to its dependability on trusted network connection. Security is a method of protection against any attacks on the system and the data itself.

In the absence of solid security of Internet of Things application, system attacks may lead to malfunctions of the devices and outweigh its benefits. In the concept of IoT, all devices will be connected to each other may possibly reveal flaws that can be exploited by the hackers. It has been predicted that a large number of integrated devices will be compromised to allow the well function of all devices. As the usage of cloud system and the Internet of Things are getting more compatible to cater the needs of network consistency, methods to mitigate the risk associated with cloud and IoT is important to ensure the system employed will run legally, ethically and in acceptable way (Li et al., 2016). Thus, safeguard to ensure the robust security, privacy and reliability of the devices must be in place to ensure a long life cycle of it (Abomhara & Koien, 2014).

Apart from the issue of security of individual data in smart home, protection of such information is significant to be considered upon due to the status of individual information that is considered private in nature. It is well known that the nature of technology adopted in a home is invasive and the cloud system employed to hold bulk of individual information is inevitable to be hacked. The blending status of different concept of situation requires a balance between technology and its consequences which probably be protected through the enforcement of law. In terms of privacy, the concept of it comprised of various ways including right to confidentiality of communications, a right to be left alone, a right to control one's own life or a right to the protection of one's personal data [16]. Thus, in any issue of data intrusion will lead to the issue of privacy which possible of exposing someone's life and cause the degradation of the standard of the information. The grievance consequence will not only revolve on the information itself but may hamper someone's life in a way of injuring their credibility and reputation and also cause other defamation issue. Therefore, it is important to highlight on the protection addressed by the legislations to lessen the effect of it.

CLOUD SYSTEM IN SMART HOME

Cloud computing is a large-scale distributed computing paradigm simulated real traditional computer. It is massively abstracted in the aspect of service offered to the users, virtualized, dynamically-scalable, managed computing power, storage, platforms, and services are delivered on demand to external customers over the Internet (Foster, 2008). It inspired by the cloud symbol to represent the virtual internet flow that simulates the physical computers to run any software, from operating system to end-user applications.

Cloud's structure comprises of hardware and software to ensure the effective management of the servers. Hardware tools include number of physical devices such as processors, hard drives and network devices being operated for storage and processing needs at the data centers independent from geographical location. While, the software system is operating on virtual-based which function locationally independent, resource pooling and rapid elasticity. With the infinite capacity possessed by cloud computer, it is able to support the traffic congestion problem in the server (Anantwar, 2012). Thus, in the context of smart home, cloud function as a server resembles the usage of communication network which is able to receive and collect data from sensors or actuators, continue to be processed and the result will be carried out by the devices or any home appliances (Yuan, 2015). The interconnecting devices may react independently by initiating action either with or without human involvement (Kalmar, 2016).

Smart meter and smart grid system is currently used and able to metering electricity in smart home. Its integrating system with the devices may help in reducing energy through details feedback of energy use, providing tips for saving energy and identifying high energy usage of certain equipment. These meters are also able to transmit information directly from the metered property to the utility company, potentially in near-real time and with a much higher detail of data with the assistant of the cloud system (Papakonstantinou & Kloza, 2015). Cloud may capture information delivered by the home devices and will be automatically uploaded into system as response to the actual activities in the home.

Smart home system requires high capacity of technology in bridging the infrastructure and clouds to ensure embedded devices function efficiently. Adoption of cloud in smart home encompasses of several infrastructures such as internal system connection, intelligent control and uniformity of interface which operated based on the cloud available services model such as Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS) (Zissis & Lekkas, 2012) to help users to run applications and store data online. System connection is the core component in smart home to integrate all appliances either through Ethernet, Bluetooth and Wi-Fi. Connection of all devices relied so much on the fast speed of the wireless network for example to trigger an emergency alarm, it needs the information sent from the sensor and actuator which is able to detect any unwanted situation such as any movement or any unusual thing happened in the house.

The control system of a smart home is based on intelligent control which would enable the house owner to manage and coordinate the devices through tab or smart phone. In this level, cloud offer services known as 'Software as a Service (SaaS)' and 'Infrastructure as a Service (IaaS)' to run smart home's controlling software to adjust the devices according to the needs of the users. Software as a Service (SaaS) is a software deployment model where applications are remotely hosted by the application or service provider and made available to customers on demand, over the Internet which could be accessed from various client devices (Jaiswal, 2015). Whilst, 'Infrastructure as a Service (IaaS)' enables the user with processing, storage, networks, and other fundamental computing resources, and allow the consumer to deploy and run arbitrary software, which can include operating systems and applications (Zissis & Lekkas, 2012). One such example of this is the Amazon web service (Jaiswal et al., 2015) which is considered as a cloud service provider (CSP) who is responsible in managing and maintaining data stored in the cloud server (CS). In most of the situation, cloud service

provider is trusted and authorized to handle massive of personal data of individual or business entity either to back it up, update or managing the storage.

Though the cloud usage in storing smart home users' data is significantly beneficial, as it is susceptible, method of mitigating it risk has to be introduced which among that would be in a form of enforcement of law and policy.

MALAYSIAN PERSONAL DATA PROTECTION ACT 2010

Security is a method of protection against any attacks on the system. In this aspect, security includes wide coverage of scope from confidentiality, information reliability, privacy protection and others. In spite of the fact that technology is playing a significant role in establishing a smart home, the issue of privacy, security and confidentiality of individual data information should not be compromised (IoT privacy). Information security is the basic requirement in the provision of cloud and IoT system that should be addressed and made available in the provisions of law rather than added on later once needed in place.

