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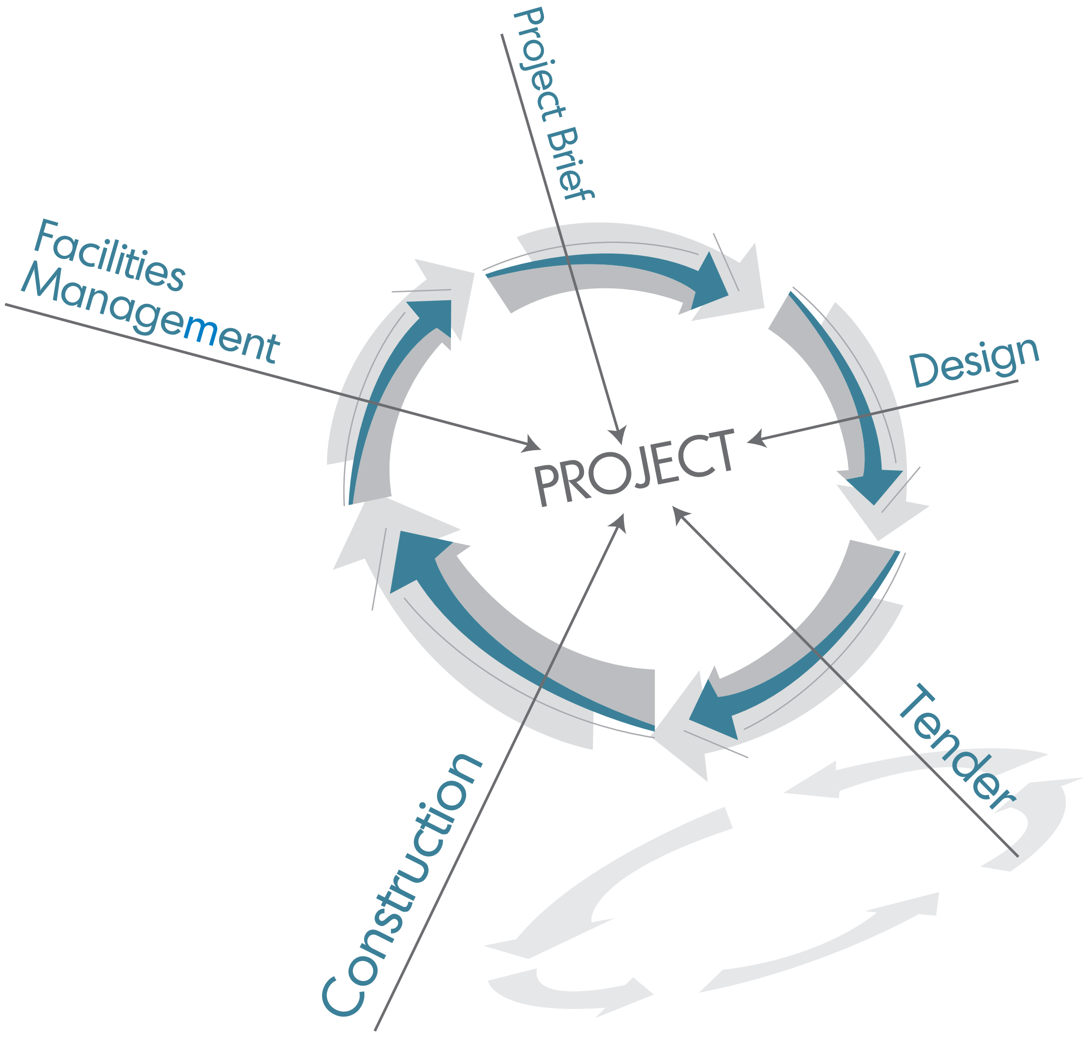

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Construction Research Institute of Malaysia (CREAM)
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Editorial

Welcome from the Editors

Welcome to the thirty-seventh (37th) issue of Malaysian Construction Research Journal (MCRJ). In this issue, we are pleased to include eight papers that cover a wide range of research areas in construction industry. The editorial team would like to express our sincere gratitude to all contributing authors and reviewers for their contributions, continuous support and comments.

In this issue:

Loo Kok Hoo and Foo Chee Hung compared wood wool cement panels (WWCP) and conventional brickwall on thermal performance properties. Methodology use in this study is using test cell for both components involving field measurements of air temperature, globe temperature and relative humidity (RH). The findings show that WWCP performs better than the conventional “brick and plaster” on thermal performance. The result from the study shows that WWCP humidity level is higher in the daytime. It is suggested that further study should including a Malaysian housing prototype which is a landed terrace house.

Farhanah Faisal et al., reviewed the factors that influence the cost increase for reinforced concrete structural frames in Malaysia by incorporating the seismic design. The narrative literature review was used as the methodology of the study. The findings show that cost increases would be because of designing the building with the same reference PGA, in which buildings with the lowest ductility class require the highest amount of steel reinforcement. It also shows that the reference PGA directly influences the material cost by increasing the base shear force.

Har Einur Azrin Baharuddin et al., assessed internal early preparation through the stakeholder engagement process for infrastructure projects. Case studies, project documentation, and interviews were used as the methodology for assessing early preparation. A comparative study involving two different infrastructure projects case studies in New Zealand and Malaysia. The finding shows that there are significant attributes arising from the initial early preparation process involving stakeholder engagement in large infrastructure projects. It also provides insight into the factors of engaging stakeholders and the public early and closely, improves the transparency of information, and understanding the design concept would help in improving the international early preparation of stakeholders in projects.

Mas Anasha Rosman et al., investigated the benefits and challenges of Energy Management System (EMS) implementation in building sustainability components. The survey questionnaire was used to distribute to the G7 contractors registered under Construction Industry Development Board (CIDB). The findings from the survey questionnaire found that three main components contributed to the benefits of EMS environmental, economic, and social benefits. However, the challenges of EMS adoption were identified as knowledge/information, legal/contractual, and economic/financial. Several recommendations was also addressed in this study to implement the adoption of EMS.

Noor Akmal Adillah Ismail et al., assessed the Building Information Modelling (BIM) capabilities toward a better safety climate in the Malaysian construction industry. The methodology used in this study was a qualitative approach through semi-structured interviews and discussions with selected representatives from both private and government sectors. The data was then analyzed using content analysis. The finding shows that Visualisation for Safety and Simulation for Safety is the most important factor of BIM capabilities. The study also provides insights towards outlining potential BIM capabilities on policy or Safety Rules and Procedure implementation by the government or top management of the organization.

Siti Aekbal Salleh et al., reviewed the significant differences of Land Surface Albedo (LSA) and Land Surface Temperature (LST) across the multiple types of land use and land cover (LULC) using remote sensing technique. The methodology use in this study was Emerging Geospatial technology application for urban studies. The data then analysed using ANOVA Post Hoc Tukey's Honesty Significance Difference (HSD) to performed 25 comparisons of five (5) land use land covers. The findings shows that there are significant differences in term of values of LSA and LST across the LULC in year 1999. It is indicated that it is important to quantify LSA and snow free region have a significance difference value.

Natasha Dzulkalnine et al., analysed the level of residential satisfaction of public housing in Klang Valley. Survey questionnaire was conducted to the 600 residents of public housing in Klang Valley. The data was analysed using descriptive statistics, realibity test, ANOVA and Post Hoc Tests. The Post Hoc test was analysed between income group. It can be concluded that higher income group have higher expectation than the lower income group. The findings show that the main issue of public housing are physical issue involving limited area for washing area, inadequate size of kitchen and poor quality of interior construction. Besides that, the factors of satisfaction are garbage disposal, accessibility to city centre and types of house occupied.

Nasrudin Sharkawi et al., identified the sustainability energy initiatives implemented at eight (8) selected local authorities from City Hall and Municipal Council categories. Qualitative method was used through semi structured interview between eight key practitioners with Facilities Management (FM) experiences. It found that the commitment from the local authority organisations towards implementing sustainable energy practices was still at an initial stage, with seven initiatives found. Introducing energy-saving techniques, installing energy-saving technology and energy-saving equipment, and encouraging the involvement of officers and staff in energy-saving was identified as the most significant initiatives.

Arniatul Aiza Mustapha and Nur Maizura Ahmad Noorhani affirmed the process, flow and order of interior design project delivery process in establishing interior design work development plan (IDWDP). This study adopted the Guttman Scale with 20 questions were directed at 11 respondnets on the project delivery work phases only in the pre-contract using the purposive sampling. The finding shows that all parties and stakeholders participating in interior design project circles who seek to conduct transparent businesses, the implementation of the IDWDP may be useful.

Editorial Committee

A COMPARATIVE STUDY ON THERMAL PERFORMANCE PROPERTIES OF WOOD WOOL CEMENT PANELS AND CONVENTIONAL BRICKWALL

Loo Kok Hoo[1] and Foo Chee Hung[2]
[1]Surbana Consultants Sdn Bhd, Kuala Lumpur, Federal Territory of Kuala Lumpur, Malaysia.
[2]MKH Berhad, Jalan Semenyih, 43000 Kajang, Selangor, Malaysia.

Abstract
Building façade is a significant comfort parameter for buildings. The selection of material used for building façade can greatly influence the building's thermal performance, thereby affecting the overall building sustainability. This paper compares thermal performance properties of wood wool cement panels (WWCP) with the conventional "brick and plaster" wall, so as to assess if WWCP can be an alternative material for wall construction in the tropical climate country like Malaysia. Two test cells were constructed, both using WWCP and conventional "brick and plaster" wall. Field measurements were conducted over a period of four months, to monitor air temperature, globe temperature, and relative humidity (RH); followed by validation with simulated air temperature, dry resultant temperature, and RH. Then, simulations on mean radiant temperature (MRT) and conduction gain were run, to evaluate the thermal performance of WWCP and conventional "brick and plaster" wall. Validation shows that simulated results are not only in congruent with field measured readings, but also can be used for extrapolating other thermal performance properties. Meanwhile, through simulations, WWCP is proven to be comparable to, and somehow, possesses better thermal performance than the conventional "brick and plaster" wall. Furthermore, WWCP can also function effectively as roof insulation.

Keywords: *wood wool cement panel; brickwall; thermal performance; building façade; tropical.*

INTRODUCTION

Built environments make a long-term impact on the communities they house as well as the surrounding environment they located. Where they are, how well designed and built they are, and how well they knit into the fabric of existing communities, are factors that can influence the lives of people in a daily basis (Loo et al., 2016). Researches have shown that built environments are the major CO_2 emitters and contribute substantially to climate change due to their high energy, water, raw material, and land consumption (Hamid et al., 2014). About 40% of the total world energy consumption is initiated from the built environments, and the property industry was found to contribute to about 20% of CO_2 emissions via energy use, waste and water production (Mustaffa and Ahmad Baharum, 2009). Given that buildings are normally planned to last for 50 to 100 years, and that building envelope contributes more than 60% of the building surface in terms of walls and roof, understanding the performance of the building envelope to the successful construction and operation of a building can help to enhance building sustainability (Manioglu and Yilmaz, 2006). Wall, in particular, is a major contributor to energy saving as well as maintaining internal comfort conditions (Irene and Robert, 2007). It aims to block adverse external environmental effects while maintaining internal comfort conditions with minimum energy consumption (Aksamija, 2016). In this sense, the selection of material used for the construction of wall is an important factor to building sustainability (Mahmoudkelaye et al., 2018).

There are a lot of materials available for wall construction. In Malaysia, the masonry clay brick and sand cement brick are the most common materials used for wall element in building construction. However, these materials are produced from non-renewable natural resources, highly carbon emission, heavy-weight, labor intensive, and consumed long construction period (Md Noh et al., 2016). The development of wood-based products with cultivated trees has been a popular sustainable solution for building industry in the developed countries. For instance, mineral-bound wood-wool composites were already produced in the early 1900s (Aro, 2004; Wolfe, 1999).

The wood-wool cement composite panel (WWCP) is considered as a wood-based product. It is manufactured from renewable resource – fast grown timber species known as Kelampayan. It is in general strands, particles or fibers of wood mixed together with Portland cement as a mineral binder and manufactured into panels (Mrema, 2006). WWCP has been a commonly used building material in the temperate countries for years and was found as a good alternative material as building envelope. It is characterized as less embodied carbon emission, lightweight, easy to process and fabricate, and with attractive features such as fire resistance, wet and dry rot resistance, termite and vermin resistance, thermal insulation, acoustic performance, and the acceptance of a wide range of finishes (Md Noh et al., 2016). Previously, the application of WWCP was limited to non-structural application such as ceiling, partition, sound insulation panel and decorative panels. Based on several studies conducted on mechanical properties of WWCP, the results suggested that WWCP have the potential to be used in structural applications as the properties meet the minimum requirement specified in ISO and DIN 1101 standards (Ahmad et al., 2011; Ashore et al., 2011; Md Noh et al., 2014).

Despite of its advantages, WWCP is rarely known and was recently introduced in Malaysia – a tropical climate country. Literature review found that only a few studies on WWCP were conducted in Malaysia, and these studies mainly focus on the mechanical properties of WWCP. For example, Md Noh et al. (2016) studies the structural behavior of WWCP, with different fabrication techniques, panel thickness, bonding agent thickness, plastered, and without surface plaster, under axial and diagonal compression loads. The results show that the fabrication technique of wallettes significantly influenced the load carrying capacity of wallettes. Fatihah (2011) investigates the axial compression behavior of wall fabricated using 50 mm and 75 mm thicknesses of wood-wool cement composite board which vertically stacked at running bond pattern. The results indicate that buckling failures at the panel joint were observed for wall without surface plaster, whereas the highest loading capacity was reported for 75 mm thick walls with surface plaster. Meanwhile, in a study to determine the density, flexural, compressive, and tensile strength of wood-wool cement composite boards (WWCB) with wood-wool sized 1.5 mm, 2.5 mm, and 3.5 mm; and board thickness of 25 mm, 50 mm, and 75mm; Ahmad et al. (2011) concluded that the compressive strength increased with thicker boards but the modulus of elasticity and modulus of rupture declined as the thickness of the board was increased. In short, due to variant of the vegetation composite, the structural strength of the WWCB is not consistent compared to reinforced concrete. However, in another study, Firdaus (2012) investigates the performance of a timber frame wall in-filled with 50 mm thick wood-wool cement composite board under in-plane lateral load. The results show that using timber frame and diagonal corner bracing can effectively increase the lateral load capacity of the walls. Also, Ahmad et al. (2014) investigated the fire resistance performance of reinforced concrete column embedded with wood-wool cement composite board, and the two hours fire exposure has satisfied the requirement of BS 476: Part 22: 1987.

Realizing that the key to effectively design a building with comfortable indoor environment in the tropical climate is through passive design strategy (Altan et al., 2016) – which is by taking the advantage of the appropriate building orientation, building materials, and landscaping – the selection and use of materials for the construction of building envelope are of crucial to prevent or minimize heat gain. There is a high potential that WWCP can be used as an alternative material for the construction of tropical buildings, provided there is an in-depth investigation on its thermal performance properties, as well as reliable field test on its construction properties which is defined as the material or groups of materials in a particular configuration as used in the building. It is with this background the present study is conducted: to compare the thermal performance properties of WWCP with "conventional brick and plaster wall", so as to assess if WWCP can offer an alternative option for wall construction in a tropical climate country like Malaysia.

MATERIAL AND METHODOLOGY

At present, the only company in Malaysia that produces WWCP is Duralite (M) Sdn Bhd. The product is marketed under the name of "Duralite Board" (Figure 1). It is manufactured in accordance with the international certification of BS1105 (England) and DIN1101 (German) standards. The size of WWCP used in the study is 75mm thick, with 12.5mm cement rendered on both sides. Meanwhile, the size of sand brick used for comparison is 100mm thick, also with cement plaster of 12.5mm on both sides.

The methodology used in this study involves both the field measurement and IES simulations, with the aim of capturing and analysing environmental factors that deemed to have impact on the thermal performance of WWCP and "conventional brick and plaster wall". In this study, thermal performance of a building material was evaluated in terms of its construction properties, which tend to reflect the integrity of a particular material when interacting with other architectural elements to perform the functions of a habitable building, rather than a standalone entity.

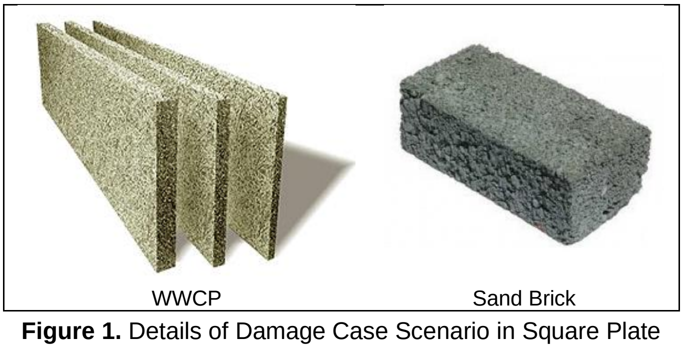

Figure 1. Details of Damage Case Scenario in Square Plate

Field measurement on air temperature, globe temperature, and relative humidity (RH) were collected through the experimental test cells, and were compared with the simulated air temperature, dry resultant temperature, and RH. Later on, simulations on mean radiant temperature (MRT) and conduction gain for the test cells were run to evaluate the thermal performance of WWCP and conventional "brick and plaster" wall. Details for both the field measurement and IES simulation are depicted in the following sections.

Field Measurement

Two experimental test cells, each with the size of 3m x 3m and with the same design layout were constructed based on natural ventilation condition and in the north-south orientation (Figure 2). The field measurement took place in the main campus of the Universiti Putra Malaysia (UPM), with the coordinate of 3.00°N 101.7°E, for a period of four months; in which the first phase is conducted from February to March, while the second phase is from September to October. Both Figure 3 and 4 shows the architectural drawings of TC1 and TC2, respectively.

Site of Field Measurement | Construction of TC1

Construction of TC2 | Completed Test Cells

Figure 2. Experimental Test Cells

Babuc data logger and Hobo meter were used to measure the indoor condition of both test cells. The Babuc data logger was put on a table with 1m height, which was placed in the center of the test cells. It was calibrated into every 30 minutes recording. All the louvers and windows were opened with the door kept close. The data was taken and exported to the computer in excel format after one week. In terms of the Hobo meter, it was installed on the internal walls of the test cells right above the window. It was calibrated in the computer at every 5 minutes' interval. Similarly, the data was taken and exported to the computer in excel format after one week. The results were then converted into graphs for detailed investigation and interpretations.

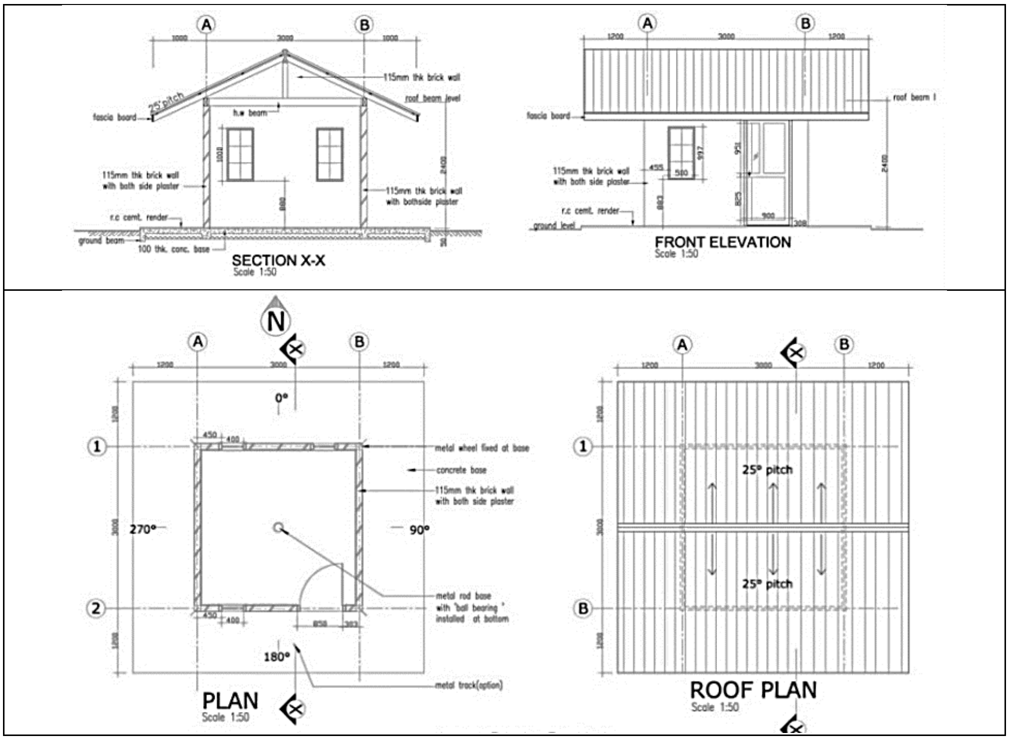

Figure 3. Architectural Drawing of TC1

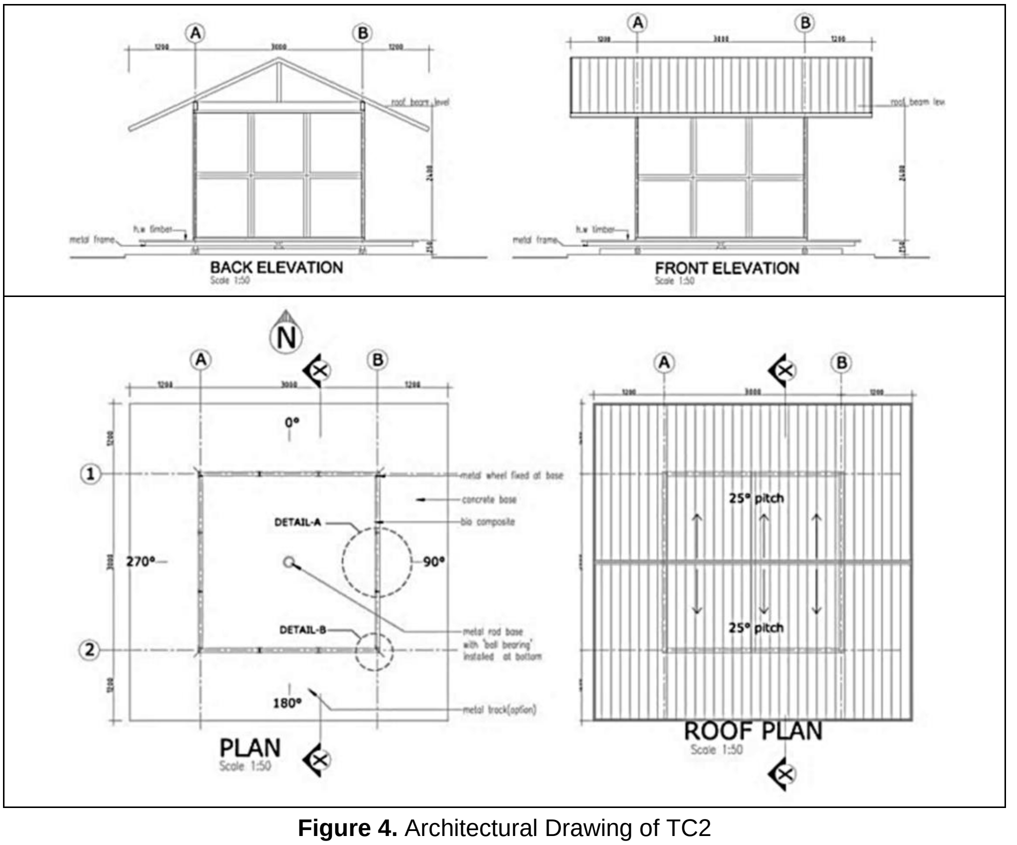

Figure 4. Architectural Drawing of TC2

IES Simulation

IES software was used to simulate the indoor thermal condition of the two test cells, as well as to validate the data obtained through field measurement. Figure 5 shows the test cell models constructed for simulation purpose. Validation was conducted to compare air temperature and RH obtained from field measurement with the simulated air temperature, dry resultant temperature, and RH. Since the location of field measurement is about 17km from the center of Kuala Lumpur city, the zone setting and thermal properties for local climate simulation were based on the one applicable in Kuala Lumpur, which is as summarized below:

- Very small variation in monthly temperatures (less than 8ºC).
- Mean daily temperature of the hottest month (February/March) is 27.8ºC.
- Mean daily temperature of the coolest month (December) is 25.9ºC.
- Daily temperatures exceed the value of 25ºC more than 50% of the time.
- Monthly relative humidity exceeds 70% with a mean annual value of 83%.
- RH exceeds 55% most of the time.
- Wind speeds are quite low with a mean value of 1.2 m/s.
- Prevailing winds blow from the North East, East and South East.
- Rainfall exceeds 200 mm/month for 8 months in a year.