As response to the needs, Malaysia has taken steps in introducing the Personal Data Protection Act 2010 to regulate the processing of personal data collected and processed for commercial purposes and all other matters connected or incidental to consumers' personal data. Cloud data system is an emerging method of data collected virtually that possibly addressed by PDPA 2010. Section 4 of the Act states on the definition of "personal data" to include the meaning of any information in respect of commercial transactions, any information in respect of a commercial transaction which is: a) being processed; b) recorded with the intention that it should be processed; or c) recorded as part of a relevant filing system (Personal Data Protection Act 2010, Sec 4). The "relevant filing system" is referring to the personal data including any information or opinion as far as it relates to an identified or identifiable living person and processed both manually and automatically (General Data Protection Regulation 2016, Sec 4). Automatic means any data gathered or stored in a traditional computer or on the online database (Munir, 2010). Though the Act does not specifically direct its applicability on cloud system, the nature of data processed electronically makes it falls within the scope of the PDPA 2010.

The main aim of introducing the PDPA 2010 is to prohibit any person who processes and has control over the processing of any personal data which is referred to cloud service provider (Personal Data Protection Act 2010, Sec 4) or any data user who jointly in common with other persons processes any personal data such as licensed insurer; legal, auditing, accounting, engineering and architecture firms; housing developers; medical and dental clinics from processing an individual's personal data without their consent. In protecting the confidentiality of the personal data, express consent (Personal Data Protection Act 2010, Sec 8) is required from data subject to make aware of data processing purpose, especially in the situation of any involvement of any sensitive personal data such as health, political opinion, religious beliefs, or any commission of offence (Personal Data Protection Act 2010, Sec 4). The Act prohibits individual's personal data from being processed without consent of the owner unless it is for a lawful purpose directly related to the activity of the data user in which the data processed is not excessive in relation to that purpose (Personal Data Protection Act 2010, Sec 6).

The processing of personal data should be commercial in nature regardless of its contractual or non-contractual form which may include exchange of goods or services, agency, investments, financing, banking and insurance. However, it creates an issue of determining the commercial matters in the processing of personal data due to the circumstances of difficulties in drawing lines between the commercial and non-commercial activities (Munir, 2010).

Such matters have been illustrated in European case concerning Article 8 of the European Court of Human Rights (ECtHR) which shows that it may be difficult to completely separate matters of private and professional life case. In *Amann v. Switzerland*, authorities intercepted a business-related telephone call to the applicant. Based on that call, the authorities investigated the applicant and filled in a card on the applicant for the national security card index. Although the interception concerned a business-related telephone call, the ECtHR considered the storing of data about this call as relating to the private life of the applicant. It pointed out that the term 'private life' must not be interpreted restrictively, in particular, since respect for private life comprised the right to establish and develop relationships with other human beings. Furthermore, there was no reason of principle to justify excluding activities of a professional or business nature from the notion of 'private life'. Such a broad interpretation corresponded to that of Convention 108. The ECtHR further found that the interference in the applicant's case had not been in accordance with the law since domestic law did not contain specific and detailed provisions on the gathering, recording and storing of information. It thus concluded that there had been a violation of Article 8 of the ECHR.

In light of the above case, we might presume that individual data stored in cloud system is considered as personal data alluded to the status of private capacity. However, in the Malaysian context, since the PDPA 2010 excluded the protection for the processing purpose of personal data for non-commercial matters, it might be presumed that there is no protection granted to the smart home users' information in cloud in the situation whereby data is stolen or misused. Rather smart home user would choose to have contract and agreement with cloud service provider to bind both parties with certain obligations, terms and conditions, still the processing of such data does not fall within the scope of commercial purpose. Thus, such personal data is not justified to be protected under the PDPA 2010.

The idea of the intended agreement is to entitle the cloud provider with an authorized access over certain data to be processed and to provide protection of smart home users' data stored in datacentre from being misused, manipulated, transferred or altered without consent of the data owner. However, it must be borne in mind that, most of the cloud users are not aware on the significant of concluding of agreement between cloud service provider which consequently may waive their right in terms getting protection or in recovering any damages if data being manipulated.

Besides that, establishing a contract or any agency relationship between cloud service provider and cloud users is significant for the process of obtaining document as evidence. Courts have determined the legal right to obtains documents or information from another is through contract relationship as emphasized in the case of *Covad Communs Co., v. Revonent, Inc.*, the courts provide some guidance on practical ability requiring that 'balancing factors' be taken into account including whether the discovery is "unreasonably cumulative or duplicative" and (2) whether the party seeking discovery had ample opportunity to obtain the

information by discovery in the action. Thus, in *Shcherbakovskiy* it has made it clear that cloud users should make certain that the contracts they enter into with providers clearly explain the providers' responsibilities with respect to discovery and other litigation subjects.

Another main obstacle of the PDPA 2010 is due to its non-applicability to govern personal data processed outside Malaysia (Personal Data Protection Act 2010, Sec 3(2). Smart home users' information seems not to be that important as compared to the information of big organization, yet the individual's information is still valuable and through the protection given shows the law recognize the individual's right to privacy which is the fundamental right of human being. Thus, ignoring this issue may waive the obligation of cloud service provider to ensure the confidentiality of the data since most of the cloud datacentre and cloud service provider is located outside Malaysia.

EUROPEAN UNION GENERAL DATA PROTECTION REGULATION

General Data Protection Regulation was proposed by European Commissioner as EU legal framework for data protection to replace Data Protection Directive (hereafter known as DPD) of the European Union. GDPR is seen as the current and influential regulation in the field of data processing legislation that addresses the protection of personal data. The introduction of new regulation is important in ensuring the compliance of common cloud computing usage patterns with legal constraints and requirements to protect the consumers against any data misuse and to preserve their data privacy. The main objectives of reforming the data protection rules is to modernize the EU legal system for the protection of personal data to respond to the use of new technologies; to strengthen users' influence on their personal data and to reduce administrative formalities; as well as to improve the clarity and coherence of the Member States' rules for personal data protection (Kalmar et al., 2016).

Reference to EU legal framework is significant in terms of adopting guidelines to protect personal data transferred over the cloud system. However, for the purpose of this discussion, comparison will only be made on three main aspects which are the coverage of GDPR to include personal data, the need of creating agreement between parties and the law that address the transfer of data across country.

GDPR is enacted to protect personal data of individual regardless of it connection to commercial matters. It is more relevant to protect personal data of individual in this aspect is referred to data of smart home users as GDPR applies to the processing of personal data wholly or partly by automated means and in a form of manual filing system (General Data Protection Regulation 2016, Art 2). In *Bodil Lindqvist*, the Court of Justice of the European Union (CJEU) held that: "the act of referring, on an internet page, to various persons and identifying them by name or by other means, for instance by giving their telephone number or information regarding their working conditions or hobbies, constitutes the 'processing of personal data wholly or partly by automatic means' within the meaning of Article 3 (1) of Directive 95/46."

GDPR has stipulated the meaning of personal data which includes any information relating to a natural person who can be identified, directly or indirectly, by any reasonable means used by the controller or by any other natural or legal person, in particular to an identification number, location data, online identifier or to one or more factors specific to the

physical, physiological, genetic, mental, economic, cultural or social identity of that person (General Data Protection Regulation 2016, Art 4). Continuance from that, Article 9 of GDPR also has listed the 'special categories of personal data' that is prohibited from being process unless with several condition that allow the processor to do so (General Data Protection Regulation 2016, Art 9(2)). These exemptions include explicit consent of the data subject, vital interests of the data subject, legitimate interests of others and public interests (General Data Protection Regulation 2016, Art 9(2)). The special categories of personal data includes revealing racial or ethnic origin, political opinions, religious or philosophical beliefs, or trade union membership, and the processing of genetic data, biometric data for the purpose of uniquely identifying a natural person, data concerning health or data concerning a natural person's sex life or sexual orientation.

Unlike in the process of non-sensitive data, a contractual relationship with the data subject is not viewed as a general basis for the legitimate processing of sensitive data. Therefore, if sensitive data are to be processed in the context of a contract with the data subject, use of these data requires the data subject's separate explicit consent, in addition to agreeing to enter into the contract. An explicit request by the data subject for goods or services which necessarily reveal sensitive data should be considered to be as good as explicit consent. The extension of definition is significant to include data processed using advance technological methods which reflects changes in technology. Thus, the applicability of protection to cover matters not only confined to commercial purpose makes the GDPR relevant to significantly address protection and safeguard of the data of smart home user in cloud.

Pertaining to the contract or agreement that will require processor of the personal data to be putting alert on has also been highlighted in the GDPR which states consent of the owner of personal data should be freely given, specific, informed and unambiguous either through written statement, including by electronic means, or an oral statement. Consent is also considered in a form of ticking a box when visiting an internet website, choosing technical settings for information society services or another statement or conduct the data subject's acceptance of the proposed processing (General Data Protection Regulation 2016, Art. 32). Thus, the service provider will be an unauthorized person if there is indication that data owner is not consented to the processing of his or her personal data.

Another issue that creates fear of the smart home users is relating to the cross border transfer of information to cloud provider's country where the data is processed. The former DPD stated on the applicability of local low of the location of cloud data processed to govern matters arise. However, the inconsistency of the law of different countries and inadequacy of local law to govern that issue will cause variable. Thus, GDPR is introduced to uniformly govern the protection of data flow across country (Kalmar et al., 2016). Matters relate to information transfer to third countries or international organisations other than EU country are mentioned in Article 44 of GDPR. Any transfer of personal data shall take place only if the conditions laid down are complied with by the controller and processor. The conditions require data controller and data processor (Personal Data Protection Act 2010, Sec 2 to ensure the adequacy of the protection level of the country in terms of (a) the rule of law, respect for human rights and fundamental freedoms, relevant legislation, both general and sectoral, including concerning public security, defence, national security and criminal law and the access of public authorities to personal data, as well as the implementation of such legislation,

data protection rules, professional rules and security measures, including rules for the onward transfer of personal data to another third country or international organisation which are complied with in that country or international organisation, case-law, as well as effective and enforceable data subject rights and effective administrative and judicial redress for the data subjects whose personal data are being transferred; (b) the existence and effective functioning of one or more independent supervisory authorities in the third country or to which an international organisation is subject, with responsibility for ensuring and enforcing compliance with the data protection rules, including adequate enforcement powers, for assisting and advising the data subjects in exercising their rights and for cooperation with the supervisory authorities of the Member States; and (c) the international commitments the third country or international organisation concerned has entered into, or other obligations arising from legally binding conventions or instruments as well as from its participation in multilateral or regional systems, in particular in relation to the protection of personal data (General Data Protection Regulation, Art 45).

GDPR has significantly provided further protection on the data information especially to cater the needs of extra protection due to the emerging of technology usage. Thus, the new amendment of GDPR may give ideas on improving the law of personal data protection in Malaysia.

RECOMMENDATION AND CONCLUSION

Data information stored that relate to an official organisation and in the private individual home is different based on the weightage of its privacy status, in the situation whereby cloud storage system is vulnerable to hacking, personal data information in a house is important to be protected. The definition of personal data is not only limited to the name, identification card, address but deliberately a very broad one such as traceable information that will bring to the real person. In principle, it covers any information that relates to an identifiable living individual. Furthermore, data may also become personal from information that could likely come into the possession of a data controller. Thus, there is a need for individual information to be protected regardless of the status of the information. In the aspect of smart home, the system that hold information on the output behaviour of the owner that work to provide fully housing automation may store a lot of information about people which if exposed may prejudice their life. For example, the system has captured their daily routine, whereabouts, financial transaction that has been made and several other information. This type of information is vulnerable if intruded may open up to other criminal cases. For example, in the situation whereby the data processor reveal smart home user's information may leave traceable information to the other person, later give opportunity for the system of the home to be hacked which will later cause other types of problems.