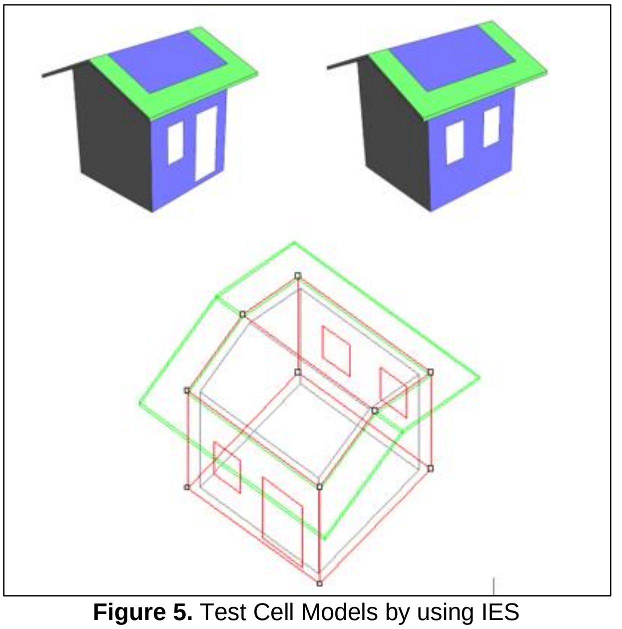

Figure 5. Test Cell Models by using IES

Thermal performance of a building refers to the process of modelling the energy transfers between a building and its surroundings. In the case of a non-air-conditioned building, it involves the calculation of temperature variation inside the building over a specified time and helps to estimate the duration of uncomfortable periods. As such, simulation on mean radiant temperature (MRT) and conduction gain for the two test cells were run, to evaluate the thermal performance (in terms of construction properties) of both WWCP and conventional “brick and plaster” wall. These quantifications enable one to determine the effectiveness of the design of a building and help in evolving improved designs for realizing energy efficient buildings with comfortable indoor conditions.

MRT was selected as a property of thermal performance as it has a strong influence on thermo-physiological comfort indexes such as physiological equivalent temperature (PET) or predicted mean vote (PMV). What one experiences and feels relating to thermal comfort in a building is related to the influence of both the air temperature and the temperature of surfaces in that space. MRT is expressed as this surface temperature and is controlled by effective design of the building, interior and with the use of high temperature radiant cooling and low temperature radiant heating.

Meanwhile, the conduction gain was simulated as it reflects the heat gain or loss that is transmitted by means of radiation, conduction, and convection through various building structural elements such as walls, floors, roof, door etc. The subsequent thermal response determines the amount of energy required for heating and cooling to maintain an optimal comfort conditions for the occupants. In this study, the heat gain or loss is measured in KW through the following elements: (i) internal surfaces of externally exposed elements; (ii) external wall; (iii) roof; (iv) window and glazing; and (v) ground floor.

RESULTS AND DISCUSSION

Data Collection Through Field Measurement

Figure 6 shows the typical example of daily air temperature obtained from the two test cells through filed measurement. Since the variations of temperature are fairly consistent throughout the year, and the daily temperatures did not show any significant differences, the discussion on field measurement results will only focus on the reading set obtained in the month of September.

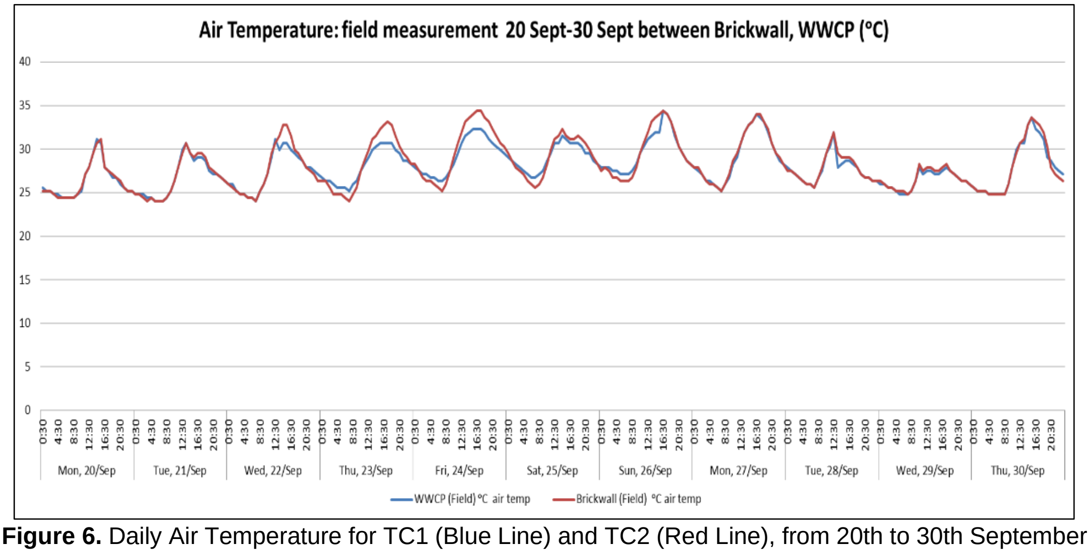

Figure 6. Daily Air Temperature for TC1 (Blue Line) and TC2 (Red Line), from 20th to 30th September

In general, the daily air temperature (Figure 7) and globe temperature (Figure 8) show a similar pattern. Readings from TC 1 (with sand brick wall) and TC2 (with WWCP wall) are almost overlapping, indicating that no significant differences were observed. However, TC1 is getting hot faster during daytime, from 9:00am to 5:00pm, in which the peak indoor temperature is higher than the one in TC2 by an average of 0.60ºC. At night, especially during the period of 6:00pm to 12:00am, indoor temperature is higher in TC2 than the one in TC1 by an average of 0.52ºC; and both test cells take about 10 to 13 minutes to reach the lowest indoor temperature. The implication is that, WWCP can function better as a heat buffer to delay the heat transfer to indoor.

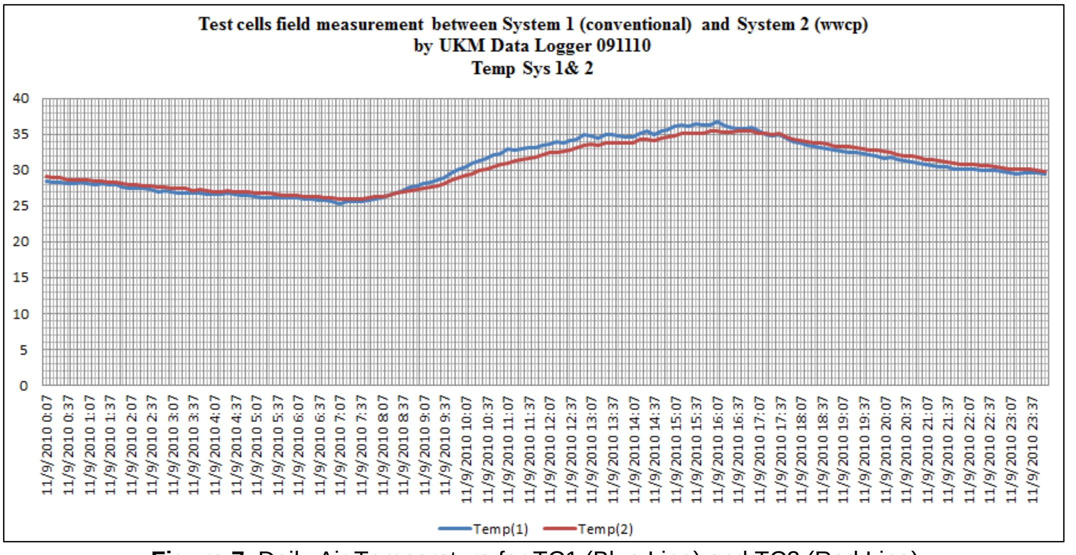

Figure 7. Daily Air Temperature for TC1 (Blue Line) and TC2 (Red Line)

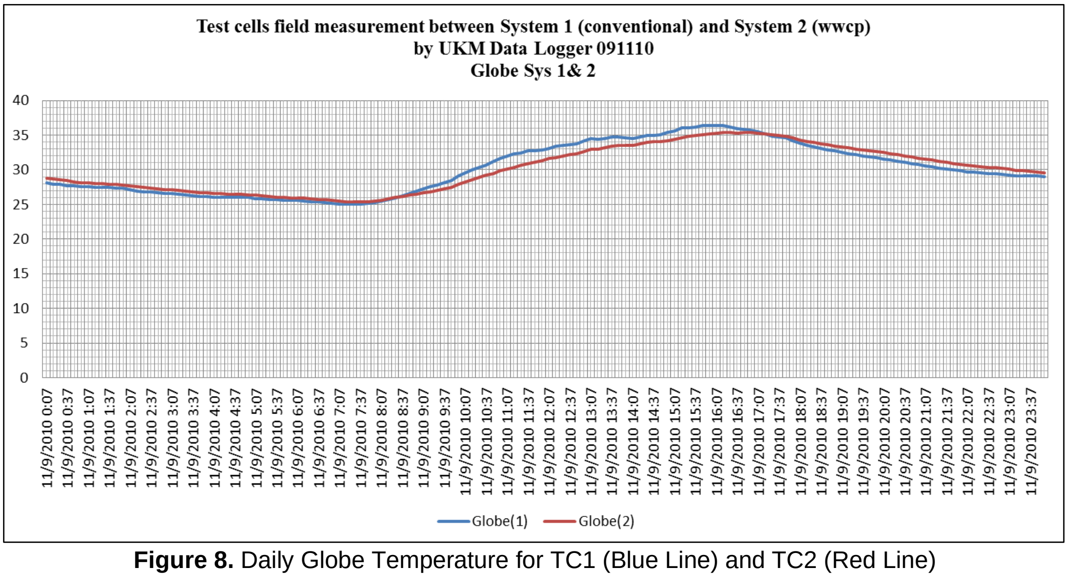

Figure 8. Daily Globe Temperature for TC1 (Blue Line) and TC2 (Red Line)

In terms of relative humidity (RH) (Figure 9), it was found that TC2 is more humid than TC1 during daytime, while TC1 is more humid than TC2 in the evening and at night. The recorded RH in TC1 is higher at night, especially from 12:00am to 9:30am. Thereafter, RH in TC2 is higher until 3:00pm. Starting from the evening, which is after 5:30pm, RH in TC1 becomes higher than the one in TC2. This is due to the air cavity in WWCP, where humidity in the air is partly penetrated into the cavity at night and hence reduces the humidity level in the air. Meanwhile, during daytime, water vapor in the cavity started to evaporate due to the sunlight; and hence, the humidity level in WWCP is higher in the daytime. This has advantage to the indoor environment as it helps to cool down the air temperature in the day and reduce humidity in the night. The peak value of RH in both TC1 and TC2 is 72.97% and 68.33%, respectively; while the lowest value of RH in both TC1 and TC2 is 45.28% and 47.06%, respectively. It was observed that RH in TC1 always reaches the lowest value at a faster pace, with an average lead-time of 102.86 minutes.

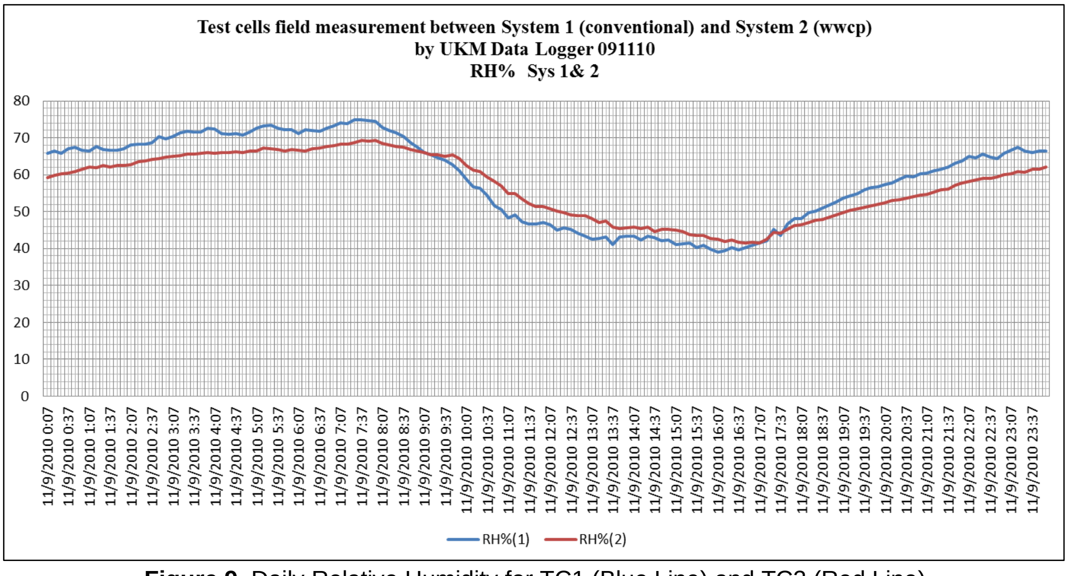

Figure 9. Daily Relative Humidity for TC1 (Blue Line) and TC2 (Red Line)

Data Validation with IES Simulated Results

The IES simulated air temperature and dry resultant temperature are as shown in Figure 10 and Figure 11. In general, both graphs show a similar pattern to the one obtained from field measurement, in which temperature in TC2 is higher at night while lower in daytime than the one in TC1. The average difference of air temperature between field measured and simulated results is 0.33ºC and 0.46ºC, for both TC2 and TC1, respectively. In terms of dry resultant temperature, the average difference was even smaller, which is of 0.2ºC and 0.17ºC for both TC2 and TC1, respectively (Table 1). Small difference that ranges within ±0.5ºC indicates that the simulated results are not only in congruent with field measured readings, but also can be used for extrapolating other thermal performance properties.

Table 1. Test Cells – Field Data and IES Data Comparison

Item	TC2		TC1	
	Field Measurement	IES Simulation	Field Measurement	IES Simulation
Average Air Temperature	27.96	27.63	28.12	27.66
Difference	0.33		0.46	
Average Dry Resultant Temperature	27.96	27.76	28.12	27.95
Difference	0.2		0.17	

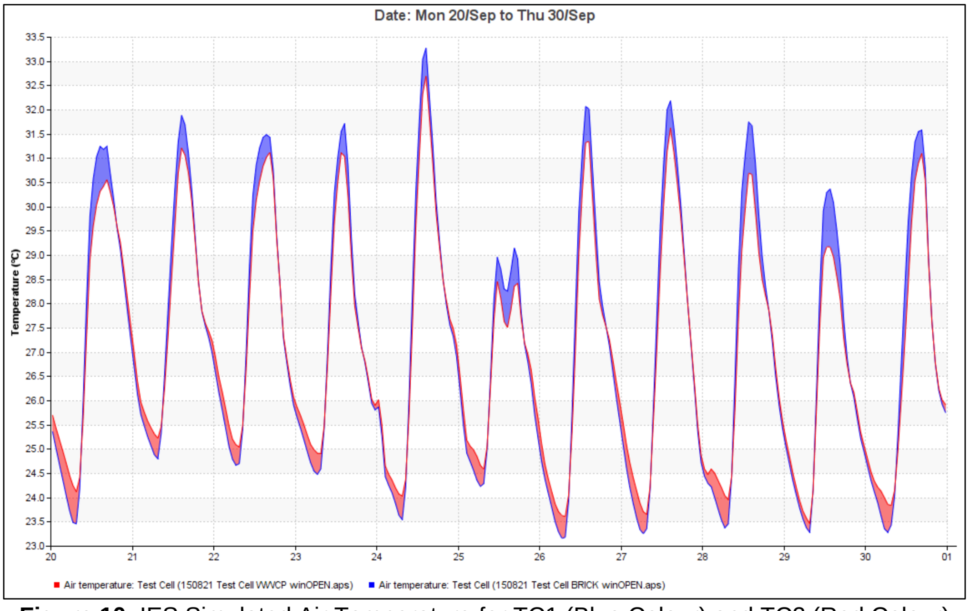

Figure 10. IES Simulated Air Temperature for TC1 (Blue Colour) and TC2 (Red Colour)

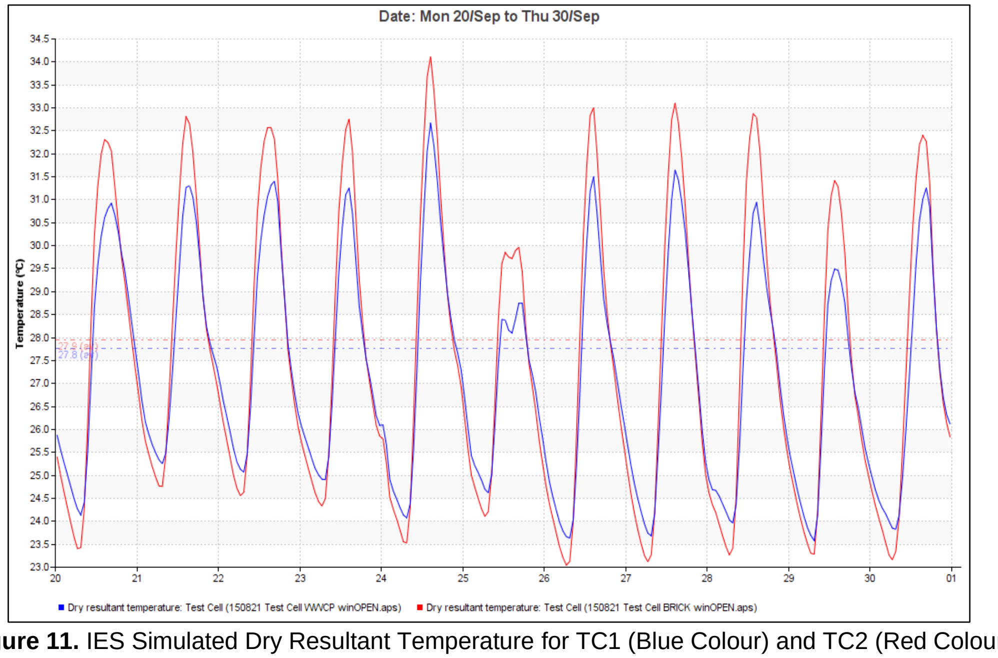

Figure 11. IES Simulated Dry Resultant Temperature for TC1 (Blue Colour) and TC2 (Red Colour)

IES Simulation for Thermal Performance Properties

The simulated MRT for TC1 and TC2 are as shown in Figure 12. TC1 was consistently having a higher MRT than TC2 during the daytime, while having a lower MRT than TC2 at night. The temperature difference at the upper limit was 1.1ºC as compared to the lower limit of 0.4ºC. This means WWCP always possesses a lower MRT than the conventional "brick and plaster" wall; and somehow, the range of temperature for WWCP is narrower, which is 1.2ºC as compared to 1.4ºC for the conventional "brick and plaster" wall.

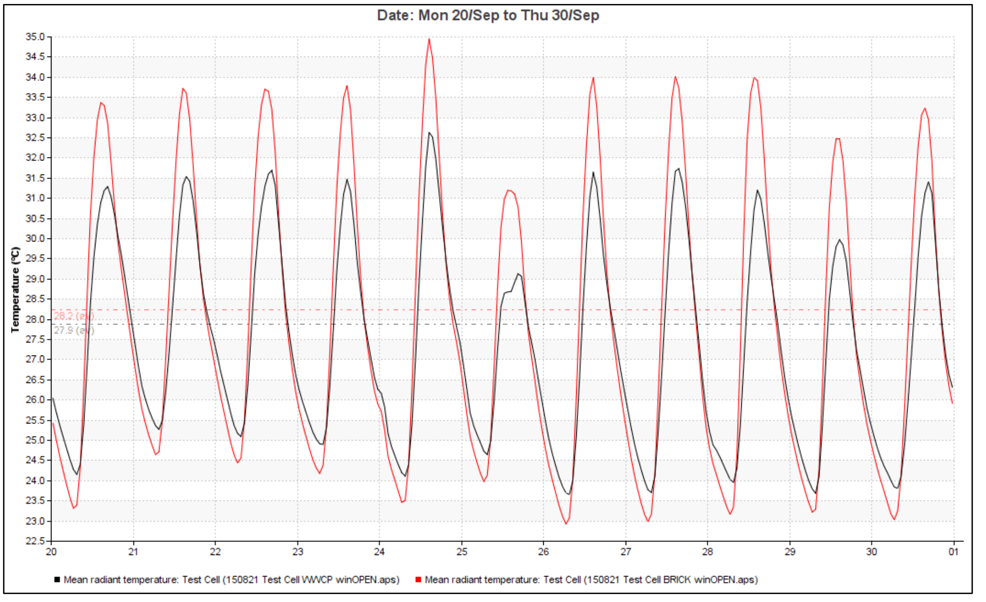

Figure 12. IES Simulated MRT for TC1 (Blue Colour) and TC2 (Red Colour)

In terms of conduction gain, the total energy gains (in KW) by the test cell through walls, roof, external door, external glazing and ground floor is 0.1939KW for TC1 and 0.0893KW for TC2, with a difference of 0.1046KW (Table 2). This indicates that, being the main material of building façade, the conventional "brick and plaster" wall tends to gain more heat than WWCP as an alternative wall construction material; and the heat gained is released into the internal space leading to a higher indoor MRT.