In discussing the provisions provided by Malaysian Personal Data Protection Act 2010 and European Union General Data Protection Regulation, there are several significant differences between provisions in which some part of the PDPA 2010 are lacking of to provide protection to the cloud users. Thus, some of the provisions in the GDPR is suitable to be referred to for the purpose of extending the scope of protection to the cloud users in the smart home particularly. The most important part in highlighting the lacunae in the PDPA 2010 will be on the need to include the applicability of the Act to protect not only commercial data but also the non-commercial transaction. Non-commercial transaction is also known as 'personal

data' which bring the meaning of any data relating to a living individual which can be identified either from the data or from the data in conjunction with other information that is in, or is likely to come into, the possession of the data controller (Information Commissioner's Office). Developing a smart concept of home deals with bulk of information relates to personal, family and household affairs in which all of the information is categorized as non-commercial transactions which is not applicable under the protection provided by PDPA 2010. Thus, the needs of inclusion of protection on personal data under the PDPA 2010 is significant to protect smart home user's information from any misuse of information and also to protect the fundamental right of individual as well as maintaining the right to privacy of natural persons during the processing of personal data. Besides, the idea of including the personal data under the said Act is to prevent from individual personal data from being transferred for the benefits of the other party without consent of the data owner.

Apart from the inclusion of the coverage for personal data to include non-commercial purpose in the PDPA 2010, it is also suggested that the employment of cloud service in the smart home system should be included in the contract and agreement specifying the duty and obligation of both parties including cloud service provider and cloud users. As referred to the method of implementation of agreement by GDPR, it has been made compulsory on the data processor to reach consent from the data owner which is freely given, specific, informed and unambiguous either through written statement, including by electronic means, or an oral statement before the processing of any personal data in which PDPA 2010 should give emphasis on. Although housing developer seems waved from bearing any obligation in securing the data of smart home user, yet they are still under the obligation of providing a reliable cloud service provider. Cloud service provider will normally be selected based on the requirements that suit the needs of types of data saving. In ensuring the protection of data, the developer has to be certain in choosing aspect of data location as it will determine the level of protection granted by the law of that jurisdiction or it should be based on the contract that clearly states the choice of territorial jurisdiction and the choice of law that is applicable in determining any dispute. The term of the contract must not favour only one side. It should be opened up to the negotiation so that the real objective of protecting the data of the cloud user will not be hindered. Among the matters that should be certain is on the intellectual property rights of the data, roles and responsibility of the cloud provider and data provider, and the liabilities of the cloud provider and remedies (Mohd, 2012).

The issue of data location is critical as it is an often regulated issue, which does somewhat go against the transparency principle of cloud computing and the concept of pooling storage resources (Fitzpatrick et al., 2012). It is significant to address the location of the service provider due to inapplicability of the local Act to govern the processing of data outside Malaysia which may hinder the purpose of protecting the information of smart home user in cloud. Information which is in intangible form, once transferred outside Malaysia will no longer protected by Malaysian law and it is subject to the country in which it currently resides. Thus, in the issue whereby the data will reside outside Malaysia, vendor of the smart home cloud provider must ensure the third country having kept all the data must have adequate level of protection during the processing data as suggested by GDPR. Although it may not seem like a significant issue, but when it comes to individual personal data, it is not something that would be considered secure. In suggesting that, cloud providers have to provide access to data to customers, regulators and auditors. It is because of the fact that they are holding all that information and these groups would like the ability to see where the information is being held.

Thus, in this situation, the data whereabouts should be addressed by the Act to ensure information of the cloud user is safe and the owner of the data may have accessed to their own information.

The most important thing is on the security system employed by the cloud service provider to trace any hacking or theft matters occurred in the system and the way of solving it. Although it is not within the power of home developer to monitor the cloud service provider system, still the service provider should be able to provide their web standards and details of the security features such as user authentication and authorization or administration controls known as encryption (Mohd, 2012). Since the usage of cloud system and the Internet of Things are getting more compatible to cater the needs of network consistency, methods to mitigate the risk associated with cloud and IoT is important to ensure the system employed will run legally, ethically and in acceptable way (Li et al., 2016). Thus, the PDPA 2010 should be made comprehensive to make the parties involved aware of their duty and obligation to ensure their right is protected. A revision on the PDPA 2010 is also necessary to cope with the advance of technology application in order to protect the technology users from being victimized by it. This issue, if not properly addressed, may impede the successful deployment of the cloud architecture as well as the objective of introducing the law.

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APPRAISAL OF WORKPLACE INDOOR ENVIRONMENTAL QUALITY (IEQ) IN OFFICE BUILDINGS AT PENANG ISLAND

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Abstract
As the weather is quite a big challenge to Malaysia, thus the Malaysians are tending to create the living environment as comfortable as we can. Workplace environment is very important as it ensure the health, activeness and productivity of workers who work in there. To ensure an optimum working environment, the indoor environmental quality, or frankly said, the HVAC system plays a big role. The objective if this paper is to determine the current indoor environmental quality of the selected offices in Penang Island. A few parameters were determined such as temperature, humidity, air velocity, air flor, noise level and lighting condition. Through indoor environmental quality measurement, it is found that most of the offices facing the lighting and noise problem.

Keywords: *Indoor air quality; temperature; noise level; HVAC; air velocity*

INTRODUCTION

There are many researches considered indoor environmental quality or indoor air quality as a factor that cause the sick building syndrome, although it is not ascertained yet. The high level of carbon dioxide, low ventilation rate and various other indoor air pollutants always been criticized as the main factors in indoor air quality to lead to serious health effect on human beings (Giddings et al., 2013). In this section, the parameters of indoor environmental quality will be explained in further.

In 2001, Hedge states that there are 6 factors that will affect the productivity of human beings in work. These including temperature, lighting, sound, vibration, indoor air quality and personal control. The imbalance or deficiency on above factors will cause the diseases such as sick building syndrome or even infectious diseases that thus decrease the human performance. In recent years, many philosophers are encouraged to study about workplace comfort level by using field studies. By this, they can study on various parameters within the workplace (Hassan et al., 2015). However, in many studies that the researcher hands on, the existing condition of indoor environment is obviously not good for humans to work in term of either physical work or mental work. To change the condition, standards recommending the various building indoor environmental quality optimum condition such as ASHRAE is being established.

When a person is wearing a normal amount of cloth, and he or she feels neither too cold nor too hot, the person is said that to be achieved a thermal comfort zone. It is essential for a person's great behavior and for his or her productivity on work. The thermal comfort normally refers to the air temperature and humidity, sometime including air movement too.

The temperature often becoming the most important factor to maintain the optimum indoor thermal comfort when the humidity is kept at around 50% with absent of air movement. Even though scholars prove the above statement, there is no one temperature that can satisfy everyone – if the office is too warm, the occupant will feel tired and drowsy. In contrast, if the office is too cold, they'll be easy to distract and may face to flu or other diseases. It is really very hard and essential to maintain constant and optimum thermal conditions in the offices as human beings are actually very sensitive to the thermal changes. Even minor deviation from comfort may be stressful and affect performance and safety for the workers.

In order to determine the indoor thermal comfort, questions regarding indoor temperature and humidity will be asked to the occupants. Besides, most of the studies require field test before asking for the occupants' opinions. According to ASHRAE Standard 55-2010, the optimum temperature for an office is 23℃ to 28℃, with humidity of 30%-65%. However, in tropical country like Singapore and Malaysia, majority of the occupants worked in offices equipped with air-conditioning system suggest that the 27℃ might be comfort enough. They think that 24℃ will create overcooling for the occupants (John, 2011). For humidity, little humidity will cause the dryness of the human skin. If the humidity in a room is high, the people will sweat and feel uncomfortable in this condition. Figure 1 shows the operative comfort temperature function of clothing and activity

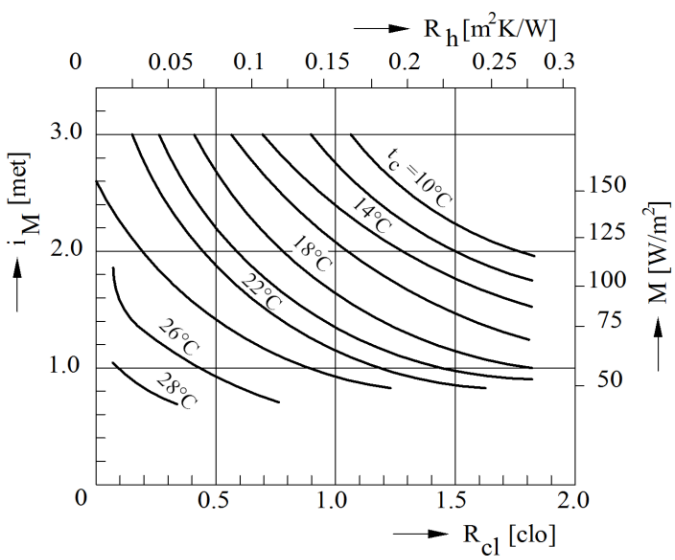

Figure 1. Operative comfort temperature function of clothing and activity (John, 2011)

Room temperature could influence productivity indirectly through its impact on prevalence of SBS symptoms or satisfaction with air quality. There are quite a number of studies that show the linkage between high temperatures and a higher prevalence of symptoms. Most of the studies show that high indoor air temperature in winter will like to cause more SBS symptoms compare to when the indoor air temperature is low.

The high humidity is present if the high amount of water is heated and evaporated to the surrounding environment. Relative humidity is the ratio between the actual amount of water vapour in the air and the maximum amount of water vapour that the air can hold at that air temperature. In some offices, humidity is usually kept between 40-70% because of computers

even though the optimum is 30-60%. However, in workplaces without equipped with air conditional system, or where the tropical country where the outdoor air quality will indirectly affect the indoor thermal environment, the relative humidity could achieve more than 70%. High humidity environments have a lot of vapour in the air, which prevents the evaporation of sweat from the skin. When the room temperature is high, humidity is important to allow the evaporation of sweat from human body to prevent facing heatstroke unconsciously (Kariya et al., 2016). Humans are sensitive to humidity in the air as it will affect the evaporation cooling action that is used by human to control body temperature. Human will feel warmer when the relative humidity is high. However, if the relative humidity is higher than 80%, the sweat from human bodies is unable to be release due to the disturbance of osmosis gradient. Besides, a high relative humidity (greater than 60%) in an area supported with enough warmth will cultivate mould spore germination and growth. The mould will cause people to experience symptoms such as difficulty in breathing and skin and eyes allergy (Kenney, 1998). Figure 2 shows some common sick building symptoms distribution.