Table 2. Heat Gain/Loss (KW) for TC1 and TC2

Conduction Gain through	TC1	TC2	Difference (TC1 – TC2)
Internal surfaces	0.0135	0.0188	-0.0053
External wall	0.0654	0.0281	0.0373
Roof	0.0933	0.0214	0.0719
External door	0.0037	0.0044	-0.0007
External glazing	0.0161	00148	0.0013
Ground floor	0.0019	0.0018	0.0001
Total conduction gain	**0.1939**	**0.0893**	**0.1046**

Among the building structural elements, heat conducted through roof accounts for 0.0933KW in TC1 and 0.0214KW in TC2, contributing to the largest portion of the total conduction gain. This is because roof is the largest exposed area to the Sun; and hence, most heat is absorbed by the roof. Heat gain through the roof in TC1 is about 4 times much higher than in TC2 as the material used for roof construction in TC1 is roof tiles installed on rafter; while in the case of TC2, roof tiles are installed on top of the WWCP layer, which helps to reduce conduction gain substantially.

Even if the same roof configuration is applied to both test cells, TC1 still absorbed more heat than TC2 (Table 3). This indicates that WWCP can perform as a good heat insulation for roof. In short, simulation on conduction gain shows that WWCP possesses a better thermal performance, in terms of construction properties, than the conventional "brick and plaster" wall, and is found suitable to be used as an alternative building material in the tropical climate country.

Table 3. Reconfiguration of Heat Gain/Loss (KW) for TC1 and TC2

Conduction Gain Through	TC1	TC2	Difference (TC1 – TC2)
Internal surfaces	0.0135	0.0188	-0.0053
External wall	0.0654	0.0281	0.0373
Roof	0.0933	0.0933	0.0719
External door	0.0037	0.0044	-0.0007
External glazing	0.0161	00148	0.0013
Ground floor	0.0019	0.0018	0.0001
Total conduction gain	**0.1939**	**0.1612**	**0.0327**

CONCLUSION

The main principle of building design in tropical climate is to keep indoor temperature as low as possible through the reduction of heat gain. Investigation through field measurement and IES simulation indicates that WWCP not only can thermally perform better than the conventional "brick and plaster" wall, but also can function as roof insulation that can substantially lower down the overall conduction gain into the indoor environment. This is largely attributed to the non-monolithic nature of WWCP, which consists of pores, gaps, and tiny spaces that contain air, moisture, or water droplets that can affect the heat exchange within the panels. Whereas, the conventional "brick and plaster" wall is a monolithic material with constant properties.

Since WWCP is a "plant-based product", one should realize that its thermal performance properties are greatly relying on the nature of its fibers, the species of the plant (i.e., Kelampayang, Telinga Gajah, Mahang), as well as the percentage of content of its mixture with the Portland cement. Different species will have different vegetation structures, in terms of density, fiber contents, capillary capacity etc. All these characteristics will eventually affect the heat resistance, heat conduction, water retention, moisture retention etc.; and hence the performance of the end product – WWCP. In this sense, further study can be dedicated to assessing the thermal performance properties of WWCP with different species of plant, as well as different percentage content of Portland cement mixture.

Furthermore, since the size of the experimental test cells is small (3m x 3m) and the layout is designed without any internal partitions, further study can be dedicated to evaluating the thermal performance of WWCP in a typical Malaysian housing prototype – landed terrace house. The field measured readings and the simulated results obtained in the present study can be extrapolated to provide a basis of future investigation.

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A REVIEW ON THE FACTORS THAT INFLUENCE THE COST INCREASE FOR REINFORCED CONCRETE STRUCTURAL FRAME IN MALAYSIA BY INCORPORATING SEISMIC DESIGN

Farhanah Faisal, Shaharudin Shah Zaini, Fadzli Mohamed Nazri and Taksiah A. Majid
School of Civil Engineering, Engineering Campus, Universiti Sains Malaysia, Pulau Pinang, Malaysia.

Abstract
Although the level of seismic hazard in low-seismicity regions is considered as low, most earthquake-related casualties are caused by the collapse of buildings due to the ground shaking. In recent years, many low to moderate seismicity countries took an initiative towards the use of a seismic code for the earthquake-proof structures to resist the dynamic loading imposed by small to medium magnitude earthquake. For example, Malaysia has come to realise that seismic design becomes more important, particularly for new buildings located in moderate earthquake zone. Unlike countries that have long established seismic loading for structural design, Malaysia is still in the transmission phase and there are issues related to the increase in construction cost that need to be put into consideration. This paper presents the narrative review the seismic impact by discussing the previous related studies on cost analyses of earthquake-resistant reinforced concrete (RC) buildings in Malaysia in terms of ductility class, behaviour factor, peak ground acceleration (PGA) and structure height. By designing with the same reference PGA, building with the lowest ductility class requires the highest amount of steel reinforcement and cost material. The RC building requires lower flexural reinforcement and greater shear reinforcement when it is designed based on the higher behaviour factor, *q* instead of the lower one. As the reference PGA increases, the percentage increase of structural building cost also increases due to the increment in the quantity of reinforcement. Building on the softer ground condition requires more additional reinforcement compared to the similar building built on the harder soil type. The increase cost also can be influenced by the building height where taller buildings showed higher increase in construction cost for incorporating seismic load compared to low rise buildings.

Keywords: *earthquake; seismic design; ductility class; behaviour factor; peak ground acceleration (PGA); cost.*

INTRODUCTION

Occurrence of ground shaking, surface faulting, ground failure and tsunami in most low-seismicity regions are affected by high magnitude of distant seismic sources. The catastrophic 2004 Aceh earthquake with Mw 9.0 that triggered the disastrous Indian Ocean tsunami (Paul et al., 2012) impacted Malaysia due to general lack of preparedness and resilience towards seismic effects (Ahmadun et al., 2020). The government, researchers and engineers then begun to focus on issues related to this field such as seismology, tsunami, disaster management and seismic assessment on existing structures. However, only after the 2015 Ranau earthquake, designing buildings that possessed earthquake-resistant detailing became the primary concern among the local agencies in Malaysia. This is due to the fact that, failure of important structures may directly or indirectly disrupt the nation productivity. Among the seismic related works includes surveying and mapping processes for seismic hazard maps, incorporation of seismic load in design practice and cost analysis for earthquake resistant structures. The change from non-seismic design to seismic design buildings has caused the increase in the material cost following the increase in the load received by the RC buildings. Therefore, this paper seeks to review past studies on the effect of seismic design implementation on the quantity and cost of materials of earthquake-resistant RC buildings in Malaysia.

METHODOLOGY

The review on the past research work was conducted using the non-systematic or commonly known as the narrative literature review. This type of review aims at identifying and summarizing what has been previously published pertaining to the comparison of the cost and material required between non seismic and seismic design. A total of 15 articles we reviewed with numerous supporting references. In addition, a new study area is addressed.

PAST RESEARCH ON COST OF EARTHQUAKE RESISTANT REINFORCED CONCRETE BUILDINGS

Understanding the cost implications of incorporating earthquake loadings for the design of RC buildings in Malaysia is becoming more important with the introduction of the seismic design standard. The cost study addresses the change in the percentage of steel and quantity of concrete of RC framed structure as well as its influence on the overall construction cost when different parameters such as level of reference PGA (a_{gR}), ductility class (low, medium and high ductility), behaviour factor, site location, height and type of building are applied in the design. These types of research work using Indian Standard IS 1893 (Part 1): 2002 Criteria for Earthquake Resistant Design of Structures have been conducted by several authors (Perla, 2014; Quraishi et al., 2015; Shakeeb et al., 2015 and Sudha and Venkateswarlu, 2016). On the other hand, the use of Turkish Seismic Code for investigating the influence of local site effect and associated costs towards building construction have been conducted by Yön et al. (2015) and İnce et al. (2018), respectively.

Ductility Class

Awaludin and Adnan (2016) compared the difference in terms of material cost between conventional and earthquake-resistant buildings for different ductility class. In their study, several ground accelerations (A_g) were used namely 0.06g (DCL), 0.2g (DCM) and 0.4g (DCH) to develop the response spectrum. Figure 1(a) and 1(b) show the increment in the cost of the materials with different ductility class. For the 3-storey frame structure, the reinforcement cost of the DCL, DCM and DCH structure increase up to 7%, 26% and 48% of the for the conventional structure, respectively. Similarly, for the 8-storey frame structure, it can be seen that the reinforcement cost of the DCL, DCM and DCH structure increase up to 21%, 30% and 54%, respectively. The reinforcement cost in low ductility class for both 3 and 8-storey buildings showed the smallest increment because the DCL structure does not require any additional requirements for local ductility. The DCL structure can neglect the seismic provisions given in EC8 and follow the EC2 design as it is designed without seismic provision and ductile detailing (Penelis and Penelis, 2014). As such, the cost of reinforcement kept increasing when the ductility class is applied from low to high. Although higher ductility class can reduce the seismic-induced force and acceleration as the design is more dominant in inelastic and energy dissipative behaviour, more additional reinforcement is still needed in the structural members to fulfil the requirement of internal forces and ductility class. In the case of higher ductility class, the design, dimension and detailing of the structure are based on the specific seismic provisions as addressed in EC8. As the design is based on the increasing ductility class, the percentage of transverse reinforcement also increases due to the special detailing provisions for ductile concrete frames (Choopool and Boonyapinyo, 2011). Consequently, the total weight and cost of reinforcement increased.

For the 3-storey frame structure, the concrete cost of the DCH structure increase up to 90% of the concrete cost for the conventional structure. Meanwhile, there was zero increment in the cost of concrete for DCL and DCM structures. For the 8-storey frame structure, it can be seen that the concrete cost of the DCL, DCM and DCH structure increase up to 42%, 42% and 114%, respectively. The cost of concrete for DCL and DCM design of the 3-storey building showed no changes because the sizes of structural members such as beam and column were found to be similar as in the conventional structure. The concrete cost of the DCH structure for both 3 and 8-storey buildings showed the most significant increment among the three ductility classes because the DCH structure requires more transverse reinforcement to cater the ductility demand. The result of the analysis shows that the DCH structure requires larger size of beam and column compared to the other ductility classes. Moreover, the reinforcement embedded in the structural elements of the DCH frame is larger in size or higher in quantity than in the other frames. It was reported that in some cases, the size of the beam and column need to be increased in order to overcome the maximum percentage of reinforcement allowed for the higher ductility class. Therefore, the volume of concrete increases that eventually increases the cost of concrete for the seismically designed concrete framed structure.

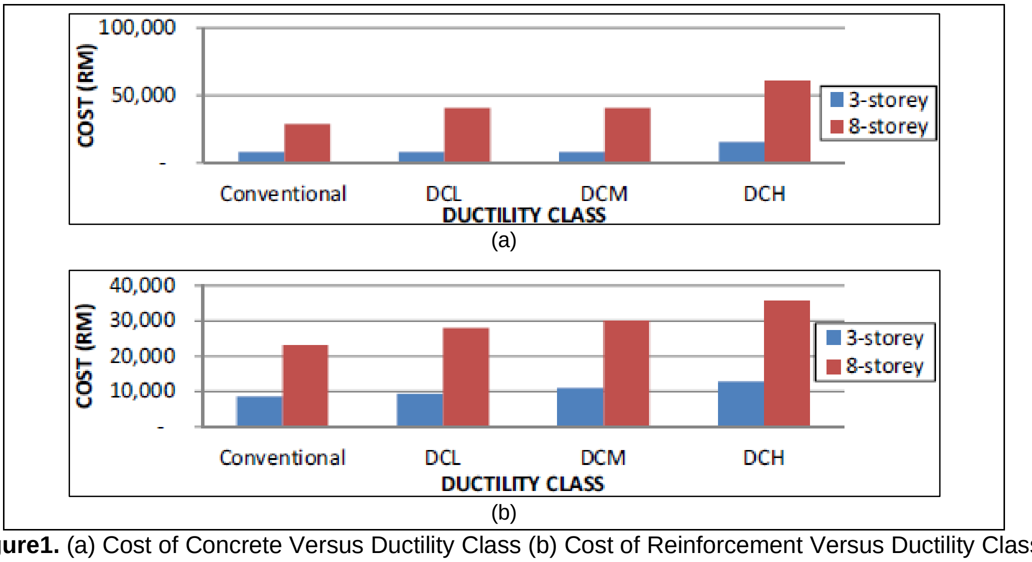
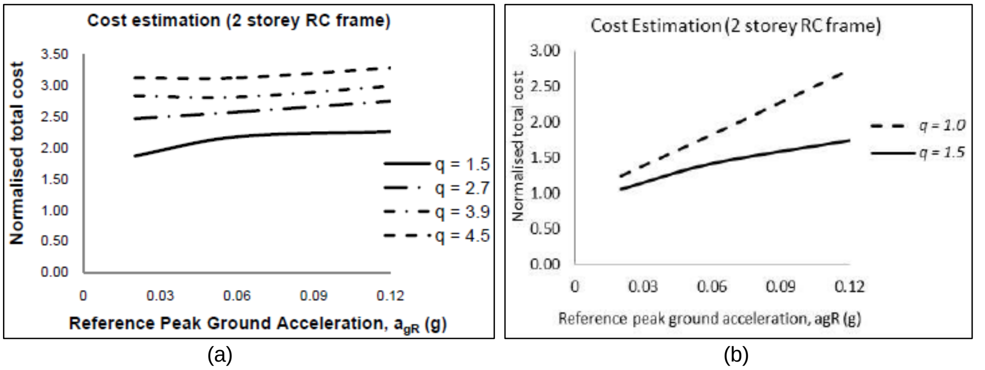


Figure1. (a) Cost of Concrete Versus Ductility Class (b) Cost of Reinforcement Versus Ductility Class (Awaludin and Adnan, 2016)

Behaviour Factor

Various codes of practice use a single parameter for the seismic design to reduce the seismic force caused by earthquake excitation as most structures are designed for inelastic behaviour (Ozmen and Inel, 2008; Fayed et al., 2018). This parameter is known as the response modification factor (ATC 1978; UBC 1997; FEMA 2000b; IBC 2000; TEC 2007; ASCE, 2010). Eurocode recognise this parameter as the behaviour factor, *q* (EN1998-1, 2004) for linear-elastic method.

Adiyanto and Majid (2013) and Adiyanto and Majid (2014) carried out a cost estimation exercise to evaluate the influence of behaviour factor, *q* on the normalised total cost (material cost for adopting seismic design normalised to non-seismic design). Figure 2 (a) and Figure 2(b) show that the normalised total cost can be observed for all levels of reference peak ground acceleration, a_{gR} as the behaviour factor, *q* increases. Based on the previous result of base shear force by Adiyanto and Majid (2013), the higher level of behaviour factor generated lower magnitude of base shear force acting laterally on the structure. Logically, the required strength of structural elements is also reduced with respect to the magnitude of the seismic force (Hernández-Martínez et al., 2015). Therefore, the total cost of material should be lower for the structural frame designed with a higher behaviour factor. The authors reported that the contradicting findings in this work were due to the fulfilment of ductile detailing in beam and confinement reinforcement in columns (EN 1998-1, 2004). As such, the frames with a higher behaviour factor require a higher amount of material, especially transverse reinforcement (local ductility demand) that contributes to high normalised total cost.



(a) (b)

Figure 2. Estimated Normalised Total Cost (a) For q = 1.5 to 4.5 (Adiyanto and Majid, 2013) and (b) 1.0 to 1.5 (Adiyanto and Majid, 2014)

Adiyanto and Majid (2014) and Adiyanto et al. (2014) also investigated the effect of behaviour factor on the flexural and shear reinforcement in columns. The results showed an overall similar trend that the weight of flexural reinforcement for column design decreases as the level of behaviour factor increases as shown in Figure 3 (a) and Figure 4 (a). The authors associated the findings with the decreasing lateral load acting on the structural frame for the increasing level of behaviour factor. Consequently, lower bending moment in the beam was generated and resulting in lower design moment of resistance of the beam, M_{Rb}. This situation contributes to the lower design moment of resistance of column, M_{Rc} and reduced the amount of required steel bar for column flexural reinforcement. The column design for DCM structure depends on the beam reinforcement as the bending moment for the design of column flexural reinforcement is derived from its corresponding beam strength. Similarly, flexural reinforcement for the column design is related to the flexural reinforcement of its corresponding beam.

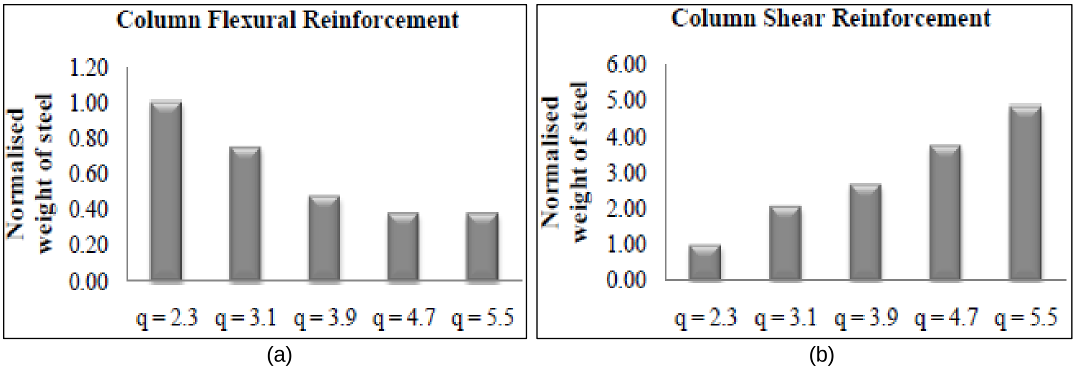
For moment-resisting frame system, RC columns act as the main load-bearing elements to support the beams and slabs as well as transferring the loads to the foundation (Subramanian, 2011). Thus, the RC columns in the earthquake-resistant buildings have to be designed, dimensioned and detailed based on specific seismic-resistant provisions to resist both gravity and lateral load during an earthquake event. The column design should fulfil the strong column - weak beam concept where the design moment of resistance of the column, M_{Rc} shall be equal to 1.3 times the design moment resistance of its corresponding beam, M_{Rb} (EN 1998-1,2004; Elnashai and Sarno, 2008). This concept is proposed to prevent the formation of column sway mechanism. As shown in Figure 3(a), the normalised weight of column flexural reinforcement is found to be similar for both frames with behaviour factor equal to 4.7 and 5.5. This result is due to the detailing requirement of the primary seismic column for DCM that requires the total area of flexural reinforcement to be in the range of 1% to 4% of the total area of column (EN 1998-1, 2004; Acun et al., 2012). The frame with behaviour factor 5.5 can be designed with a lower amount of column flexural reinforcement than the frame with behaviour factor equal to 4.7. However, the amount of column flexural reinforcement for the frame with 5.5 of behaviour factor was increased because the total area of steel provided must at least 1% total area of column section.

Apart from the flexural reinforcements in columns to resist bending moment, shear, or transverse steel (such as hoops, cross-ties and spirals) are also important to act as the confinement reinforcement (Subramanian, 2011). Figure 3(b) and Figure 4(b) show the influence of behaviour factor towards the amount of shear reinforcement. It can be seen that the weight of shear reinforcement in the column design increases with respect to high behaviour factor. The increasing trend is related to the requirement of confinement reinforcement for column design in DCM structures (EN 1998-1, 2004) as stated in the equation1. According to the seismic provisions in EC8, the mechanical volumetric ratio, $\omega_{wd}$of the confining hoops shall be not less than 0.08 in the critical region at column base to meet the requirement of confinement reinforcement and mainly influenced by the curvature ductility ratio, μ_{ϕ}, the normalised design axial force, v_d and the confinement effectiveness factor, α.

Parameters such as $\varepsilon_{sy,d}$, b_c, and b_o represent the design value of tension steel strain at yield, the gross cross-sectional width, and the width of confined core, respectively. The mechanical volumetric ratio of confining shear reinforcement within the critical regions is mainly influenced by the curvature ductility ratio, μ_{ϕ}, and the confinement effectiveness factor, α. Since the magnitude of the curvature ductility ratio is proportional to the behaviour factor, q_o, more shear reinforcement needs to be provided within the critical regions. Moreover, the spacing of link, *s* also affects the confinement effectiveness factor, α. In order to fulfil the confinement requirement in EC 8, closely spaced shear reinforcement need to be provided within the critical regions (Elghazouli, 2009).

(a) (b)

Figure 3. Effect of Behaviour Factor, q on Column Design (a) Flexural Reinforcement (b) Shear Reinforcement (Adiyanto and Majid, 2014)

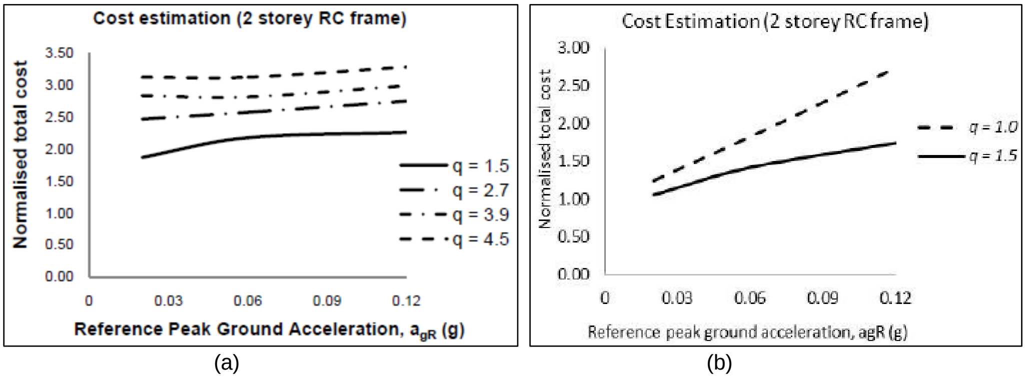


(a) (b)

Figure 4. Normalised Weight of Steel Provided in the Column (a) Flexural Reinforcement (b) Shear reinforcement (Adiyanto et al., 2014)

Reference Peak Ground Acceleration

Past researches on the effect of reference PGA to the normalised total cost in the seismic design of 2-storey RC frame have been carried out by Adiyanto and Majid (2013, 2014). As shown in Figure 5 (a), the cost estimation of the DCM frame is only slightly increased when the reference PGA is increased. Although different values of reference PGA are applied, almost similar bending moment and axial force are generated in the seismic design as the gravitational load dominates the load combinations. This finding implies that when the behaviour factor is constant and DCM is considered, the material cost for the same RC building whether it is built in West Coast of Peninsular Malaysia (PGA = 0.08g) or in East Coast of Sabah (PGA = 0.12g) will not be significantly affected. On the other hand, significant changes in the normalised total cost are observed in Figure 5 (b) when considering different levels of reference PGA for the DCL frame. As such the level of reference PGA is influencing the total cost when the same structure is built at different seismic areas. In their study using behaviour factor = 1, the estimated cost normalised to the non-seismic design of 2-storey RC building is 2.1 for a PGA of 0.08 g (West Coast of Peninsular Malaysia) and 2.7 for a PGA of 0.12 g (East Coast of Sabah). Similarly, for behaviour factor = 1.5, the normalised cost of the seismically designed building is higher than the non-seismic design, approximately 1.5 for West Coast of Peninsular Malaysia and 1.72 for East Sabah.