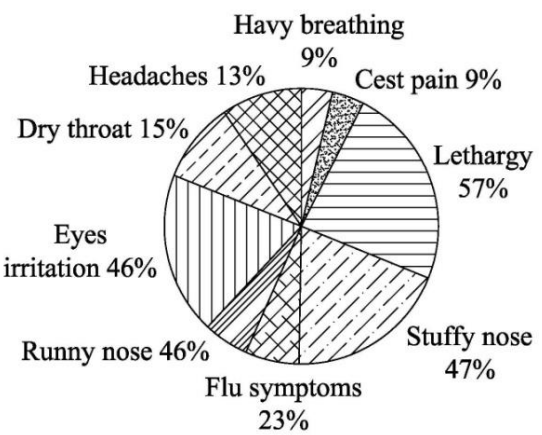

Figure 2. Common sick building syndrome symptoms distribution (Kenney, 1998)

Air movement will affect the human significantly by affecting the heat transfer. The higher the air velocity, the greater the rate of heat flow from the body through convection and evaporation. When the surrounding temperatures are within acceptable limits, the air velocity has no limitation on how fast or how slow it should be provided. The natural convection of air allows the continuous dissipation of body heat. When temperature increases, the natural air flow velocity will be no longer adequate. In this condition, the air velocity must be increased artificially, such as by the use of fans. Insufficient air velocity will cause stuffiness and air stratification. However, when air motion is too rapid, unpleasant drafts are felt by the room occupants (Nicol and Humphreys, 2002). In a study, the researcher states that the speed of air flowing across the worker and may help cool the worker if it is cooler than the environment temperature. Air velocity is a vital factor in thermal comfort because people are sensitive to it. If the air is still or stagnant in indoor environment which has artificial heat that is produced, the occupants will feel stuffy and it may also lead to build-up in odour, mostly mouldy smell. In contrast, moving air in warm or humid conditions can increase heat loss through convection for human bodies through sweating. Small air movement in cool or cold environments may be perceived as draught, which can cause skin dryness. The heat loss will be increase through convection if the room temperature is less than body temperature.

Physical activity also increases air movement, so air velocity may be corrected to account for a person's level of physical activity.

In the early and mid-1900's, building ventilation standards called for approximately 15 cubic feet per minute (cfm) of outside air for each building occupant after dilution and removal of body odours. As a result of the 1973 oil embargo, however, national energy conservation measures called for a reduction in the amount of outdoor air provided for ventilation to 5cfm per occupant. In many cases these reduced outdoor air ventilation rates were found to be inadequate to maintain the health and comfort of building occupants. Inadequate ventilation, which may also occur if heating, ventilating, and air conditioning (HVAC) systems do not effectively distribute air to people in the building, is thought to be an important factor in SBS. In an effort to achieve acceptable IAQ while minimizing energy. Figure 3shows some common causes of sick building syndrome

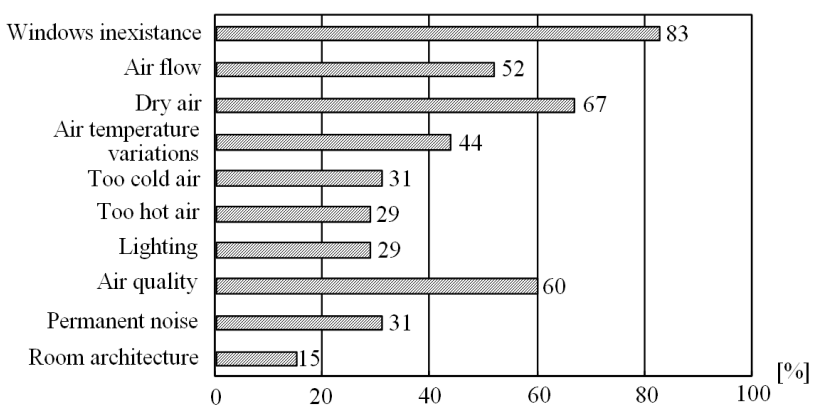

Figure 3. Common causes of sick building syndrome (Nicol and Humphreys, 2002)

Lighting is an important requirement for any places, especially in offices. The uniform illumination should be provided over the whole workplace. It is better if both natural and artificial lighting is provided in the same time. To save cost and to provide lighting for certain places that require, localized lighting may be provided. Good lighting helps us to see dangerous conditions. Optimum lighting can soothe the eye irritation and discomfort. Poor lighting will affect workers' performance and increase absentees. Besides, the poor lighting may cause dangerous condition as the visibility will be lesser, thus increases the opportunity to cause errors. Besides, natural working posture may not be possible under poor lighting, thus resulting in musculo-skeletal strain (Passarelli, 2009).

Artificial lighting is normally equipped when work especially during modern time, as most of the offices are using open plan design. Thus, general lighting and localized lighting are needed to suit different purposes. Normally, general lighting is like the fluorescent lights and is placed at the ceiling, it is designed for movement and casual work, such as filing (Pourzeynali and Jooei, 2013). Whereas localized lighting provides intense and central illumination at the workstations. It will illuminate only on specific work areas, like a desk. Natural lighting is good for health rather than artificial lighting. However, it is often undependable varies according to the weather conditions and even window spacing. Besides, it cannot provide enough illuminance to the occupants in the open plan office, and also it cannot provide the lighting during night time. Therefore, most of the modern offices are

equipped with combining natural and artificial lighting. While for inadequate lighting condition, it may cause one to squint and cause eye irritation. A condition called backlighting will happen when one's body or a thing avoid the lighting from penetrate to the destination. It will cast the shadows on the destination and decrease the lighting level on the work place. The optimum lighting is 300-500 lux, but the least lighting level should not be lesser than 200 lux. In this research, the Light Meter Extech is being used to measure the indoor lighting level. While questions will be implemented in the questionnaire to ask the occupants about the satisfaction level and comment about the lighting system in the building in user perception