(a) (b)

Figure 5. Estimated Cost Normalised to Current Practice without Seismic Design (a) Adiyanto and Majid, 2013 (b) Adiyanto and Majid, 2014

Many studies (Hee et al., 2015; Awaludin and Adnan, 2016; Ramli et al., 2017; Adiyanto et al., 2019; Roslan et al., 2019; Adiyanto et al., 2020) have been conducted to investigate the influence of reference PGA on the changes of steel reinforcement and structural building cost when considering seismic design. Several values of reference PGA that represent the level of seismicity in Malaysia were used in the non-seismic (EC2) and seismic designs (EC8) to demonstrate the seismicity cases in Malaysia. In general, all studies reported that the total amount of reinforcement and cost of material of the seismic-designed structure were higher compared to the similar structure with non-seismic design. As shown in Table 1, Table 2, Table 3 and Figure 6 (b), the quantity of steel bar depends on the region's seismicity level and tends to rise from 4.2 % - 5% (Hee et al., 2015), 6% to 55% by Awaludin and Adnan (2016), 10% to 65% by Ramli et al. (2017) and 6% to 290% by Adiyanto et al. (2019) when seismic loading is considered. In addition, Roslan et al. (2019) found that regardless of the soil type, the model with seismicity level of 0.1g required approximately 2.19 and 2.55 times higher in terms of the weight of reinforcing steel in the beams and columns, respectively compared to the conventional design. A similar pattern of results also can be observed from Adiyanto et al. (2020) where the weight of reinforcement bar in the beams and columns can increase up to 2.19 and 3.47 times, for reference PGA equal to 0.16g. This finding is associated to the high base shear force generated for high magnitude of reference PGA. Similarly, the response spectral ordinate, S_d (T_1) will be increased with respect to the reference PGA as shown in Figure 6(a).

Table 1. Preliminary Cost Estimation for Structural Building

Location	Reference Peak Ground Acceleration, a_{gR}	Cost Increase (%) (with 1 Standard Deviation)	
		Single Link	Double Storey Link House
Peninsular Malaysia	0.07g	2.0	4.2
Sarawak	0.07g	2.9	4.2
Sabah	0.12g	4.7	5.0

(Source: Hee et al., 2015)

Table 2. Quantity of Reinforcement Between Non-Seismic and Seismic for 3 and 8 Storey Buildings

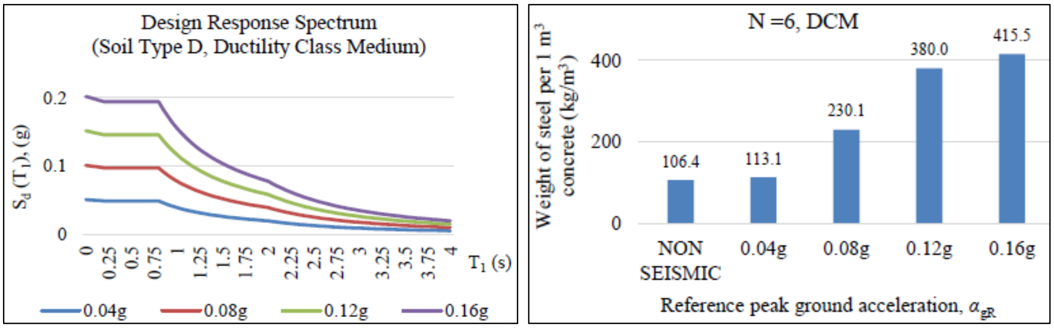
Ductility Class	Reference Peak Ground Acceleration, a_{gR}	3-Storey		8-Storey	
		Quantity of Reinforcement (kg)	Increment (%)	Quantity of Reinforcement (kg)	Increment (%)
Conventional	None	3,647		9,725	
DCL	0.06g	3,898	+6.9	11,839	+21.7
DCM	0.2g	4,603	+26.2	12,727	+30.9
DCH	0.4g	5,334	+46.3	15,005	+52.3

(Source: Awaludin and Adnan, 2016)

Table 3. Quantity of Reinforcement Between Non-Seismic and Seismic for 5 and 10 Storey Buildings

Ductility Class	Reference Peak Ground Acceleration, a_{gR}	5-Storey		10-Storey	
		Quantity of Reinforcement (Tonne)	Increment (%)	Quantity of Reinforcement (Tonne)	Increment (%)
Conventional	None	125.6		1,041.0	
DCL	0.06g	138.5	+10.2	1,388.9	+33.4
DCM	0.08g	185.8	+32.4	1,683.3	+61.7
	0.14g	188.0	+33.2	1,683.8	+61.8

(Source: Ramli et al., 2017)



(a) (b)

Figure 6. (a) Design Response Spectrum and (b) Total Weight of Steel Reinforcement for 1m³ Concrete for Different Value of Reference Peak Ground Acceleration (Adiyanto et al., 2019)

Soil Type

A number of recent studies (Roslan et al., 2019; Azman et al., 2019; Mustafa et al., 2019; Adiyanto et al., 2020) have been conducted to investigate the effect of different soil types on the amplification of seismic load that affect the demand of the steel reinforcement in the beams and columns as shown in Figure 7 and Figure 8. It can be seen that the level of seismicity in the softer soil condition is amplified by higher soil factor which contribute to the higher seismic force compared to dense/rock condition. Moreover, despite different value of reference PGA, model with soil class E is subjected to the second highest horizontal lateral load after model with soil type D. Hence, the model with softer soil type requires higher quantity and larger diameter of steel reinforcement to cater the higher bending moment, shear force and axial load. Consequently, the higher area of steel bar provided leads to the higher cost of steel reinforcement. Building models situated on soil type D requires the heaviest weight of steel bar in beams and columns due to the highest value of the base shear force, F_b and spectral acceleration at the fundamental period T_1. In addition, the increase in the material cost was shown to be more significant for soil type D and E when normalized with the non-seismic design condition.

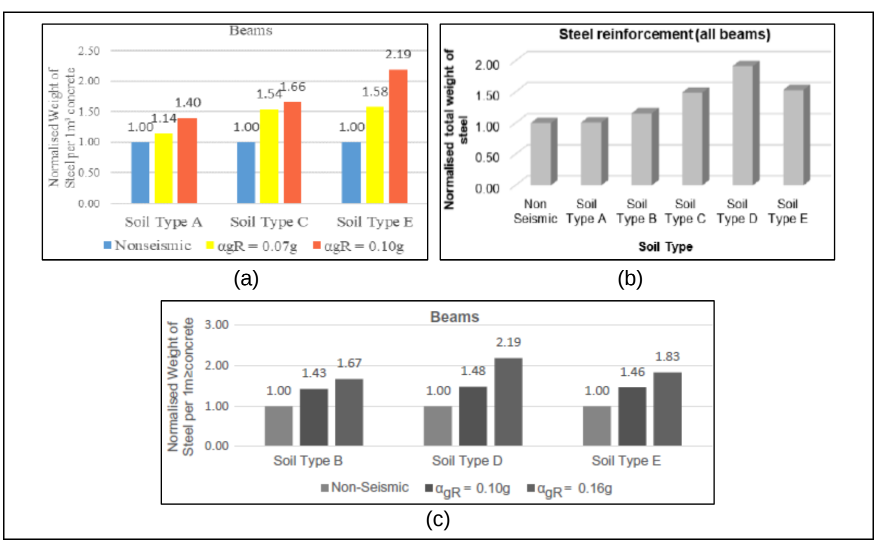


Figure 7. Effect of Soil Type on Normalised Weight of Steel Reinforcement for All Beams (a) Roslan et al., 2019 (b) Mustafa et al., 2019 (c) Adiyanto et al., 2020

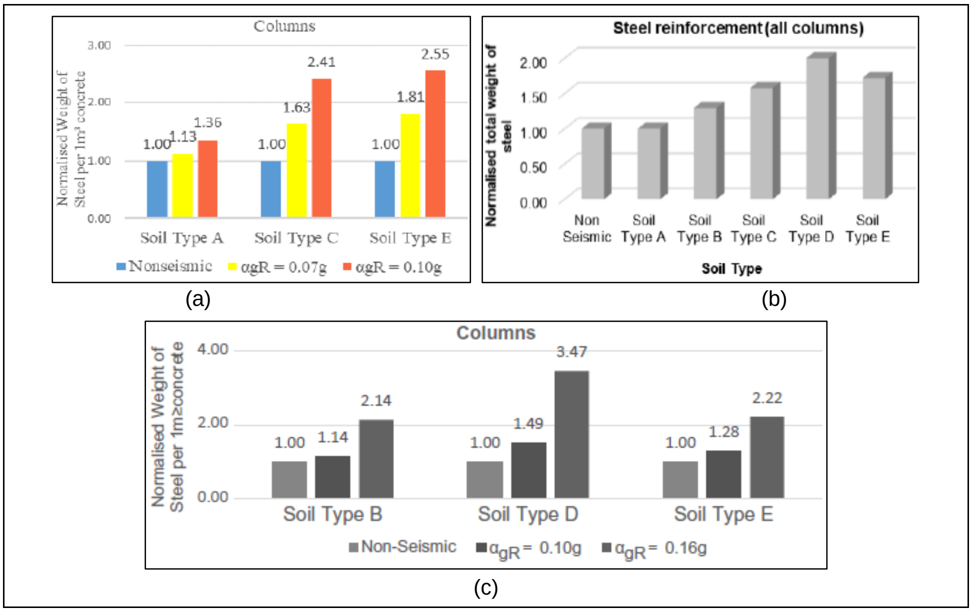


Figure 8. Effect of Soil Type on Normalised Weight of Steel Reinforcement for All Columns (a) Roslan et al., 2019 (b) Mustafa et al., 2019 (c) Adiyanto et al., 2020

Building Height

Hee (2015); Hee et al. (2015); Hee et al. (2016); Awaludin and Adnan (2016); Ramli et al. (2017) and Faisal et al. (2020) investigated the influence of the number of storey (corresponds to the building height) on the quantity of reinforcement and cost increase in the earthquake-resistant design of RC buildings. In Table 4, it can be seen that the increase in the cost is in the range of 0.2% to 8.1% depending on the height of structure, type of building and PGA being considered. As expected, the structural materials for buildings situated in Sabah require additional quantity due to the use of higher PGA and DCM detailing compared other locations. However, the trend is inconsistent with respect to the building height. This phenomenon can be associated to the effect of wind load applied to the structure that becomes the dominating lateral force compared to the seismic load as the building height increases (Gaur and Goliya, 2015; Reddy and Kumar, 2017). On the contrary, Awaludin and Adnan (2016); Ramli et al. (2017) and Faisal et al. (2020) reported that the increase in the reinforcement tonnage is consistent with the building height as shown in Table 5.

Table 4. Preliminary Cost Estimation

Reference	Type of Building	Storey	Cost Increase (%) (with 1 Standard Deviation)		
			Peninsular Malaysia	Sarawak	Sabah
Hee (2015)	Office buildings	1-storey MRF	+0.7	+0.3	+7.7
		5-storey MRF	+0.9	+0.3	+2.5
		10-storeyDual (MRF & shear walls)	+1.1	+0.8	+6.4
		30-storeyDual (MRF & shear walls)	+0.3	+0.4	+1.4
Heeet et al. (2015)	Link houses	Single	+2.0	+2.0	+4.7
		Double	+4.2	+4.2	+5.0
Heeet et al. (2016)	Office buildings	1-storey	+0.2	+0.2	+7.0
		5-storey	+0.7	+0.5	+4.4
		10-storey	+0.7	+0.6	+8.1
		20-storey	+0.2	+0.2	+4.3
		30-storey	+0.2	+0.2	+3.3
	Link houses	Single	0	0	+2.0
		Double	0	0	+4.8

(Source: Hee, 2015; Hee et al., 2015; Hee et al., 2016)

Table 5. Quantity of Reinforcement for Various Buildings

Reference	Storey	Quantity of Reinforcement (Tonne)						
		Conventional	DCL 0.06g	DCM 0.08g	DCM 0.14g	DCM 0.165g	DCM 0.2g	DCH 0.4g
Awaludin and Adnan (2016)	3-storey	3.647	3.898	*N/A*	*N/A*	*N/A*	4.603	5.334
	8-storey	9.725	11.839	*N/A*	*N/A*	*N/A*	12.727	15.005
Ramli et al. (2017)	5-storey	125.6	138.5	185.8	188.0	*N/A*	*N/A*	*N/A*
	10-storey	1,041.0	1,388.9	1,683.3	1,683.8	*N/A*	*N/A*	*N/A*
Faisal et al. (2020)	5-storey	3.9457	*N/A*	*N/A*	*N/A*	5.9024	*N/A*	*N/A*
	10-storey	7.6287	*N/A*	*N/A*	*N/A*	11.424	*N/A*	*N/A*
	20-storey	22.9534	*N/A*	*N/A*	*N/A*	25.9984	*N/A*	*N/A*

(Source: Awaludin and Adnan, 2016; Ramli et al., 2017; Faisal et al., 2020)

CONCLUSIONS

In order to implement seismic design for low to moderate seismicity regions such as Malaysia, this article has reviewed the cost implications in designing quake-proof RC buildings based on previous studies found in the open literature. It can be concluded that by designing the buildings with the same reference PGA, building with the lowest ductility class requires the highest amount of steel reinforcement that in turn, will add the material cost. Moreover, buildings designed with a higher behaviour factor requires lower flexural reinforcement but higher shear reinforcement than a building designed with a lower behaviour factor, *q*. As expected, the reference PGA directly influenced the material cost by increasing the base shear force. Buildings located on soft soil are vulnerable to seismic amplification where high design forces are generated that consequently increased the material demand. In low seismicity region, wind force can be the determining factor that influences the percentage increase in the material cost and this is particularly true as the building becomes taller. However, inconsistent trend was observed. Despite the inconsistency in the trend of the material demand, almost all of the results showed that the incorporation of seismic load requires additional volume and tonnage of concrete and reinforcement, respectively. In the future, more studies should be conducted especially by using actual building models as this can provide a broader spectrum of results on the structural material cost for any country (especially in the low seismicity region) that is opting for the incorporation of seismic load.

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ASSESSING INTERNAL EARLY PREPARATION THROUGH STAKEHOLDER ENGAGEMENT PROCESS FOR INFRASTRUCTURE PROJECTS

Har Einur Azrin Baharuddin[1], Noor Akmal Adillah Ismail[1], Hamimah Adnan[1], Wan Norizan Wan Ismail[2] and Imelda Piri[3]

[1]Centre of Studies for Quantity Surveying, Faculty of Architecture, Planning and Surveying, Universiti Teknologi MARA, 40450 Shah Alam, Malaysia.

[2]Faculty of Architecture, Planning and Surveying, Universiti Teknologi MARA, Kampus Sri Iskandar, Perak.

[3]Department of Construction and Quantity Surveying, Otago Polytechnic Auckland International Campus, 1010, New Zealand.

Abstract

Large infrastructure project involves multiple stakeholders with various interest. Conflicting interest of the stakeholders is common issues arise during the construction phase. As the large infrastructure project are complex in nature, politically sensitive and uncertain, the management of stakeholders should not be neglected. This may lead to unexpectable problem such as communication breakdown, reworks, dispute and cost overruns to the projects. In any massive infrastructure projects, it is undeniable that the stakeholder engagement has become important element to the project. Thus, early engagement of the stakeholder is a must either directly or indirectly to overcome any problem to arise throughout the project. Hence, this paper aims to seek for an improvement of stakeholder engagement process through initial early preparation which involve in stakeholder engagement process in an infrastructure project. A comparative study across two different infrastructure projects case studies in New Zealand and Malaysia has been brought through a comparative qualitative analysis and observation. The information also taken from project documentation and interviews. The results from the comparative analysis shows that there are a significance attributes arising from initial early preparation process involving stakeholder engagement in large infrastructure projects. The findings provide insight into how the factors of engaging stakeholders and public early and closely, improve transparency of information, and understanding of the design concept would help in improving international early preparation of stakeholder in both projects. The paper provides a point of reference for project owner and project team to assist them in emerging best practices of stakeholder engagement in major infrastructure construction projects.

Keywords: *stakeholder; stakeholder engagement; internal early preparation; infrastructure projects.*

INTRODUCTION

Large infrastructure involved a huge project scope which influence the stakeholders either externally or internally. Stakeholder involvement in large infrastructure project can be scoped from a general consultation through dialogue on contribution of ideas in design to making stakeholders responsible for the design i.e., components, systems, process or service they could provide (Aapaoja et al., 2013). Due to the complexity and uncertainty of the infrastructure projects, the engagement of the stakeholder should be involved earlier. Supported by Erkul, Yitmen and Celik (2016), it is vital to engage key project stakeholders in infrastructure project during planning, appraisal and delivery. They added it is to ensure management of risk, uncertainty and complexity of the project will take into account in setting out project objectives. Stakeholder roles and responsibilities may have direct impact on the degree of stakeholder participation. Hence, any external stakeholder with low level of responsibility can be involved later stage of the project (Monczka et al., 2000).

As soon as the project began, stakeholders, the community, and the general public were consulted could deliberate the possibility of poor project performance. Similarly, Magassouba, Tambi, Alkhalaifat and Abdullah (2019) observed the involvement stakeholders in project identification, planning, implementation and monitoring will improve project performance based on case study in Guinea. In order to have a good relationship with the stakeholder, the process of engaging stakeholder should be implemented in any project especially in mega infrastructure projects. Which, it has been argued that the stakeholders in the construction business should be consulted to establish what they require. In order to ensure their interest will not be left out. The study of stakeholder engagement during internal early preparation scoped to the project's early stages, prior to the commencement of the planning phase to the beginning of construction activity on site (Olander and Landin, 2008). Project team should identify and engaged all stakeholders, make an observation towards the stakeholder activity to ensure a successful project implementation (Buertey et al., 2016). Buertey et al. (2016) added the project team should observe any fail project by looking at the poor stakeholder consultation and engagement rather than poor project execution. Previous literature emphasised the significance of involving stakeholders during early stage of the project. Thus, according to Smith and Love (2004) there have been few methods developed and reported for assessing stakeholder needs. The paper presented was to recommend improvement to the initial process in stakeholder engagement in infrastructure which involved the internal preparation of engaging the stakeholder and best practices that could be highlighted. This present a practice by the different countries involving developed and developing countries in practising the stakeholder engagement issues and method that have been used to gather the stakeholder at the first attempt. Two case studies analysed through cross case synthesis method which involved New Zealand and Malaysia projects in analysing the dissimilarities and common practice in nature.

LITERATURE REVIEW

Mega infrastructure projects are difficult and complicated to build, requiring alliances of different stakeholders with diverse interests, drives, authority, and background (Cornick & Mather, 1999; Aaltonen & Kujala, 2010). In addition, internal and external stakeholder played a part in the development and operation of projects in order to achieve project success (Eyiah-Botwe et al., 2016; Lam et al., 2011). This can be achieved by coordinating the project objectives and interests with the stakeholders and local community through transparency and accountability in decision making. Thus, by doing this it could enhance a shared view of project objectives and help to improve project performance Di Maddaloni & Davis (2017). Furthermore, multiple stakeholder engagement process may be developed by looking at how massive is the infrastructure project, the nature of work and its complexity. As a result, depending on the level of stakeholder participation, several techniques of engagement will be used. Internal early preparation in engaging stakeholder involves the process and management of the stakeholder.

Various Practices of Stakeholder Engagement Process

Basically, individual meetings are one type of engagement for infrastructure projects which involve one-to one meeting to group meeting which involved wider participants conducted. Karlsen (2002) described the engagement process in six steps. According to Karlsen, six engagement steps described involved, commence from early planning, stakeholder identification, stakeholder analysis, regular communication, action done and follow-up. Three steps of engagement presented by Young (2006) include identifying stakeholder, collection of information, and analysis of stakeholder influences. In addition, Walker (2008) described five steps of stakeholder engagement process which involved initial process are identifying stakeholder to prioritising stakeholders, visualising and mapping stakeholder, involving the stakeholder, and finally, assessing the impact of communications. Jeffery (2009) indicated that the engagement process should start with internal preparation and alignment, then, developing trust among the stakeholders, consulting, respond and implementation of stakeholder process, planning and lastly comprehending stakeholder at later stage of the project.

Methods of Engaging Stakeholder at the Initial Stage

Early briefing work tended to recognise the need for more collaboration among clients, design teams, and construction teams. Additionally, some of it also prescriptive by creating standard check lists. During the early phases of the project, it became clear that the stakeholders and local community had lack of ideas with the engagement processes. Furthermore, the parties were unfamiliar with one another and interactive collaboration within the participatory processes (Patel et al., 2007). During early stage of the project methods that currently be used to interact with the stakeholder involved a phone call, newsletter, media and email. These methods deal with the one-sided form of communication or can be two-side of communication (Foo et al., 2011), leaning on the movement of information. For instance, one-sided or one-way communication involve stakeholder through project presentation, information booth or project exhibition. In later detail stage of one-way communication involves dialogue sessions and customer satisfaction surveys. On the other hand, two-sided or two-way communication as defined by classical Freeman 1984 definition, is more harmonious in getting a mutual understanding between both parties-the organisation and the stakeholders. Leung et al. (2005) emphasised that on public engagement projects, different stakeholders have varied levels of authority and interests. Interaction occurred during the implementation of the project specifically on managing stakeholder. In order to help with the interaction among stakeholders, focus meeting, community workshops, social media and public forum could be used in assisting to building a platform for stakeholder involved and interested with the project. Such platform could be used to discuss issues and debate on the benefits and drawbacks of various alternatives and measures before it can be presented to policymaker for consideration (Deegan & Parkin, 2011; Rowe & Frewer, 2000).

RESEARCH METHODOLOGY

Two case studies were chosen from New Zealand and Malaysia, as a result to compare the similarities and differences of the stakeholder engagement process. Two case studies of infrastructure projects were selected across country which is the first case study was major expressway project in New Zealand and another case study, a megaproject railway in Malaysia. Thus, this study explores the cross-case analysis methodology. Cross-case analysis will help the researcher to get input, verdict and compare of specific studies. This practice allows in developing the best practice guidelines of the study. Two different infrastructure projects were selected based on the similarities in nature of infrastructure projects and numbers of stakeholders involved to the project. A cross-case design entails collecting data on various cases at the same time. This also involve connection of data with two or more variables. This connection will help in examined the patterns of combination Bryman & Bell (2015). According to Bryman and Bell (2015), multiple case studies enable the researcher to make a comparison from the findings from each case study. By doing so, research will be encouraged to consider what is unique across both countries' cases, thus encourages theoretical contemplation on results. Observations which under empirical material, gathered from taking part of formal and informal discussion and meetings with the stakeholders. Such discussion involved project office meetings, construction site meeting and at design-construction team workshops. Outcome to this, the empirical data obtained is extensive, consisting primarily of field notes from participant observations such as notes from formal and informal discussion and meetings at the project and construction meetings as well as from collaboration workshops meetings. Other than that, interviews with project practitioners from various stakeholders (property owner/client, tenant, architectural firm, engineering companies, and general contractors) and internal and external documents (i.e., project time plans, organisation charts, statement of collaborative project goal, memos of meetings, project information booth).

The semi-structured interviews were conducted with 14 stakeholders in New Zealand and 13 stakeholders in Malaysia. The interviews conducted on key stakeholders, external and internal stakeholders ranging between 60 minutes to 2 hours. The interview was tape-recorded and transcribed. This research applies comparative analysis through the two-case studies. The reason of using multiple case study, where the case was diligently selected and researched in order to envisage the comparative outcome either contrast or comparable (Yin, 2009). With regard to massive infrastructure projects in distant context, assessing the data is a critical part in initiating comparison. The two abovementioned projects provide the researchers the opportunity to learn on the topic interest across these two case studies in two different countries. The researcher able to access both countries infrastructure projects information and collect cross-country data and comparison was made possible in addition to the in-depth interview. Differences in mechanisms of stakeholder involvement, project governance, the varied set of stakeholders involved, and the system always create various variations between these two cases. The project was chosen based on a variety of factors, including political, social, economic, and cultural disparities. These case studies have a proper stakeholder engagement team which deal with the consultation of the external stakeholder and community at large.

Table 1. Case Studies Involved

Code	Case Study	Country	No of Respondents	Type of Projects
P_1	Case Study 1	New Zealand	14	Expressway
P_2	Case Study 2	Malaysia	13	Railway

DATA ANALYSIS AND FINDINGS

The findings from two case studies shows the process methods that have been used at the early preparation and alignment of the stakeholders' issues. The process of stakeholder engagement process from case study selected from New Zealand and Malaysia became clear that the case studies involved expressly adopted stakeholder engagement at the early stage of the project specifically planning stage. Findings from the in-depth interview with the stakeholders and documentation studies of P_1, less external stakeholders were engaged during the initial phase of the project. Alternative method, includes town hall meetings, newsletters, and visiting community member door-to-door, were adopted by the project team to 'meet and greet' the stakeholder and community for better interaction. As the project team had learned that project booths, open public engagement and expos are lacking adequate power for interacting with the community. Such problem was remedied by organising additional engagement gatherings and meet door-to-door those affected by the project. Stakeholder involvement with the community was expanded as a result of early experiences. Three stages of consultation series with the stakeholders and community were conducted with the initial stage conducted by the project owner. In Stage 2 (preliminary design and options concepts) and Stage 3 (scheme assessment – testing and refinement) were fully managed by the P_1 alliance team. In this project, stakeholder was participated from day one, and series or arranged meetings among stakeholders and community was conducted. The project team also announce national media coverage of the project (national television station and newspaper), to inform any affected community and public. At this point onwards, the project owner supplied information to stakeholders to assist them understanding the project, as well as alerting the general public and the community about the project and the impacted area. During the case study interview, stakeholder and the community want to participate in the project. The stakeholder stated that they are not opposed to the project, but they are dissatisfied with how the project being executed and managed without due regard for the well-being of those who will be directly impacted by the initiative. During the initial stage, then in second and third stage of the project, it was recognised as a good practice method that entailed significant stakeholder participation at all levels. According to the interviewee, perpetual engagement from 2010 to 2013 resulted in open communication with relevant regulatory bodies which also incorporated as part of the regulatory consent documentation preparation.

For a P_2, based on the interviews and observations from the case study, the project experiences the same issue as P_1, having a smaller number of stakeholders involved during earlier stage of the project. Begin by educating the local community and other external stakeholders, the engagement approach was diligently planned. Through the initiatives the project team had established, the project team organisation starts to build a good rapport with the community. This includes campaign and event activity. The goal of this process was to raise public awareness and educate community on the importance of the railway project. The logo competition and slogan were two of the most successful campaigns. The project team also provided progress updates on social media platforms such as Facebook, Twitter and Instagram to follow the progress of the railway construction. This indicates that the project was more actively involved with the community in order to promote awareness of the project's benefits. The project owner, for example, engaged public schools within the vicinity of Klang Valley. This activity heighted awareness among students on the importance of railways as a public transportation.

In the comparative study of NZ and Malaysian, lead to an alternative way of involving stakeholder and community at the early stage of infrastructure projects. Result from these two case studies indicated that it is critical to involve as many stakeholders as possible throughout the early process. If stakeholders affected by the project are not considered, problems will arise. This refers to the sensitivity issues raised by stakeholders from both P_1 and P_2, who believe they are a part of the project. The public and community should know what will occur in their area and if their land will be affected.

Stakeholders and the community should be involved in the project early and closely. This will be the project owner assurance. Campaigns that involved public such as awareness campaigns and open day are needed to engaged stakeholder indirectly. Also, campaign help to raise awareness and get feedback and opinion on the project from the general public. Findings shows that external stakeholders and the community were happy and would like to be a part of the project and it is critical that their viewpoints be heard. be heard and ideas be developed in the infrastructure projects design. Thus, it is essential to improve the engagement methods in order to achieve project success. Throughout the cases, the public and community gained a better understanding of the necessity of public infrastructure development.

DISCUSSION

From two case studies, different range of approach in conducting the stakeholder and the community in infrastructure project. The case study illustrates that the very first process of engaging stakeholders is important in engaging as many stakeholders as the project owner could deal with. The issues will be developed if the stakeholder which affected with the project is overlook. These are related to the sensitivity issues of the stakeholders where they felt that they are part of the project. Apart from that, engaging with the community also is utmost important issues. The public and community should know what are going-on in their area and some of their land also affected. Therefore, these factors need to be taken into account during initial early preparation of stakeholder engagement.

Engaging Stakeholders and Public Early and Closely

The awareness campaign involving the public and the community for the P_1 project needed. Such campaign developed awareness and obtained feedback and opinion from the public on the project. It is critical that their views be heard and that their suggestions be implemented in the expressway design. According to the stakeholder interviewed for the case study, they were given the choice of choosing which expressway would have the least impact on their land and would satisfy their needs. Therefore, from the case study of P_1, it is vital to improve methods in engaging community and stakeholder to achieve project success. Throughout the campaign, the public and community developed the awareness and wider the perception on the importance of building the public infrastructure. For a mega project authorities need to make sure that they take everything into consideration to ensure that they take everything into consideration to ensure that it goes well and is cost effective. Also, Innes and Booher (2004) and claimed that one of the purposes of public participation is to promote equity and fairness because individuals and groups who are excluded from the decision-making processes.

Transparency of Information

In term of transparency of the information, P_1 case study showed more information transparency then P_2 case study. For example, P_1 has a central webpage that is open to the general public and community where it consists of large information regarding the project and the stakeholder. Stakeholder entities (agency, organisation, individual landowners, traders, etc.) that were directly or indirectly affected by the project were accessible to be accessed through the website. In the P_2 case study this important information was not accessible through the website. This information has to be retrieved from informal channel such blogs and online forums. Both P_1 and P_2 have information on community perspective. The community in both countries able to provide their comments comment through the website and social media. On the other hand, the community comments were analysed through a full community report that could be accessed on the internet for P_1. This report included feedback assessments, such as what piqued their interest, their ideas and opinions on the project, and a list of stakeholders. In Malaysia, public community were able to provide comment which was consolidated into a short report. In order to provide a better understanding a recommendation on more detailed analysis could improve stakeholder understanding as was conducted in New Zealand. Detail information, such as a compilation of their interests, feedback, and a stakeholder list, for example, was not available through the website. This shows that the information from the P_1 case study is more transparent and accessible to the public than P_2 case study. Therefore, P_2 case study can improve document transparency by providing a comprehensive community report for the public and can give improvement to the holistic information regarding community feedback and interest.

Understanding on the Design Concept

In P_2 case study, the engagement stage could be improved when each party get the mutual understanding on the design concept of the project. The authority declined to offer details on the plans, saying the main focus of the launch was on the final alignment of the railway track line. The assurance given when feedback from the public obtained during the three-month engagement process incorporated into the line. The authority views recorded 6000 views of which 91 per cent were said to be in support of the project. The public would like to see the consultation process was done at the very beginning of the project. They had a protest on the land to be overtaken by the project where for them they are not being properly consulted during that phase. The popular trade area which is popular destination to the tourist seeks a judicial review to stop the acquisition. The affected community expecting a clear-cut answer as to whether their property ownership rights would in any way be jeopardise, residents have to vacate their buildings for six months for tunnelling works. The stakeholder manager was asked regarding that matters and they said the problem had been solve by giving them compensation and reallocated the railway track. So that the area is not fully demolished. On the other hand, P_1 had design three option of the expressway which they present to the stakeholder and the public. The stakeholder can make a decision on which path the expressway based on the majority voice. Project client should aware that the stakeholder should be handling with diligence and trusteeship.

CONCLUSION

This paper has focused on how to be improving an engagement process in a large infrastructure project. This study involving multiple stakeholder interest and perception which have demand, interest, expectation, reasons needs and values to the project which covers on the initial preparation of the engagement and shows the practices from two different countries namely New Zealand and Malaysia. The data were obtained using cross case analysis of case studies with descriptive research design. Result from the case studies shows that what the project owner could do during the initial early preparation of the engagement process. Features such engaging with the public closely, being transparent with the information and understanding the design concept. These continues with the recommendation of the improvements which limited from the case studies. The improvement that could be made must include these factors of engaging stakeholders early, giving a transparency information and understanding on design concept especially massive projects such as infrastructure. All of this is believed to be big influence in the decision-making process.

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ENERGY MANAGEMENT SYSTEM (EMS) IN BUILDING SUSTAINABILITY COMPONENTS: BENEFITS AND ITS CHALLENGES

Mas Anasha Rosman, Nurul Afida Isnaini Janipha and Nor Azlinda Mohamed Sabli
Centre of Studies for Quantity Surveying, Faculty of Architecture, Planning and Surveying, Universiti Teknologi MARA, Shah Alam, Malaysia.

Abstract
Construction industry is one of the key contributors to the increase of climate change and the destruction of natural resources. Energy Management System (EMS) is an essential approach to maximise buildings' energy efficiency. As a result, users benefit from better power management throughout their operations, while reducing the environmental impact on the building and enhance building sustainability. Therefore, this research aim is to investigate the EMS in enhancing sustainability in building for Malaysian construction industry. Two objectives were outlined: to investigate the benefits of EMS implementation in building sustainability components and to determine the challenges in implementing the EMS. The quantitative methods of data collection were used in this study where data collections were carried out in two stages, i.e., through literature review from related sources and through a questionnaire survey that were distributed to 205 G7 contractors registered under CIDB. However only 31% feedback obtained and the results indicated that three main components were classified for the benefits which were environmental, economic, and social benefits. For its challenges, three categories were determined; knowledge/information, legal/contractual and economic/financial. Hence, EMS approach is considered as one of the driving factors for sustainable building and can provide a better environment in the building, which is more flexible, convenient, and comfortable while remaining energy efficient for the occupants in this modern lifestyle.

Keywords: *Energy Management System; Building Sustainability; Malaysian Construction Industry.*

INTRODUCTION

The construction industry plays a major role in sustainable development, not only because of its importance in the national economy, but because the built environment has a significant impact on the quality of life, comforts, protection, health, and relations (Zabihi et al., 2014). Over the last decade, the urban development and technological advances have increased, posing a challenge to global ecological as well as problems to maintain sustainability inside the building. According to Yunus & Yang (2011), as sustainability awareness increases around the world, the construction industry is under growing pressure to boost project efficiency and delivery to meet sustainability in building. The goal highlighted in this recent year is to achieve sustainability in architecture and design as sustainability in these areas is important for sustainable growth in country. A potential contribution to improvements in sustainable development can be created from the construction industry and action is required to make construction activities sustainable. The key concept of sustainability is to focus on environmental factors and to achieve a built product with maximum internal environmental factors so that the negative impacts on environment can be reduced. Construction industry is forced to pay more attention to the environment in order to achieve sustainable building. The reason is because environmental protection and sustainability relate closely to each other (Cristian et al., 2015). A concept known as sustainability is involving the development of brighter future for the society, environment, and economy. However, the inefficient usage of energy in buildings is growing expensive as well as unsustainable.

Thus, an evaluation of existing energy usage and total energy efficiency output is vital in every building. These mentioned issues can be tackled with implementation of EMS inside the building. In order to decrease energy consumption and enhance environmental sustainability, EMS inside the building is therefore essential. This statement can be emphasised by Sin (n.d.) which stated that energy efficiency is a keyway to enhance sustainable energy and reducing the environmental effects of the building sector. Therefore, to achieve sustainability in building, the implementation of an EMS will be the best option and able to encourage the energy efficiency in this modernization era. As an outcome, consumers benefit from better power management across their operations while reducing the building's environmental impact.

LITERATURE REVIEW

Fundamental of Building Sustainability

In developing countries, global contributions from buildings to energy demand for both residential and industrial sectors have risen gradually (Saidur, 2009: Enshassi et al., 2018). With an increase in population, increased demand for building quality of service, comfort, and time spent in the building, energy usage will be expected to continue indefinitely with energy demand (Ochieng et al., 2014: Díaz López et al., 2019). However, the exponential growth in the use of energy has increased energy issues internationally. This has resulted in the shortage of energy supplies and major environmental impacts, such as ozone layer depletion, global pollution and climate change (Abdul Rahman et al., 2011). Various strategies and incentives must be implemented to reduce energy consumption towards the sustainability in the building. Energy consumption is therefore closely linked to energy management, where good energy consumption output can help improve and increase the efficiency of energy management within the building.

The construction industry plays an important role in enhancing development towards sustainability by collaborating with other industries such as manufacturing to ensure environmental issues able to reduce for the future of available resources such as natural resources which are heavily used by the construction industry. However, as concerns about climate change and the limited existence of these resources arise, construction industries are under pressure to reduce their environmental effects. The sustainable construction is significant as the construction industry has a huge impact on the environment from energy usage to emissions (Omer, 2014). It uses high energy consumption because of the dependent on heavy machinery used and inefficient electricity. These issues need to be tackled the components of building sustainability which are environmental, economic and social sustainability components. These sustainability components are interconnected and equally critical in achieving a sustainable community. These three pillars of sustainable can be applied to any industry or business also to a construction industry.

Benefit of EMS Implementation in Building Sustainability Components

Environmental Sustainability

In environmental sustainability, the proper management of natural resources tends to be a significance concept as an approach towards sustainability. A system that is environmentally sustainable must have a secure resource base and maintaining integrity of environment while preventing overexploitation of renewable resources. As reported by Cristian et al. (2015), the ability to expand and offer the environment and its uniqueness, while maintaining the preservation and renewal of natural resources is called environmental development. Instead of harming the natural environment, environmental sustainability is able to preserve and enhance it. In addition, sustainable construction benefits the environment by considering the building's lifespan while reducing environmental effects and resulting in more environmentally friendly construction (Ismail, 2015).

Furthermore, sustainable building benefits to the environment in various ways. Building construction that emphasizes sustainability, lead to more environmental protection and less harmful to the environment. Enshassi et al. (2016) and Zabihi et al. (2014) mentioned that among the benefits obtained from sustainability implementation, the natural resources able to be preserved and to protect the environment. Environmental effects such as global climate change, environmental degradation, and pollution able to be reduced by using eco-friendly products that attain from sustainable construction (Kamar & Hamid, 2012). In view of energy conservation, sustainable buildings are normally built to optimize natural lighting in addition to provide natural indoor air quality. It also optimizes energy usage to reduce dependency on fossil fuel and non-renewable energy. As a result, mentioned that sustainability able to minimize waste energy consumption and improve indoor air quality together with better health for the consumer (Milosavljevi et al., 2019).

Economic Sustainability

A system that is economically sustainable must be able to produce goods and services on a consistent basis. It must also able to improve the country's economic development by utilising technology, improving productivity, and avoid severe sectoral imbalances that damage agricultural or industrial productivity (Ismail, 2015). The major concern in this approach is how countries grow their economies. It has been demonstrated that rapid economic growth with the goal of maximising benefits, places a massive pressure on the country's capacity to sustain development (Cristian et al., 2015).

The benefit aspect of sustainability is concerned with issues such as resource efficiency, cost reduction through efficiency and reduced energy waste. In construction perspective, sustainable construction in economic aspect can bring cost savings as the building are appropriately planned and designed in sustainable way thus decreasing environmental damage costs. As reported by Saidur (2009), sustainable building is less expensive than a conventional building because it uses less material, such as water and electricity energy to complete the project. Since there is less waste, the overall costs of the construction are therefore lower. Hence, this gives a reason to take into consideration economic as significance pillar towards sustainability.

Plessis (2002) indicates that the economic aspect of sustainable development involved improving productivity of economy with not just for economic profit but also for the basic human right. Energy related costs can be saved and reduced. Most of the authors supported that sustainable development saved the energy that currently being used in the building (Wai et al., 2011; Tahir et al., 2014) and thus result to reduce in energy cost and environmental damage cost (Milosavljevi et al., 2019). In addition, Zabihi et al. (2014) mentioned that sustainable building also benefits in economic growth of the country especially in developing countries. The overall cost of sustainable building can be reduced due to less material waste when constructing the sustainable building. Hence, the key players in construction industry must look into these benefits when considering constructing building towards sustainability.

Social Sustainability

The philosophy of social sustainability is based on the idea that a decision benefits society. It ensures that future generations able to enjoy the same or better quality of life as the present generation. Sustainable buildings have the potential to enhance human's quality of life and satisfy human needs. The benefits include improved health due to safer materials, increased efficiency due to improved surroundings, and more efficient noise control in construction project.

In the construction industry, social sustainability is a critical solution that enhances the way people live and build. While creating healthier working environments, social sustainability helps in the improvement of areas of well-being that could have an effect on health. The reason behind this is because, buildings built with less waste and pollutants lead to a healthy living environment (Lee, 2014). The practice of sustainable construction can help solve many issues in industries in the aspect of social sustainability towards more quality of social life in the future.

According to Letake & Pawar (2011), sustainable construction has numerous advantages throughout all stages of the construction process. The benefits that can be gain include improved health owing to cleaner materials, increased efficiency by reason of improved surroundings, and optimizing social benefits (Zabihi et al., 2014). Zabihi et al. (2014) also mentioned that social benefits of sustainability include satisfying human needs. On the ground of these advantages, sustainable buildings have the potential to improve quality of life from now to the future which also promoting harmony between humanity and nature and maximize social benefits (Milosavljevi et al., 2019).

Challenges of EMS Implementation

Knowledge and Information

EMS can provide numerous of benefits to the building, but it is not generally adopted within the Malaysia construction sector. This is due to lack of technical knowledge on energy management technologies by some parties that involved in building construction. There are several researchers stated that lack of expertise and professional knowledge are barriers in implementing these practices (Aliaagha et al., 2013; Junaid, 2020). Research by UNIDO (2007) mentioned that engineers and designers are not taught on how to optimise industrial systems for energy management at university but instead they learn via experience. This statement supported by (Smith et al., 2006) which reported that lack of education is one of obstacle to sustainable building. This challenge clearly comes from the lack of training and education in energy management, sustainable design and construction as reported by Enshass et al. (2018).

This also identified and supported by Danielson (2015), who stated that one of the tactics that has a major impact on the implementation of sustainable building is to provide training professionals due to a lack of information about technologies that serves as a barrier to implementation. Thus, Ochieng et al. (2014) suggest that a major and long-term investment in education and training is required to resolve this issue and raise awareness and understanding of the concept of sustainable construction (Abidin, 2010). Another challenge is difficulties to access technical information and expertise related to energy management in construction as mentioned by Enshass et al. (2018). Research by Aliaagha et al. (2013) also mentioned that the challenges of energy practices are technical information and expertise on the adoption of energy management practices is difficult to access.

Economic and Financial

The rapid growth of the building industry has resulted in an increase energy demand throughout the global. Increased costs are one of the most major challenges attributed to energy management. As reported by Baloi (2003), EMS is frequently linked with a huge upfront investment to cover various costs. One of the challenges to attaining sustainable development as mentioned by Aliagha et al. (2013) is recognizing the actual cost involved. Several studies found out that construction energy costs are not sufficiently important as compared with other costs (Enshass et al., 2018; Ochieng et al., 2014). Lee (2014) also stated that energy cost is not significant as it drawn the investor from invest in energy management option. Enshassi et al. (2018) have indicated that lack of budget funding to adopt energy management practices and technologies acts as barriers in EMS implementation. This statement supported by several studies stated that there are insufficient credit resources to fund the costs of sustainable development (Aliaagha et al., 2013; Ochieng et al., 2014).

Other challenge of EMS implementation is low profit margins gained from adopting energy management practices. Enshassi et al. (2018) stated construction contractors claim that higher costs, longer delays, and lower profits are justifications for ignoring energy management standards and practices. Danielson (2015) also mentioned energy management costs can cause investment returns to be unpredictable, causing energy efficiency projects to be delayed. There is also perception mentioned by Aliaagha et al. (2013) that implementation of sustainable construction increase cost and reduce overall profit gained from adopting these practices.

Legal and Contract

As according to numerous studies, one of the challenges to the implementation of sustainable development is the government's lack of encouragement and enforcement in construction. This statement is supported by several studies which mentioned that there is lack of enforcement by the government to implement EMS despite EMS brings towards more sustainability in building and proven to enhance building sustainability (Aaligha et al., 2013; Chian, 2013; Khalfan et al., 2015; Abidin, 2010). Research into the challenges of sustainable building in Malaysia revealed that one of it is a lack of building codes and regulations (Aaligha et al., 2013; Ding et al., 2018). Enshass et al. (2018) also added in research that lack of energy management codes and government involvement are two more factors contributing to this issue. This statement is supported by Ochieng et al. (2014) stated that the regulations, incentives, policy and commitment by government is significant and not be sufficient enough to move towards the realization of sustainable developments.