The mechanical systems and equipment that provide thermal comfort to the occupants in office are often the risk factor that leads to noise problems. If they are at bad performance and with poor maintenance, they can create excessive noise that will cause the human health problem. Besides, rapid flow of air through ventilation ductwork can also transmit noise throughout a building. Additionally, beside HVAC system, equipment such as phones, computers; traffic noise; and people noise from conversation and argument also are the source of noise that will cause problem every day. Both high and low levels of noise can lead to SBS. According to the Academy of Otolaryngology, if the sound level is louder than 85 decibels (dBA), or similar to normal conversation sound level, it can affect irritate human's hearing and thus their health. While when the sound level is low, such as buzzing from fans or photocopy machine, it will cause headache and dizziness. However, the research also state that high frequency noises can actually mask the effects of low frequency noise. A study published in 1996 revealed that many occupants experienced the following symptoms: fatigue, headache, nausea, concentration difficulties, disorientation, seasickness, digestive disorders, cough, vision problems, and dizziness. After conducting the test on places, they discover the occupants have exposed to the low frequency noise of 7 Hz for long period. This study asserted that low frequency noise from the ventilation system was amplified in the tightly sealed rooms in long-term exposure will triggered a number of sick building syndrome symptoms (Passarelli, 2009). A study also states that comparing a quiet office, noisy offices will make their worker to have mood swing, particularly in negative mood. Besides, certain high or low level of noise can make a person to lost interest or unable to work well, eventually will bring stress to such worker. Once a person is in stress condition, the hormones will be imbalance: the long term release of epinephrine and norepinephrine found in urine and blood will cause people to feel even depressed. Besides, it will cause insulin resistance with the impact of memory lost. The noise range for an open plan office should be between 49-58dBA. In this research, the Sound Level Meter Extech is being used to measure the noise level within the office. While questions will be implemented in the questionnaire to ask the occupants about the satisfaction level and comment about the noise level in the building in user perception.

METHODOLOGY

Survey tests that are done within the case studies also provide useful primary data to this research. It can provide the most recent and precise information regarding various indoor air quality parameters that the offices possessed. Assessment of Indoor Environmental Quality (IEQ) of 6 buildings which referred as Building A, B, C, D, E and F were carried out conferring to the ASHRAE Standard 55-2010. The indoor environmental quality was measured by means of the Hygro Thermometer Clock which was used to measure the room temperature and relative humidity (%RH). In addition, hot Wire CFM Thermo-Anemometer

was used to evaluate the air velocity and air flow in the case studies. Besides, the wide Range Light Meter was used to quantify the lighting level of the case studies. Lastly the Digital Sound Meter was used to assess the noise level in all 6 buildings.

RESULTS AND DISCUSSION

Temperature

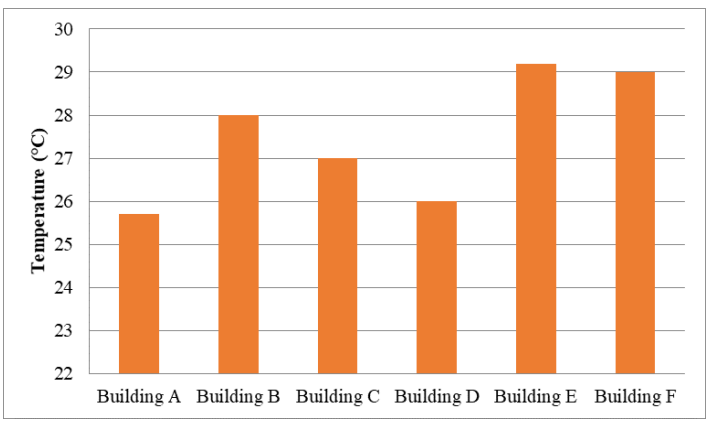

Figure 4. Temperature test results

Figure 4 shows the indoor temperature of each case study and also the acceptable highest and lowest indoor temperature for an office. There are two case studies exceed the optimum high temperature, they are Building E and Building F. While the Building B hit accurately on the optimum high temperature. Building A, Building C and Building D are within optimum temperature. The case studies tend to control the indoor temperature further high from the optimum low temperature. The analysis clearly indicated that in every case study, the occupants tend to control the indoor temperature further high from the optimum low temperature or more than the optimum temperature. The occupants disagreed with the ideal temperature, which is 24℃, which is suggested by ASHRAE. An air temperature of 27℃ would make majority of the occupants satisfy with the working environment in their research

Relative Humidity

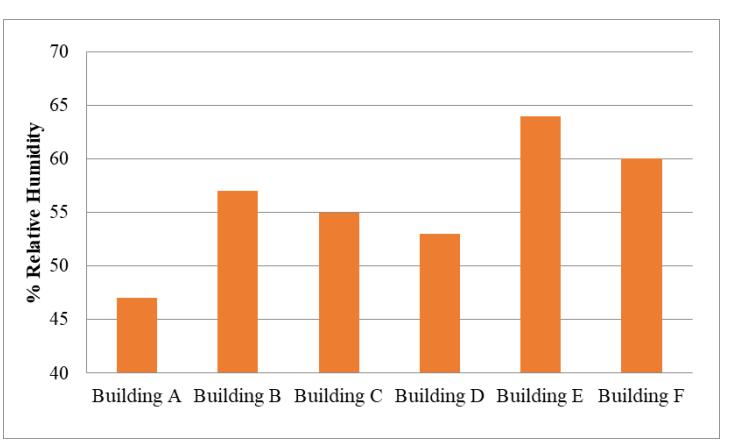

Figure 5. Humidity test results

Figure 5 shows the indoor humidity of each case study and also the optimum peak and valley indoor humidity for an office. The humidity of case studies are basically falls within the comfortable area. The only case study that has problem on humidity is Building E. It has humidity that is higher than optimum.

Air Velocity

Figure 6 shows the air velocity within each case study and also the optimum air velocity that should present in an office. The air velocity of case studies should not be higher than the optimum high value and also should not be lower than optimum low value. Building A has the air velocity that is lower than the optimum low value. While other case studies have indoor air velocities within the optimum range.