Government plays a significant role in making sure that the building that constructed brings towards sustainability. However, Plessis (2002) mentioned that governments are unable to provide the financial resources required to support the energy practice. Ding et al. (2018) indicates that there is a lack of strategy to increase sustainable development, and that it is the government's responsibility to promote sustainable development technologies. The government must impose various incentives for energy management in the construction industry for implementation of EMS to go forward rapidly and successfully and able to enhance building sustainability.

RESEARCH METHODOLOGY

Research methodology is a systematic overall procedure to solve the research problem, achieve the objectives and establish new conclusion. Research methodology is a formal approach involving a structured data collection method and the way it is evaluated. It is a method of collecting, documenting, evaluating, and interpreting the information. The scope of the study will concentrate on the parties involved in constructing buildings which is G7 Contractors to gain their perception regarding the implementation of EMS to enhance building sustainability. Klang Valley is selected as the location of the research because the areas are known as urban centres. There are 437 registered G7 contractors as listed by CIDB and the sample size for the population is 205. The questionnaire survey was used to acquire the primary data, since it was the most efficient technique to collect large amounts of data in order to meet the research objectives. A total of 205 surveys were distributed and only 64 responses obtained which contributed to 31%. This is due to the pandemic situation that hit Malaysia and slow responses obtained within the stipulated time outlined.

A software package called Statistical Packages for Social Sciences (SPSS) is used to interpret the quantitative data from this study. This method is useful for the study of broad survey data sets. When all the respondents completed the questionnaire, the package was utilised to interpret the data. All questions would be evaluated separately, taking all the variables available into consideration, and assisted with descriptive and inferential analysis. After the questionnaires were returned from the respondents, the data started to be analysed using table form to get the outcome result on the objectives of this research. All questions would be evaluated and taking all the variables into consideration, and also assisted with descriptive analysis. This method is useful for the study of broad survey data sets. SPSS can also generate an adequate result for the primary source of data. SPSS tools were used to calculate the mean score, frequency, and percentage of the response. By obtaining the mean score for each factor carried out by the survey, the rank of each factor was able to be gained.

FINDINGS AND DISCUSSION

Respondents' Background

This section covers the respondent's personal profile and the result was tabled as per Table 1. There were five items in the demographic section which included age, respondent's position in the company, years of experience in construction works and number of executed projects. Table 1 presents the summary statistics for respondents' profile. Age distribution of the respondents shows that the highest percentage of respondent is in the range of 31 – 35 years old (32.8%) followed by below 25 years (25%), 25 – 30 years (18.8%), 36 – 40 years old (15.6%) and the lowest percentage are from 40 years and above. Further analysis shows that the majority of the respondents are in position of Contractor (42.2%) followed by Quantity surveyor (25%) and Manager (12.5%) while the other respondents are Director, Engineer, Sub-Contractor, and Supervisor. The position of respondents in company provides different opinions of answering the questionnaire. Next, most of the respondents are having less than 5 years' working experience (34.4%). It is followed by 6 – 10 years working experience (25%), 16 – 20 years (17.2), 11 – 15 years (15.6%), and the least year of working experience is more than 20 years (7.8%). The working experience years of respondent are very important to ensure the quality of data obtained. The table also shows the number of executed projects by respondent in the last ten years which indicates that most respondents have executed less than 5 projects (23.4%) followed by 6 to 10 projects (23.4%), 11 to 15 years (20.3%), 16 to 20 projects (20.3%) and the least is more than 20 projects (6.3%). Basically, there are 23.4% of the total respondent have involved in the project that implement EMS although most of them (76.6%) have no experience in EMS implementation on building projects in the construction industry.

Table 1. The Background of Respondents

Descriptions	Frequencies	Percentage (%)
A. Age		
< 25 years	16	25.0
25 -30 years	12	18.8
31 - 35 years	21	32.8
36 - 40 years	10	15.6
> 40 years	5	7.8
B. Position in the company		
Director	4	6.3
Manager – Site/Construction/Project	8	12.5
Quantity Surveyor	16	25.0
Engineer - Structural/Project/Civil	5	7.8
Contractor	27	42.2
Subcontractor	2	3.1
Supervisor	2	3.1
C. Years of Experience		
Less than 5 years	22	34.4
6 - 10 years	16	25.0
11 - 15 years	10	15.6
16 - 20 years	11	17.2
More than 20 years	5	7.8
D. Number of executed projects		
< 5 projects	18	28.1
6 - 10 projects	15	23.4
11 - 15 projects	14	21.9
16 - 19 projects	13	20.3
> 20 projects	4	6.3
E. Experience in handling project that involved in Energy Management System		
Yes	15	23.4
No	49	76.6

Benefit of EMS Implementation in Building Sustainability Components

The benefits of building sustainability component for this research consisting environmental component, economic component, and social component. This section analyses on the level of agreement of respondents towards each items in environmental, economic, and social component. The mean score, perception level and rank for each component involved analysed in the following section. The total average of each mean score also indicates in the Table 2.

Table 2. Benefits of EMS in Building Sustainability Components

Item	Descriptions	Mean	Perception level	Rank
A	**Environmental Component**			
1.	Minimizing environmental pollution	4.32	Agree	1
2.	Minimizing waste energy consumption	4.31	Agree	2
3.	Maintaining integrity of environment	4.25	Agree	3
4.	Able to conserve natural resources	4.19	Agree	4
5.	Preventing global warming	4.11	Agree	5
	TOTAL AVERAGE	**4.24**	**-**	**-**
B	**Economic Component**			
1.	Reducing energy consumption and costs	4.36	Agree	1
2.	Decreasing environmental damage costs	4.25	Agree	2
3.	Improving productivity	4.20	Agree	3
4.	Decreasing overall building costs	4.16	Agree	4
5.	Improving economic growth	4.16	Agree	5
	TOTAL AVERAGE	**4.23**	**-**	**-**
C	**Social Component**			
1.	Able to improve health, comfort and well being	4.27	Agree	1
2.	Optimizing social benefits	4.25	Agree	2
3.	Improving quality of life for individuals and society	4.17	Agree	3
4.	Satisfying human needs	4.16	Agree	4
5.	Promoting harmony between humanity and nature	4.05	Agree	5
	TOTAL AVERAGE	**4.18**	**-**	**-**

Table 2 shows the breakdown of environmental component in building sustainability. The highest rank among the factors is ‘Minimizing environmental pollution’ followed by ‘Minimizing waste energy consumption’ with mean score of 4.32 and 4.31 respectively. Next, for the economic component, the result obtained from the analysis show that ‘Reducing energy consumption and costs’ (mean=4.36) give good image to the respondents. ‘Decreasing environmental damage costs’ with mean of 4.25 and ‘Improving productivity’, mean=4.20, both shows the positive feedback from the respondents. ‘Decreasing overall building costs’ and ‘Improving economic growth’ share the same mean score of 4.16 for the question regarding benefits of economic component in building sustainability. Table 2 also demonstrates some factors that contribute to social component benefits in building sustainability. The first rank is ‘Able to improve health, comfort and well-being’ (mean=4.27), and ‘Optimizing social benefits’ (mean=4.25) placed second on the social component benefits. However, there is only slightly difference among factors of ‘Improving quality of life for individuals (mean=4.17) and society’ and ‘Satisfying human needs’ (mean=4.16). Overall view of these social component benefits, all respondents give positive feedbacks for the benefits listed.

The overall mean score for the identified benefits of sustainability components categories is determined by analysing the components breakdown for each category. Refer to Table 2, category of 'Environmental component' (mean=4.24) takes the first rank among all the others. The second highest of mean score for barrier category is 'Economic component' with mean score 4.23, and 'Social component' (mean=4.18) placed lowest rank although there is not much difference of average mean score among the others. Overall view of these barriers, all respondents give their positive feedback for the barriers listed and reach 'agree' on their perception level of all the items stated in each categories.

This research analysed and found that the major benefits of this research study agreed by respondents is environmental benefits. Sustainable building is influenced by environmental concerns. This research study revealed that the respondents tend to agree on the benefit of environmental by implementing the EMS. Most of them agree it can minimize environmental pollution as well as research from Cristian et al. (2015) mentioned that environmental component has the ability to expand and offer the environment while maintaining the preservation and renewal of natural resources.

Economic component placed as the second place in the listed benefits of sustainability components. The respondents rated their opinion on economic component of sustainability able to reduce energy consumption and costs and decreasing environmental damage costs. These findings were supported by Serpa & Ferreira (2020) as the benefit aspect of sustainability is concerned with cost reduction through efficiency and sustainable construction in economic aspect can bring cost savings as the building are appropriately planned and designed in sustainable way.

On the other hand, social component also had been determined as the benefits contributed to the implementation of EMS. The respondents agree that social component benefits able to improve health, comfort, and well-being, optimizing social benefits and also improving quality of life for individuals and society. These findings were supported by Koutsogiannis (2018) as he mentioned that the benefits of social sustainability include improved health due to safer materials and increased efficiency due to improved surroundings. Thus, the practice of sustainable construction was able to solve many issues in industries in the aspect of social sustainability resulting in a greater quality of social life in the future.

Challenges of EMS Implementation

The analysis of challenges in implementing Energy Management System (EMS) presented in this section. The challenges consist of economic/financial, knowledge/ information and legal/contractual categories. The mean score and rank for each of challenges involved was analysed in this section.

From Table 3, for the knowledge/information category, 'Difficulties to access technical information and expertise related to energy management in construction' (mean=4.03) takes the first rank among the other factors. Table 3 also shows the factors that contribute to Legal/Contractual challenges category with the highest response for 'Lack of government incentives for energy management in construction industry' (mean=4.00). The respondents agree that 'The contract documents do not impose any special conditions/specification for energy management' (mean=3.91) also gives impact on the knowledge/financial category which indicates as the second highest among the factors. As can be seen from the table, 'Lack of budget funding to adopt energy management practices and technologies' (mean=4.09) is the major factor contributed to the financial/economic category. Refer to Table 3, category of 'Knowledge/Information challenge (mean=3.97) takes the first rank among all the others. The second highest of mean score is the 'Legal/Contractual' with mean score of 3.92. Meanwhile, 'economic/financial challenge' (mean=3.91) category followed with slightly difference amount of mean score. Overall view of these barriers, all respondents give their feedback for the barriers listed.

Table 3. Challenges in EMS Implementation

Item	Challenges Descriptions	Mean	Perception Level	Rank
A.	**Knowledge and Information**			
1.	Difficulties to access technical information and expertise related to energy management in construction	4.03	Agree	1
2.	Lack of technical skills/knowledge on construction energy management technologies	4.02	Agree	2
3.	Resistance to change from traditional practices to more energy efficient practices	3.95	Agree	3
4.	Lack of training and education in energy management, sustainable design, and construction	3.95	Agree	4
5.	Lack of Client awareness of importance of energy management during onsite construction	3.89	Agree	5
	TOTAL AVERAGE	**3.97**		
B.	**Legal and Contractual**			
1.	Lack of government incentives for energy management in construction industry	4.00	Agree	1
2.	The contract documents do not impose any special conditions/specification for energy management	3.98	Agree	2
3.	Poor enforcement of the government legislations related to energy issues in construction industry	3.91	Agree	3
4.	Lack of energy management codes and regulation in construction	3.80	Agree	4
	TOTAL AVERAGE	**3.92**		
C.	**Economic and Financial**			
1.	Lack of budget funding to adopt energy management practices and technologies	4.09	Agree	1
2.	Additional costs needed to improve the energy efficiency of building	3.95	Agree	2
3.	Low profit margins gained from adopting energy management practices	3.92	Agree	3
4.	High costs of energy management options	3.83	Agree	4
5.	Construction energy costs are not sufficiently important compared with other costs	3.75	Agree	5
	TOTAL AVERAGE	**3.91**		

This research analysed and found that the major challenges agreed by the respondents was Knowledge/Informational category where difficulties to access technical information and expertise related to energy and lack of technical skills/knowledge on construction energy management technologies ranks as the top items in this Knowledge/Informational. Both of these challenges were supported by several authors; Enshass et al. (2018); Aliaagha et al. (2013); Junaid (2020) and Danielson (2015) where mentioned that knowledge and informational challenges act as one of the main factors to sustainable development. As a result, the constraints of these challenges cause a limited adoption of EMS. Legal/contractual has also one of the challenges listed in this section and took second place in the listed categories identified. This research has found that lack of government incentives for energy management in construction industry contributed to the major legal/contractual challenge by the respondents.

Apart from that, poor enforcement of the government legislations and contract documents do not impose any special conditions/specification for energy management were also agreed by the respondents. These findings were supported by Ochieng et al. (2014); Ding et al. (2018); Plessis (2002); Aaligha et al. (2013) and Enshass et al. (2018). These authors lined out that each of the factors stated led to the legal and contractual challenges to the adoption of EMS. In addition, economic/financial been chosen by the respondents to be the third challenges listed in this research while the top item rank was lack of budget funding to adopt energy management practices and technologies. This finding supported by Enshassi et al. (2018) indicates that lack of budget funding to adopt energy management practices and technologies and several studies stated that there are insufficient credit resources to fund the costs of sustainable development (Aliaagha et al., 2013; Ochieng et al., 2014; Lee, 2014). Additional costs needed to improve the energy efficiency of building and low profit margins gained from adopting energy management practices also ranked at the top level as according to research by Aliaagha et al. (2013) mentioned that implementation of sustainable construction increase cost and reduce overall profit gained from adopting these practices.

CONCLUSION

Building sustainable plays significant roles to improve quality of life in developing countries. The research indicates that there are plenty sustainability benefits can be attained by adopting EMS. Thus, EMS approach is considered as one of the driving factors for sustainable building. However, in order to reach towards implementation, there are challenges being obstructed. The adoption of EMS in building has a positive impact on the environment. Additionally, the beneficial impact clearly demonstrates that using an EMS will contribute to improve the country's building sustainability. The analysed data were supported by the literature review of this research. Thus, every single objective in this research had successfully achieved through the responses from G7 contractors in Klang Valley.

With the result obtained from this research, the perception of G7 contractors towards EMS is now acknowledged with some degree of certainty. The significance of the research to the industry are to establish better understanding on the perception of EMS adoption towards the key players of construction industry and to give the G7 contractors more confidence to engage on sustainability development by implementing EMS as they aware of the environmental, social, and economic benefits. This research was based on an overview of various key players in the construction industry's perspectives. Since there are numerous challenges and benefits in implementing EMS, respondents' perspectives may differ. It is suggested to have more incentives from government for the implementation of EMS. Furthermore, there were also additional recommendation which is gives an award of achievement to building that implement EMS and government makes it compulsory to implement EMS inside the building to enhance the implementation of EMS and building sustainability. By obtaining data analysis, findings, drawing a conclusion, and making recommendation based on the collected data, it proves and exposes the benefits and challenges of EMS implementation in Malaysia’s construction industry.

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IMPROVING SAFETY CLIMATE IN THE MALAYSIAN CONSTRUCTION INDUSTRY THROUGH BUILDING INFORMATION MODELLING (BIM) CAPABILITIES

Noor Akmal Adillah Ismail, Bibi Nur Basirah Baharun, Hamimah Adnan, Mysarah Maisham and Noor Aisyah Asyikin Mahat
Centre of Studies for Quantity Surveying, Faculty of Architecture, Planning and Surveying, Universiti Teknologi MARA, Shah Alam, Malaysia.

Abstract
The Malaysian construction industry are dealing with numerous cases of permanent injuries and death of workers in construction sites. This has caused lack of productivity and also losses of human resources. The urging working condition aiming for on time completion has led to unsafe working behaviour due to the top management pressure. This is where Building Information Modelling (BIM) came into view to increase the safety on site environment and through design phase by using technology to overcome human inconsistency behaviour. However, the lack of BIM implementation in Malaysia also causes even lesser implementation of BIM in safety of construction. Therefore, this study aims to investigate the BIM capabilities towards better safety climate in the Malaysian construction industry. A qualitative approach was used through semi-structured interviews and discussion with selected representatives from both private and government sectors. All the interviewed data were then analysed using content analysis technique which correlated the findings with the literature review to support the findings. Based on the findings, it can be concluded that (1) Visualisation for Safety, and (2) Simulation for Safety are the most potential BIM capabilities to be implemented in the construction industry for improving safety climate by using BIM technology. Significantly, the study provides insights towards outlining potential BIM capabilities on policy or Safety Rules and Procedure implementation by the government authority or organizations' top management.

Keywords: *Building Information Modelling*; *BIM; Safety; Safety Climate; Malaysian Construction Industry.*

INTRODUCTION

According to statistic gained from the Department of Occupational Safety and Health (DOSH) Malaysia, from October until November 2018 (DOSH, 2018), the three highest case industries contributing to job-related injuries were construction, manufacturing, and agriculture industry. Subsequently, the construction industry, was ranked as the third most dangerous with 148 cases where 81 deaths, 61 non-permanent disabilities and 7 permanent disabilities. The dangerous condition at construction sites working with complex work packages that are obviously harmful, contributed to the job-related injuries. Rafindadi et al. (2020) analyzed data from the DOSH website and concluded that 796 fatal accidents had happened over the period of 2010-2018. From the accidents report, 38.16% were fall-related, 30.39% struck-by, 17.67% caught in-between, 9.89% drowning/asphyxiation and 3.89% others. It was revealed that the accidents had occurred because of the management's failure, unsafe site conditions, workers behavior, and environmental factors. As emphasized by Charehzehi and Ahankoob (2012), construction sites are usually in short of resources and the safety planning are not properly planned. The classification of safety culture and climate is observed as an important contributor to the reduction of occupational accidents (Bjerkan, 2010). An environment that is believed to be safe supports and emphasizes individual safety behaviour will further influence other colleagues. Increasing pressure can be put on noncompliers to fall in line when the safety behaviours have been adopted throughout the organisation (Rahim et al., 2014).

Meanwhile, to reduce the difficulties and complexities in construction, the concept of Building Information Modelling (BIM) innovation was introduced in 1970 (Eastman et al., 2011). The construction industry has actually acknowledged BIM benefits and started applying BIM technology in construction projects since mid-year 2000 (Azhar et al., 2012). While most of developed countries have actively implemented BIM, however, it might be similar with other developing countries, the BIM use is still at slow pace for the Malaysian construction industry (Othman et al., 2021; CIDB, 2017). Many challenges were identified throughout the years of the technology implementation such as lack of awareness, costs, slow adaptation, unavailability of a clear guidelines, lack of expertise, government mandate and support, and many more (CREAM, 2014; Rogers et al., 2015; Hanafi et al., 2016; Ahmad Jamal et al., 2019; Othman et al., 2021).

Despite several challenges highlighted in the BIM development of the Malaysian construction industry, it is no doubt that the BIM tools could improve the safety and health procedures in the region (Rafindadi et al., 2020). As analyzed comprehensively by Fargnoli (2020), previous studies have supported that BIM-based solutions assisted in enhancing safety and health provision in construction activities. Therefore, this study propositions that BIM has the potential capabilities to provide better safety climate for construction projects in Malaysia. It aims to promote BIM technology as one of the tools to assist with minimizing safety issues in the construction industry.

LITERATURE REVIEW

Overview of Safety Culture in the Malaysian Construction Industry

The construction industry in Malaysia is obviously a hazardous industry. The main cause is usually due to the dangerous activities during construction phase. Accidents occur at construction sites were resulted from the faults of either the management or the workers' behaviours themselves (Wahab, 2017). With reference to the Department of Occupational Safety and Health, DOSH (2018), most of the deaths were because of high fall and falling construction material on workers. It was also due to no strict supervision of the management team on site and improper work procedure conducted at a height. As discussed by Dodoo and Al-Samarraie (2019), most accidents and injuries emanating from workplaces are attributed to workers' unsafe behaviours, which are also a reflection of organization system deficiency and hazardous work-environment. Although the safety regulations are available for the workers to comply with for the sake of their safety, but the pomposity and insubordination of construction workers prevent them from complying, and always wanting to have their own ways of carrying out activities on site. As for example, a case of a construction worker died falling from height in Penang in 2016 was caused by the failure of his company to provide safe working condition and adequate supply of personal protective equipment (PPE) to the workers (Wahab, 2017). Also, two fatal casualties were hit by crane in Sarawak in 2017 were because of the construction company did not comply with Occupational Safety and Health Act, OSHA 1994 for lifting works. The accidents could have been avoided if the management supervised the workers' duties by complying with the OSHA 1994 during the construction process (Borneo Post, 2017). The presence of safety practices, procedures, and guidelines becomes an essential element for the survival and wellbeing of construction industry personnel. Furthermore, the development of health and safety principles from an organizational perspective is a significant subject of international concern (Zhu et al., 2010). Thus, both regulating authorities and organizations should prioritize the perception of safety and verify its thorough implementation on construction sites. Measuring the safety climate on worksites should be encouraged by employers, to recognize and resolve organizational and management problems of safety before the occurrence of safety accidents (Cigularov et al., 2013). Eventually, high safety climate levels in a company could result in employees perceiving that maintaining good safety practices is encouraged, in spite of increased production pressure; thus, they will behave safely (Huang et al., 2017).

BIM Safety Capabilities

BIM technology is claimed to be potentially adopted in dealing with many issues in the construction industry including safety and health concerns at construction sites. Fargnoli et al. (2020) highlighted findings from the past studies and concluded that BIM-based tools are crucial in understanding the dynamics of construction activities related hazard types, hence facilitating the safety managers to prepare safety actions more adequately. The implementation of BIM technology in the construction of safety management is the most efficient step to promote safety culture and climate in the construction environment of the organization because it will then improve the safety practices by the construction companies and affect the safety behaviour of the workers in construction industry (Zhao & Lucas, 2015). In overall, the application of BIM technology could enhance safety culture and safety climate since it augments the operator’s ability in monitoring construction activities safely, at the same time responding to the external changes and foreseeing future incidents more effectively (Fargnoli et al., 2020).

Visualisation Safety Capability

The effectiveness of visualization in construction safety contains construction sequence review (Bansal, 2011), estimation of hazard and risk (Ding et al., 2014), enhancement of safety consciousness and communication (Zhang et al., 2015), the integration of safety plans into the site layout plan in construction (Zhang et al., 2015), improvement on the development of the education materials to be provided for training and education which is allocated for safety (Park & Kim, 2013), and establishment of input on the boundary conditions of risk elements (Park & Kim, 2013). Moreover, the advantages of BIM visualization are that it can measure the machinery and equipment’s’ blind spots during handling the construction tasks, recognizing safety requirements for high-risk activities, establish a standardized safety measures to be implemented into the construction schedule, and relating safety prevention measures with temporary structures and also components of building (Zhou et al., 2012).

Simulation Safety Capability

Simulation is not the same from visualization as it is able to give a much more dynamic visual image of certain dangerous situation (Ruppel and Schatz, 2011). Simulation is more like the improvised version of visualisation. The images generated during simulation are active as it combined the analysis of the situation with visualization. In safety climate, BIM simulation is useful for planning escape routes (building egress), modelling of workers’ safe behaviour, and planning safety measures (Park & Kim, 2013; Wang et al., 2015). Simulation is also competent in modelling a far safer way of installation of building elements and the assembly of building components (Young et al., 2014), modelling of the removal of safety equipment (Zhang et al., 2015), and modelling of space-time conflict such as the analysis of workspace congestion, space disruptions, potential work interruptions, and workspace war between different construction activities (Zhou et al., 2012).

Animation Safety Capability

Shi and Zhang (1999) reported the animation of a machine or crane operation displaying activities such as the object lifted to the position, object dropping off, as well as picking up of the object, and returning the object to the earlier pick-up position. Research on BIM safety management identified the usefulness of animation in the safety climate of a construction site area. Park and Kim (2013) confirmed that animation is useful in improving site safety inspection task, improving workers' cognition of safety risks in terms of injuries that are related to their scope of work activities, and making construction workers to pre-experience the activity-specific safety risks before the execution of their work. Also, Zhang et al. (2015) stated that animation of the use of personal protective equipment, safe operation of plants and equipment, safety behaviours, safety code checking and planning, and safety rules, are ways to utilize BIM technologies in safety culture.

Digital Fabrication Safety Capability

The use of conventional formwork systems is wasteful, expensive, and unsafe construction methods. However, BIM technology potentially provides digital fabrication giving a safe construction method and acts as one of the technological solutions towards the hazardous construction environment (Kostakis & Papachristou, 2014). The technology entails cutting, lamination, 3D printing, extrusions, and also the automated assembly (Agustí-Juan and Habert, 2017). As an ecologically sustainable construction method, digital fabrication will then integrate the properties of construction materials with that of structural properties so that it will be able to create structures with complex shapes and integrate hazardous construction environment (Lloret et al., 2015; Gattas and Yu, 2016). Agustí-Juan and Habert (2017) demonstrated the use of digital fabrication in order to reduce the environmental impact of a certain multi-functional building elements.

Virtual Reality (VR) Safety Capability

As referred to Zhou et al. (2012), VR is beneficial for mock up model of different scenarios in preventing the probability of the accident occurrences due to safety hazard in construction projects, mock-up model of common unsafe acts and conditions supplemented with accident reports, regulations, and precautions, virtual experiments of innovative construction technologies, systems, and processes, modelling a dynamic construction site environment to enable dynamic navigation of construction site, modelling on-site construction situations and operations, modelling site planning and layout, and mock-up of job safety analysis and safe working procedures. BIM that embeds Virtual Reality in safety culture has been explored by creating a prototype VR system of the expected accident scenarios (Park and Kim, 2013), and a VR environment for evaluating workers' behaviour in several unsafe work scenarios (Hilfert et al., 2016). The workers or the safety officer or BIM

Manager will be able to experience their construction activities with their own feeling of gut and experience which they first gained from the VR.

RESEARCH METHODOLOGY

The study was conducted by four stages namely Stage 1 (data collection through literature review), Stage 2 (data collection through expert interviews), Stage 3 (data analysis), and Stage 4 (conclusion and recommendations). During Stage 1, the data collection was gained from the secondary resources which was from the literature review. The information obtained from the reviewed literature were then specified into the semi-structured interview questionnaire for Stage 2 to be distributed amongst BIM expertise in the Malaysian construction industry such as BIM Project Manager, BIM Architect, BIM Engineer and also project Safety and Health Officer that use BIM. The unit of analysis for this study is the Malaysian construction industry players who were experienced in BIM application and involved with construction safety and health. For Stage 3, the data was analyzed using content analysis based on the interview findings and discussed further to establish conclusion and recommendations for Stage 4. The content analysis was conducted conventionally with coding categories were derived from BIM capabilities identified through reviewed literature which are Visualization, Simulation, Animation, Digital Fabrication and Virtual Reality (VR) safely capabilities.

The telephone interview method was chosen for the study as for that moment, Malaysia was experiencing a Covid-19 virus outbreak and undergoing a Movement Control Order (MCO) to prevent the spreading of the pandemic. Moreover, as the interviewer and interviewees were too far in distance for traveling and due to restriction to cross each other state borders, hence the interviews were conducted by phone calls. As there was no database in detecting population of expertise (consisting of BIM Project Manager, BIM Manager, BIM Engineer, BIM Architect and Site Safety Officer) involved in BIM practices for safety in construction industry, the interviews were done randomly with the individuals of experienced and BIM certified personnel who were considered as samples for this study. The method of sampling conducted was through snowball sampling method as it gave advantage in obtaining the data where information on potential interviewees can be shared from one targeted respondent to others. The samples were divided into two sectors, which were government and private sectors. The samples from the private sector were from the BIM experienced personnel of construction organizations located around Selangor and Kuala Lumpur area, officially registered with the government association of Construction Industry Development Board (CIDB). The subjects of the samples were amongst the Project Manager, BIM Manager, BIM Architect, BIM Engineer and Safety and Health Officer of those selected companies. Meanwhile for the government sector, the samples were the government staff of the BIM Unit at the Public Work Department (PWD) as the unit department was also responsible in using and developing BIM based practices plan in the Malaysian construction industry.

FINDINGS AND DISCUSSION

The respondents' details for the interviews are tabulated in Table 1 below. All interviewees were selected based on their experience and expertise on BIM usage for safety. From the original targeted nine construction organizations, only seven were successfully interviewed for the study, where other two construction organizations declined to participate. To obtain fair and diversified opinions between public and private sectors, two out of seven respondents were chosen from the government organization of Public Work Department (PWD) and other five respondents were from the private sectors mostly possessing vast experience in BIM tools application.

Table 1. Respondents' Details

Respondent	Organisation	Designation	Experience/Expertise
Respondent 1 **(R1)**	Public Sector (PWD)	Senior Civil Engineer (Project Manager for BIM government projects)	14 Years (BIM Certified under CIDB)
Respondent 2 **(R2)**	Public Sector (PWD)	BIM Civil Engineer	4 Years (Certified BIM Modeller)
Respondent 3 **(R3)**	Private Sector	BIM Manager (Project Manager)	12 Years (BIM Manager certified. All BIM Disciplines Certification)
Respondent 4 **(R4)**	Private Sector	BIM Architect	4 Years (Certified Revit Professional, CIDB BIM Coordinator)
Respondent 5 **(R5)**	Private Sector	Site Safety Supervisor	5 Years (Certified Yellowbook)
Respondent 6 **(R6)**	Private Sector	BIM Engineer	4 Years (Involved in organisation's BIM Execution Plan (BEP))
Respondent 7 **(R7)**	Private Sector	BIM Architect	4 Years (Involved in organisation's BIM Execution Plan (BEP))

In investigating BIM capabilities towards improving safety climate in the Malaysian construction industry, the interview questions were divided into five BIM capabilities namely; (1) Visualization for Safety, (2) Simulation for Safety, (3) Animation for Safety, (4) Digital Fabrication for Safety, and (5) Virtual Reality (VR) for Safety.

With reference to the analysed interview findings, most of respondents applied BIM Visualization (Capability 1) for safety purposes in their organizations. R1 from the public sector revealed that the Public Work Department (PWD) has successfully implemented visualization for site safety monitoring purpose, where building models were produced demonstrating 3D images of site and earthworks through advanced BIM tools. Site visualization and earthwork was practiced in the construction stage considering that the stage is the most vulnerable phase prone to risks and hazards, exposed to the site workers. Hence the government sector has chosen BIM visualization feature as to reduce common risks and devise alert on the upcoming risks. Whilst R7 from the private sector, indicated that his organization was actively implemented BIM Execution Plan (BEP) for about two years where a BIM Coordinator has been put in charge in the BIM Department for his organization. R7 mentioned that all of the safety checking in Revit has been accessed and approved by the BIM coordinator through a Virtual Design Review (VDR). Safety checking on clash report was discussed with the BIM Coordinator through the Revit Visualization features by showing the model in the Revit software application.

In term of BIM Capability 2, all of the respondents seemed to apply Simulation for Safety in their organizations. The simulation features possess 4-Dimensional (4D) which include 3D models with time scheduling features where it enables the personnel to monitor the stages of work programme. With proper time scheduling features, 4D, the work stages in the construction phase would be executed in a more systematic way. Besides, by the simulation of work programmes stages, future risks and hazards would be able to be predicted at an earlier stage thus provide safety readiness attitude to all workers involved in the related project. Through this simulation process, risks and errors identification would be clearly visualized in the model and earlier preparation can be made for any upcoming risks or conflicts during the construction phase.

Moreover, majority of respondents have adopted BIM Capability 3: Animation for Safety in their organizations except for BIM Architect (R4), BIM Engineer (R6), and BIM Architect (R5). R1 stated that the government has already applied BIM animation for safety in the BIM Unit of Public Work Department (PWD) which was elaborated in the "Garis Panduan BIM Jabatan Kerja Raya (JKR)". Meanwhile, from the perspective of private sector, only R3 and R5 manipulated BIM for Animation for safety. However, although did not use BIM animation for site safety demonstration purpose, R7 has put his positive opinion regarding the capabilities of BIM in animation for site safety reasons. R7 positive perception towards BIM potential in implementation for safety was shown as he suggested animation from Naviswork and Revit to facilitate in preventing accidents at construction sites. BIM Animation is said to be used only for design purposes. It is then proved that BIM mechanism is still new towards construction safety and lack of skilled resources and time are amongst the factors that prevent this capability to be implemented throughout the organisation BIM workflow.

Four of the respondents did not apply BIM Capability 4: Digital Fabrication for Safety in their organizations. Only R1 and R2 from the government authority have applied digital fabrication capability in their projects. However, the two respondents were from the BIM Unit of PWD which handles BIM government projects under PWD only. This fabrication capability for safety has been used in government BIM project but still not in a wide range of implementation. Other projects which were not under the responsibility of PWD BIM Unit were possibly still large in numbers hence proving that this capability has still not been implemented widely in the government projects. Consequently, it has however proved that the government has implied its own guideline of BIM Execution Plan (BEP) to promote other projects to use BIM. Meanwhile, R3 from the private sector has also applied Digital Fabrication for Safety in the organization. Although minority, the application of digital fabrication capability of BIM for construction projects, was indeed exist in the Malaysian construction industry. Even though the respondents used the capability, but they were still new to it. Meanwhile, the other four respondents did not apply the digital fabrication capability and were not aware of its function.

For BIM Capability 5: Virtual Reality (VR) for Safety in their organisation, only R1 and R2 from the government sector applied Virtual Reality (VR) for safety purpose in their construction projects. The other respondents from the private sector did not implement the capability due to whether no demand by the clients or they did not involve in that scope of work for their related construction projects. This BIM capability is still too new, and it demands higher funding of the virtual reality devices and software. Therefore, many organizations have not put this capability into consideration. Table 2 summarizes the responses from the interviewees with regards to BIM capabilities towards better safety climate in the Malaysian construction industry.

Table 2. BIM Capabilities in the Respondents' Organizations

BIM Capabilities for Safety	Public Sector			Private Sector			
	R1	R2	R3	R4	R5	R6	R7
BIM Capability 1: Visualization for Safety	/	/	/	/	/	/	/
BIM Capability 2: Simulation for Safety	/	/	/	/	/	/	/
BIM Capability 3: Animation for Safety	/	/	/	X	/	X	X
BIM Capability 4: Digital Fabrication for Safety	/	/	/	X	X	X	X
BIM Capability 5: Virtual Reality (VR) for Safety	/	/	X	X	X	X	/

CONCLUSION

All of the respondents were asked on their BIM software capability towards improving safety climate in their organization projects. From the conducted interviews, it can be concluded that BIM capabilities (1) Visualization for Safety, and (2) Simulation for Safety are the most potential capabilities to be implemented for construction projects in improving safety climate, as agreed by most of the respondents. Meanwhile for BIM Capability (4) Digital Fabrication for Safety, and (5) Virtual Reality (VR) for Safety, most of the respondents gave negative feedback towards its implementation in improving safety climate due to lack of implementation and high operation cost on the devices and software needed upon implementing the capabilities. Hence, the capabilities 4 and 5 were not favourable for BIM safety implementation amongst the respondents. For BIM Capability (3) Animation for Safety, four of the respondents implemented it for improving safety climate in their organization projects but the other 3 respondents did not favour this capability as the most potential feature in improving safety climate in the construction industry. For future research, it is recommended that policy or Safety Rules and Procedure for BIM application is established by the government authority or organizations' top management to better enhance and promote BIM technology implementation more effectively towards safety climate in the Malaysian construction industry.

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MANIFESTATION OF LAND SURFACE ALBEDO AND TEMPERATURE DYNAMICS TOWARDS LAND COVER

Siti Aekbal Salleh*[1,2], Zulkiflee Abd Latif[1,2], Wan Mohd Naim Wan Mohd[2], Andy Chan[3], Imran Mohamad Ariffin[4] and Emad Mustaha[5]
[1]*Institute for Biodiversity and Sustainable Development, Universiti Teknologi MARA, 40450, Shah Alam, Selangor, Malaysia.*
[2]*Center of Studies Surveying Science and Geomatics, Faculty of Architecture, Planning and Surveying, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia.*
[3]*Faculty of Engineering, University of Nottingham Malaysia Campus, Jalan Broga, Semenyih, Selangor, Malaysia.*
[4]*ESRI Malaysia Sdn. Bhd, Unit 3A-1, Level 3A, Tower 2B, UOA Business Park No, 1, Jalan Pengaturcara U1/51a, Seksyen U1, 40150 Shah Alam, Selangor, Malaysia.*
[5]*Architectural Engineering, College of Engineering, University of Sharjah, UAE.*

Abstract
Land surface albedo studies have always been dominated by the snow-covered area while snow-free area albedo effects induced by the land use and land covers are much less documented. The objective of this study is to investigate the significant differences of land surface albedo (LSA) and land surface temperature (LST) across the multiple types of land use and land cover (LULC) using remote sensing technique. Single way ANOVA Post Hoc Tukey's Honesty Significance Difference (HSD) test was conducted to perform 25 comparisons of five (5) land use land covers. The LSA, LST and LULC data were acquired and prepared through remote sensing techniques, thus each gridded values of LULC classifications can be used to extract the pixel values of LSA and LST consistently. There are significant differences in term of values of LSA and LST across the LULC In the year 1999, the LSA of groups 3 and 5 were not statistically significant (mean difference of ±0.0000756) and the LST of groups 4 and 5 differences were also not statistically significant (mean difference of ±0.0281855). For the year 2009, the LST of groups 2 and 5, and 3 and 4 were not statistically significant with mean differences of ±0.0293095 and ±0.1000526 respectively. As for 2006, the LSA and LST of all groups of land cover appeared to be statistically significant ($p < 0.00048$) while in 2011 only one LST comparison (groups 4 and 5) appeared to be not significantly difference with a mean difference of ±0.0813049, which indicates that the land use from these groups does not significantly influence the fluctuation of LST in this region. Thus, the result in this study indicates that, it is important to quantify LSA and even the snow free region have a significant difference value of albedo. Hence, as it has been recorded as an Essential Climate Variables, it is crucial for climate researcher especially in the snow free region to also include and calibrates this bio-geophysical response of land surface variable in their simulation and research studies.

Keywords: *remote sensing; albedo; land use land cover; urban climate.*

INTRODUCTION

The reflectivity of a surface is highly dependent on the surface covers, types, colours and materials. The landscape heterogeneity can influence a variety of land surface processes and its ecological responses. Climate condition of each cities differs according to their locational setting and their land surface process. In modelling the climate condition of urban area specifically, there are many physical aspects of the local features need to be considered. Land use land cover (LULC) has high sensitivity effect towards formation of land surface albedo (LSA). The variations of LULC interact differently with solar radiation in terms of the chemical and physical properties. Thus, the basic indicator of reflectivity strength over the Earth's surface can be identified by recognising the LULC. The importance of LSA quantification comes with the essential needs for a reasonably good archive of spatial and temporal LSA data as an essential climate variable (ECV), particularly for the benefit of surface radiation, energy balance and climate change study (Feng et al., 2022). Buyantuyev and Wu (2010) used stratifying temperature grids across the LULC technique to examine the magnitude and temporal variability of urban heat island (UHI) phenomenon and Salleh et al. (2013) have explained the influence of LULC to the formation of UHI in Putrajaya. The relationship was established by using the ordinary least square (OLS) and geographical weighted regression (GWR).

Land surface albedo can be quantified using two modes i.e., in-situ observations using handheld or permanently installed albedo-meter or by using quantitative land surface remote sensing techniques through relative model derived from satellite reflectance. The remote sensing techniques and technology of land surface albedo derivation was reviewed in Salleh et al. (2012). LULC of the selected study area (relatively cloud- free region of Putrajaya) was briefly discussed in Salleh et al. (2013). Figure 1 shows the LULC map generated from this study. The fluctuation of these land use classes can be seen in Figures 1 and 2: Even though urbanisation expanded each year; by 16% in 2006 and 5% in 2009, forested areas seemed to be the main victim as 22% of the initially forested areas decreased to just 5%. 2006 showed signs of devastation, with a 12% and 3% reduction in forested and green areas, Putrajaya managed to recuperate the situation in 2009. The green areas managed to counterbalance the adverse effects of urban deforestation.

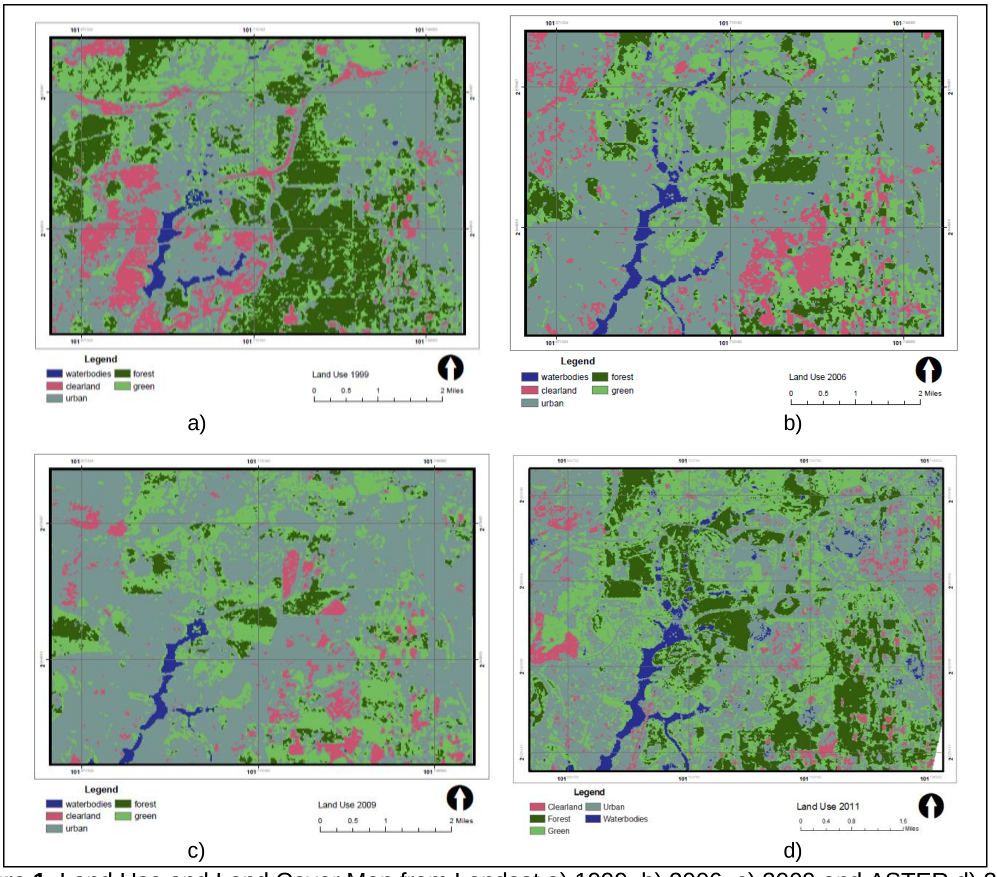

Figure 1. Land Use and Land Cover Map from Landsat a) 1999, b) 2006, c) 2009 and ASTER d) 2011 (Adapted from Salleh et al. (2013))

The land use map of year 2011 shows some significant increments and improvements towards greenery and forest land. However, the forested land here can be categorised as dense vegetation, which is resulted from the transformation of young landscapes and green surfaces in the study area. Most of the clear land area in 2009 has been converted into both green or dense areas and also urban areas. As the source image used in generating the land use 2011 map has a different spatial resolution, the comparison was performed by looking at the percentage area of land use of the image coverage. Figure 2 shows the changes of land use percentages for Putrajaya for 1999, 2006, 2009 and 2011. This Figure consists of two doughnut charts representing the temporal changes of land use at the specified dates, and also at more consistent intervals (1999, 2009 and 2011). The consistent intervals reduce the variations of land use change patterns.

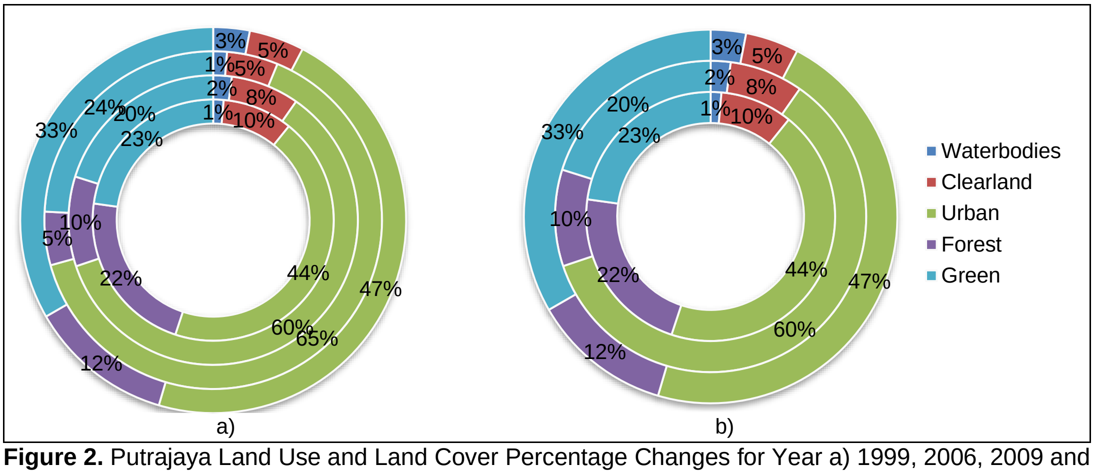

Figure 2. Putrajaya Land Use and Land Cover Percentage Changes for Year a) 1999, 2006, 2009 and 2011; and b) 1999, 2006 and 2011

There are extensive lists of albedo research conducted all over the world mentioned in Salleh et al. (2012); however, only recently a few of these research stressed tropical regions (Salleh et al., 2012a; 2012b), particularly in Malaysia. Land covers influence the percentage reflectance of radiation (Li et al., 2012) and several scientists have performed regional studies and suggested that different geographical settings affect the magnitude of reflectance toward climate change effects (Krishna et al., 2022; Qinqin et al., 2021; Sung and Li, 2012). The albedo was suggested to be increased during dry seasons consistent with the transformation of canopies to the leafless canopies and the influences of dry and bright soil (Sieber et al., 2022). As can be seen and concluded from previous studies, the gap within land surface albedo study is the non-existence of this study in the tropical and sub-tropical region and how it was being neglected in many of climate change research. Hence, this study will provide a generous insight on how land surface albedo behaves within tropical and sub-tropical regions and whether there is any significant difference between land surface albedo values across different types of land use land cover. Particularly, in looking the at the impacts of land surface albedo and temperature dynamics towards local scale weather and meteorological condition in which can further be use for climate change study. Based on this study, perhaps a novel approach of quantification and modelling of land surface albedo at a local scale for weather and climate research can be established.