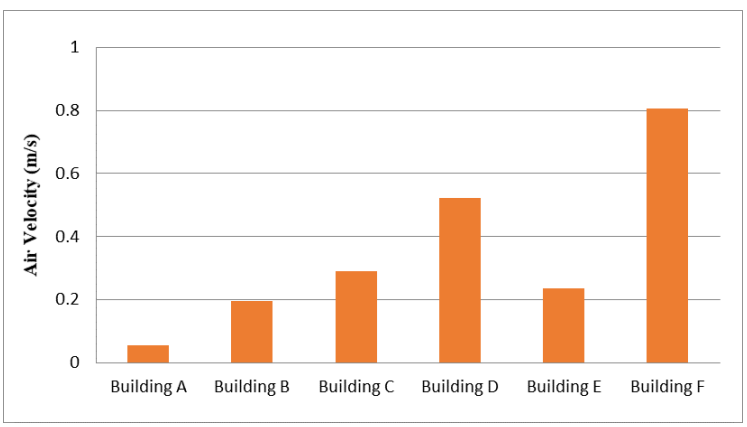

Figure 6. Air velocity test results

Air Flow

Figure 7 shows the air flow of each case study and also the optimum outdoor air flow within an office. The air flow of Building C and Building D did not achieve the minimum air flow that should be present in an office. Other case studies have optimum air flow. However, there is an outlier that fall far from the optimum which is Building F.

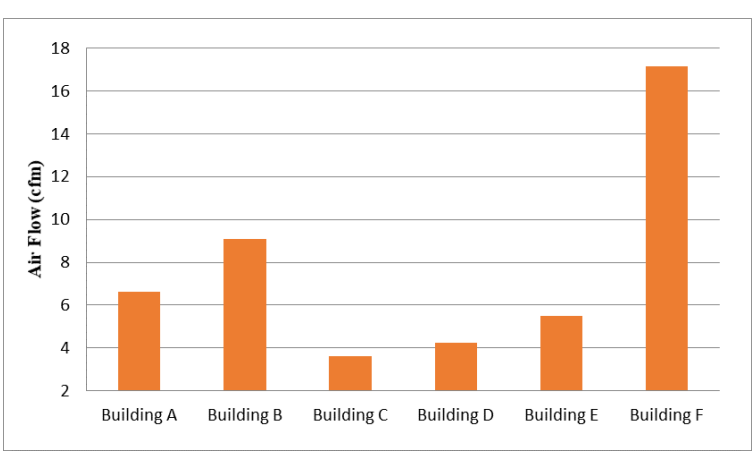

Figure 7. Air flow test results

Noise Level

Figure 8 shows the noise level of each case study and also the optimum noise level within an office. The condition divides into half-half. Half number of the case studies fall within the comfort zone, while half number of them has high noise level from optimum. Building A, Building B and Building E have optimum noise level within their office, while Building C has highest noise level within the six case studies.

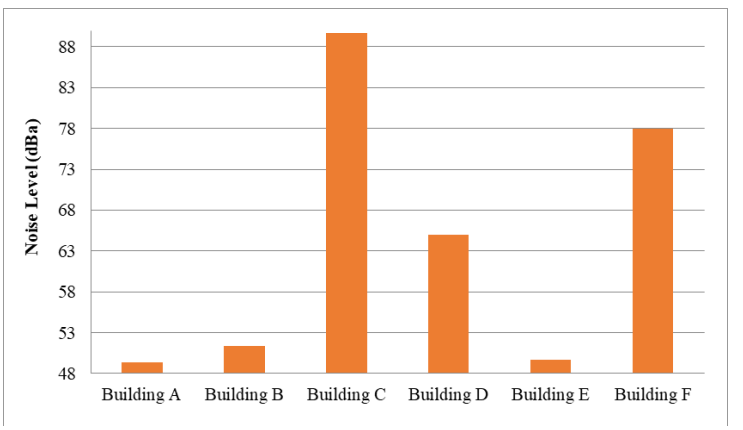

Figure 8. Noise level test results

Building F has the second highest noise level while Building D has slightly higher noise level than the optimum. High noise level from Building C is from the maintenance work of neighbour unit. The vibrations from the neighbourhood of buildings have always been indicated as a contributory factor for the increase of noise level.

Lighting

Figure 9 shows the lighting level (illuminance) of each case studies and also the optimum illuminance that an office should possess. Lighting is the most worried parameter among all as most case studies have problem regarding it. Only two case studies fall within the optimum condition, which are Building A and Building C. The others are all having low lighting level. The case studies that have the worst lighting condition are Building B and Building E.

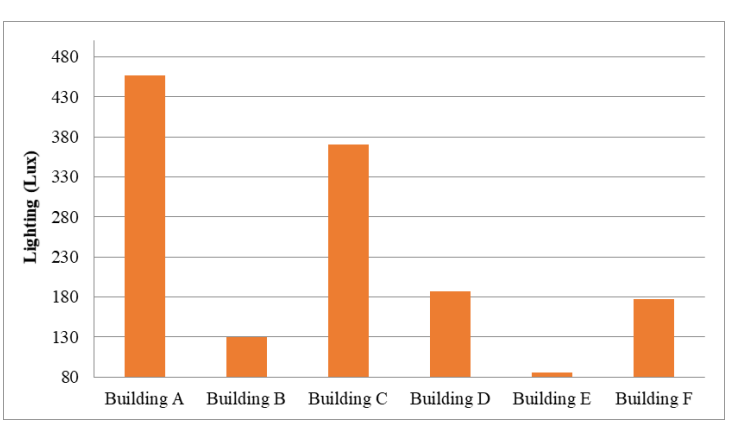

Figure 9. Lighting test results

CONCLUSION

The objective if this paper is to determine the current indoor environmental quality of the selected offices in Penang Island. This objective has been attained. Six case studies were selected according to office size. Permission and cooperation was given by the management department of all case studies to conduct some indoor environmental quality assessment within their premises. Through indoor environmental quality measurement, it is found that most of the offices facing the lighting and noise problem.

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