METHODOLOGY

Emerging geospatial technology application for urban studies can be seen in Isa et al. (2018). Thus, the methodology adopted in this study is illustrated as in Figure 3.

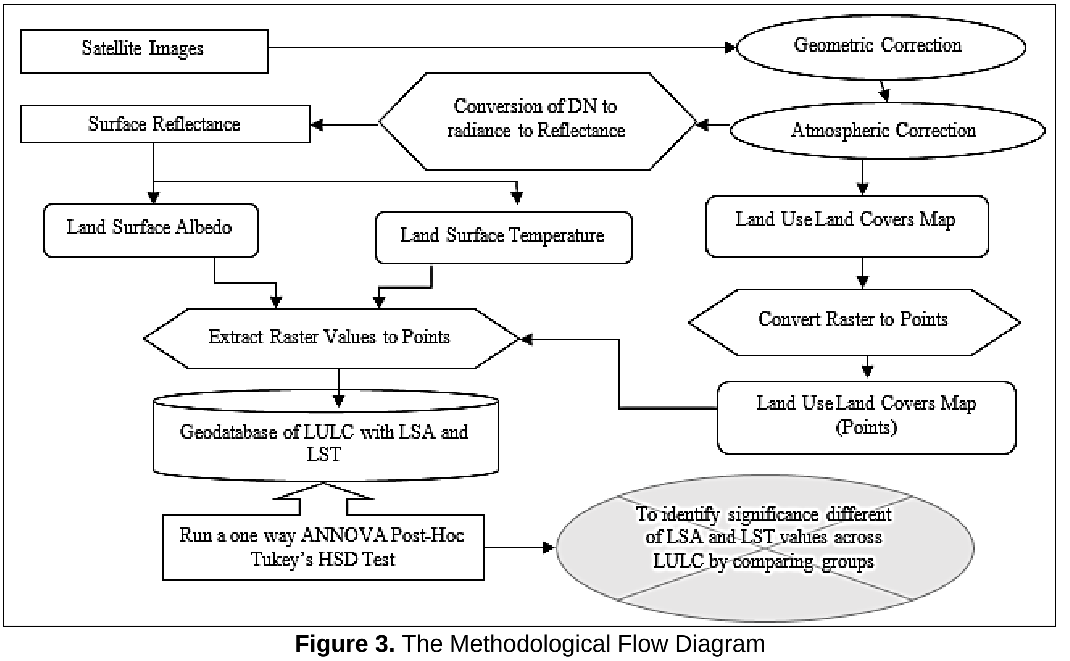

Figure 3. The Methodological Flow Diagram

Three main data used in this investigation were LSA, LST and LULC of satellite images captured on 12 December 1999, 2 December 2006, 21 January 2009 and 19 January 2011. Each of these images undergoes atmospheric and geometric corrections and further processed to become LSA, LST and LULC maps. The data used in this study is mainly raster dataset that is converted into GIS point layer. The LULC point layer is used to extract the raster values representing the LSA and LST of each of the gridded pixel of the study area. The final merged geo-database layer consists of the ranging from 70000 to 111000 thousand of pixels of categorical LULC classes with extracted centre pixel of LSA and LST values in each of the tuple.

Remote Sensing Techniques for Land Surface Albedo and Land Surface Temperature

The depiction of remotely sensed LSA is based on the method by Liang (2004) for Landsat LSA and Mokhtari et al. (2013) for ASTER very near infrared (VNIR) band.

$$Landsat\ LSA = 0.356\alpha\_1 + 0.130\alpha\_2 + 0.373\alpha\_4 + 0.085\alpha\_5 + 0.072\alpha\_7 - 0.0018 \quad (1)$$

$$ASTER_{VNIR}\ LSA = 0.697\alpha_1 + 0.298\alpha_3 + 0.008 \quad (2)$$

Notes:

LSA = Land Surface Albedo
ASTER = The Advanced Spaceborne Thermal Emission and Reflection Radiometer
VNIR = Visible Near InfaRed
α = Albedo

Prior to extracting the LST, images have undergone atmospheric correction to remove the effects of the atmosphere. The Dark Object Subtraction algorithm is applied by using the COST method (Chavez, 1996). Then the parameters are translated into Spatial Models in the ERDAS Imagine software (Leica Geosytem). Two methods for LST extraction were applied in this study known as Split Window (Mao et al., 2005) and Mono Window (Qin et al., 2001). The typical steps are similar in both methods except for the final equation arrangements (see Equation 7). The sequential processes performed to compute LST from ASTER and Landsat TM starts with converting the spectral radiance to at-sensor brightness temperature, computing the transmittance equation, and then correcting the spectral emissivity. Finally, calculations of the LST are conducted using the Split and Mono Window methods. The equations utilised in this study are Atmospheric Correction COST Method (Chavez, 1996) - All TM bands (except band 6) need to be atmospherically corrected to reduce the atmospheric effects in the image. Using the COST Method (Chavez, 1996), the image undergoes atmospheric correction according to this equation:

$$\rho Band_N = \frac{\pi[(LBand_N * GainBand_N + BiasBand_N) - (HBand_N * BiasBand_N)] * D^2}{EBand_N * [cos((90 - \theta) * \pi/180)]} \quad (3)$$

Where,

$\rho Band_N$ = Reflectance for Band N
$LBand_N$ = Digital Number for Band N
$HBand_N$ = Dignal Number representing Dark Object for Band N
$EBand_N$ = Solar Irradiance for Band N
D = Normalised Earth-Sun Distance

Conversion from Digital Number (DN) to Radiance - All TM bands are stored in DN with their ranges from 0 to 255. The data are then converted to radiance using a linear equation (Sobrino et al., 2004):

$$CV_R = G\,(CV_{DN}) + B \quad (4)$$

Where:

CV_R = The cell value as radiance
CV_{DN} = The cell value digital number
G = The gain (0.005632156 for TM6)
B = The offset (0.1238 for TM6)

This equation can be simply written as follow:

$$L = L_{min} + (L_{max} - L_{min})\ {Q_{dn}}/{Q_{max}} \quad (5)$$

Where,

Lmin = minimum at-sensor spectral radiance
Lmax = maximum at-sensor spectral radiance
Qdn = DN value of pixel
Qmax = maximum DN value of pixels

Conversion from radiance to brightness temperature - By applying the inverse of the Planck function with two free parameters (Schott and Volchok, 1985; Wukelic et *al.*, 1989), the spectral radiances are converted into satellite brightness temperature using the following relationship.

$$T = \frac{\mathrm{K_2}}{\ln\left(\frac{\mathrm{K_1}}{\mathrm{CV_R}} + 1\right)} \tag{6}$$

Where,

T = Temperature in Kelvin
CV_R = the cell value as radiance
K_1 = TM Calibration constant 1 (607.76)
K_2 = TM Calibration constant 2 (1260.56)

Land surface temperature retrieval - Land surface temperature is derived based on the brightness temperature data. The conversion is carried out using the following equation (Qin et al., 2001),

$$Ts = \frac{[a(1 - C - D) \ + \ [b(1 - C - D) + C + D] \, T_i - \ DT_a]}{C} \tag{7}$$

Where,

Ts = Land surface temperature
a = −67.355351
b = 0.458606
C = $\mathcal{E}i \times \tau$atm
D = (1 − τatm) [1 + (1 − $\mathcal{E}i$) × τatm]
Ti = at-sensor temperature
Ta = mean atmospheric temperature

Several other values are required in order to be able to generate LST from the Mono-Window equation. For certain parameters, the atmospherically corrected bands are needed (TM4 and TM5). Therefore, the Normalised Difference Vegetation Index, Emissivity, Estimation Atmospheric transmittance and mean atmospheric temperature need to be calculated as they are required as input in the LST retrieval equation.

The simplest form of vegetation index is a ratio between near infrared and red reflectance, named Simple Ratio (SR). For healthy living vegetation, this ratio will be high due to the inverse relationship between vegetation brightness in the red and infrared regions of the spectrum. Based on the geometrically corrected Landsat ETM+ images the SR can be calculated by using this formula.

$$SR = \frac{\rho red}{\rho nir} \tag{8}$$

Where the ρ*nir* is the reflectance of the near infrared band (Band 4 of Landsat ETM+) and the ρ*red* is the reflectance of the red band (Band 3 of Landsat ETM+). The Normalised Difference Vegetation Index (NDVI) is the most widely used vegetation index. It can be calculated by using this equation.

$$NDVI = \frac{(\rho nir + \rho red)}{(\rho nir - \rho red)} \tag{9}$$

Emissivity is calculated using an equation established by Sobrino et al. (2004),

$$\varepsilon_i = 0.004P_V + 0.986 \tag{10}$$

Where, *Pv* is the vegetation proportion (Carlson and Ripley, 1997) obtained from this equation:

$$Pv = \frac{NDVI - NDVI_{min}}{NDVI_{max} - NDVI_{min}} \tag{11}$$

Estimation of atmospheric transmittance is determined using Equation 12, where *w6* can be referred from the distribution of water vapour content graph (Qin et al., 2001).

$$\tau atm = 1.031412 - 0.11536 \times w6 \tag{12}$$

The mean atmospheric temperature is then computed using Equation 13, where to is the mean air temperature

$$\text{Ta} = 17.9769 + 0.91715 \times \text{To} \tag{13}$$

Statistical Analysis

The generated land surface albedo and LULC maps are used to test if there are significant differences of albedo values with respect to land use classes. For this test, the Post-Hoc Tukey's HSD was selected to assist one way ANOVA to determine the respective groups. The one-way ANOVA compares the means between the groups one is interested in and determines whether any of those means are significantly different from each other. Specifically, it tests the null hypothesis. The formula for Tukey's HSD is written as follows:

$$HSD = q\sqrt{MSE/n*} \tag{14}$$

Where *q* = the relevant critical value of the studentised range statistic and *n** is the number of scores used in calculating the group means of interest. If, however, the one-way ANOVA returns a significant result, the alternative hypothesis (H_A) will be accepted, which is that there are at least two group means that are significantly different from each other.

VALIDATION OF REMOTELY SENSED LAND SURFACE ALBEDO (LSA)

The retrieved LSA values (Figure 4) are validated using a method established by Salleh et al. (2014) with reference to the available CAQMs and meteorological AWs within the study area. To increase the number of points for validation, the whole coverage scene is used instead of the portion of the scene that represents the study area (Figure 5). The yellow points show the locations of the CAQMs and meteorological AWs location within the study area.

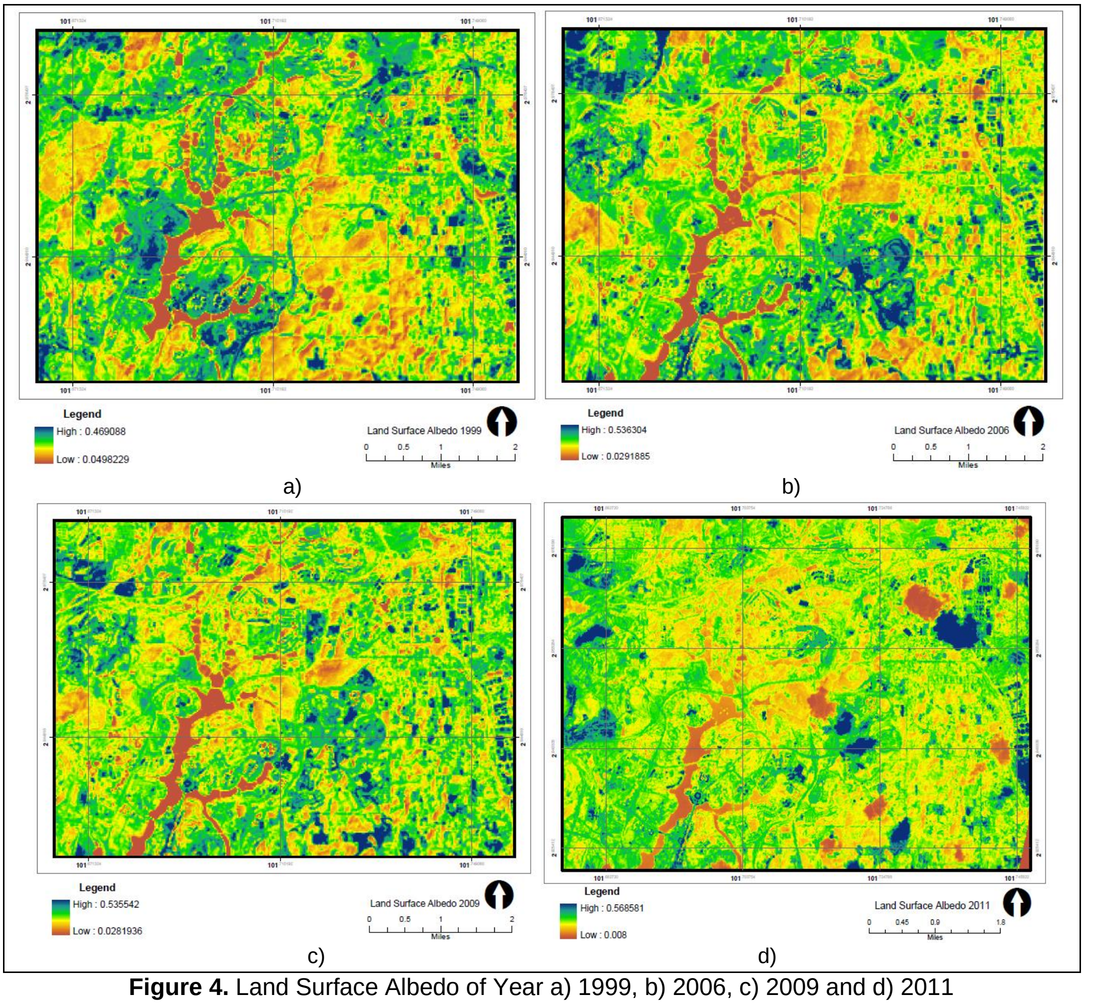

Figure 4. Land Surface Albedo of Year a) 1999, b) 2006, c) 2009 and d) 2011

Tables 1 show the values of remotely sensed LSA as compared to the relative true values. The relative validation for 2011 LSA is performed using ten (10) observation locations comprising of five (5) CAQM stations, two (2) meteorological AW stations and three (3) in-situ observations. While for 2009 LSA, there were seven (7) stations used for validation but only five (5) ambient temperature values are available for LSA estimation. In 2006, there were only six (6) daily ambient temperatures available out of seven (7) stations and finally for the year 1999, as the CAQMs had only been established in 2000, the relative validation of LSA is performed utilising ambient temperature values from meteorological AW stations. Using inputs from Tables 1 to 4, the relative standard error (RSE), root mean square error (RMSE), mean square error (MSE) and mean absolute error (MAE) are calculated.

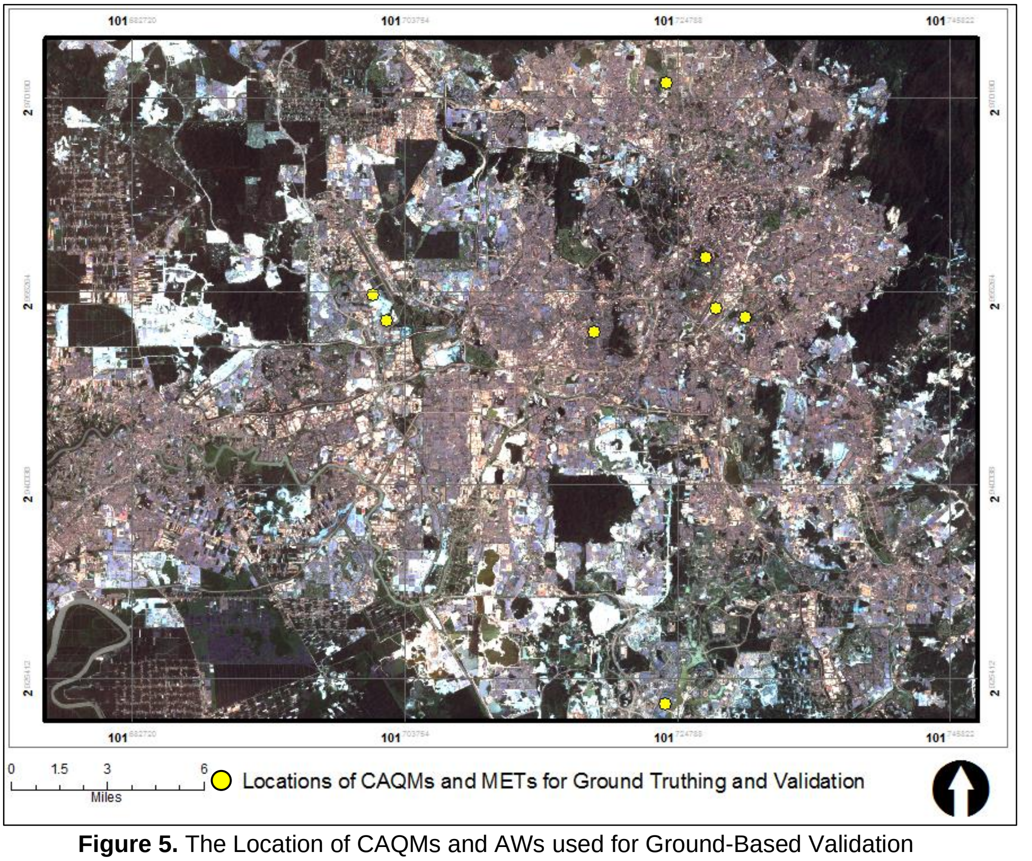

Figure 5. The Location of CAQMs and AWs used for Ground-Based Validation

Table 2 shows the RSE, RMSE, MSE and MAE of the relative true values of LSA and the specified years used for the time series analyses. It can be concluded that there are some variations in the magnitude of error since the RMSE values are larger than MAE. The same magnitude errors are indicated if the RMSE value is equal to MAE. However, since the value differences between RMSE and MAE are not big, large errors are unlikely to have occurred. Based on the MAE values, the average differences between observed and predicted values of LSA are within a range of 0.01 to 0.07.

Table 1. The Ground-Based LSA to Remotely Sensed LSA (1999-2011)

LOCATION	1999				2006				2009				2011			
	N*ii*	Landsat	°C	*d*	N*ii*	Landsat	°C	*d*	N*ii*	Landsat	°C	*D*	N*ii*	Vnir	°C	*d*
Putrajaya CAQMs	*Null*	0.198	*null*	*null*	0.210	0.227	24.8	-0.017	0.201	0.187	25.86	0.014	0.145	0.259	32.83	-0.114
Bt. Muda CAQMs	*Null*	0.174	*null*	*null*	*Null*	0.177	*Null*	*Null*	*Null*	0.178	*Null*	*Null*	0.144	0.229	33	-0.085
P. Jaya CAQMs	*Null*	0.179	*null*	*null*	0.203	0.185	25.6	0.023	0.206	0.175	25.26	0.031	0.137	0.235	33.83	-0.098
Shah Alam CAQMs	*Null*	0.212	*null*	*null*	0.202	0.201	25.8	0.001	0.188	0.157	27.56	0.030	0.172	0.240	24.79	-0.030
Cheras CAQMs	*Null*	0.218	*null*	*null*	0.206	0.197	25.2	0.010	*Null*	0.169	*Null*	*Null*	0.190	0.246	27.2	-0.089
P. Jaya AWs	0.184	0.205	28	-0.02049	0.175	0.181	29.1	-0.006	0.192	0.163	27	0.029	0.177	0.192	28.9	-0.015
Subang AWs	0.184	0.248	28	-0.06425	0.175	0.206	29.1	-0.030	0.193	0.173	26.9	0.020	0.185	0.237	27.9	-0.052

**d* representing differences

Table 2. The Accuracy Assessment and Reliability Test for Remotely Sensed LSA

YEAR	RSE (%)	RMSE ($\sqrt{MSE}$)	MSE	MAE
1999	4.2365	0.0476815	0.002273528	0.042365
2006	1.4391667	0.0175579	0.00030828	0.01439167
2009	2.47986	0.025697	0.000660336	0.0247986
2011	6.51335	0.0715771	0.005123281	0.0651335

Statistically, the values of RMSE, RSE, MSE and MAE are within the tolerance outlined by Browne et al. (1993). However, Henderson-Sellers and Wilson (1983) and Sellers et al. (1995) have documented the absolute requirements for datasets suitable for evaluating climate model demand for land surface albedo, with the level of uncertainty ranging from 0.02 to 0.05. As such, by evaluating both RMSE and MAE values; the 2006 image is selected to be used as the case study to test the relationship of remotely sensed LSA with other selected variables due to it having the lowest scores of MAE and RMSE, indicating a better fit with LSA values depicted from the remote sensing image. With reference to the recent study on examining and evaluating the MODIS and Landsat albedo with in-situ observations (Román et al., 2013; Wang et al., 2014), the findings in this section show good agreement to using Landsat to quantify LSA in subtropical regions such as Malaysia.

The land surface temperature (LST) is another biophysical parameter chosen in this study. The LST for this study is generated using Landsat thermal bands (1999, 2006 and 2009) and ASTER (2011). The LST are generated through the Mono-window method. Figure 5.8 shows the temporal changes of remotely sensed LST from 1999 to 2011. The urbanised and built-up area, with a light-yellow tone towards orange and red colour in Figure 6, indicated a warmer surface temperature. These areas spread dramatically from 1999 to 2006, suggesting the expansion of UHI. However, a slight decrease can be seen in 2009, which calls for further investigation to comprehend this situation.

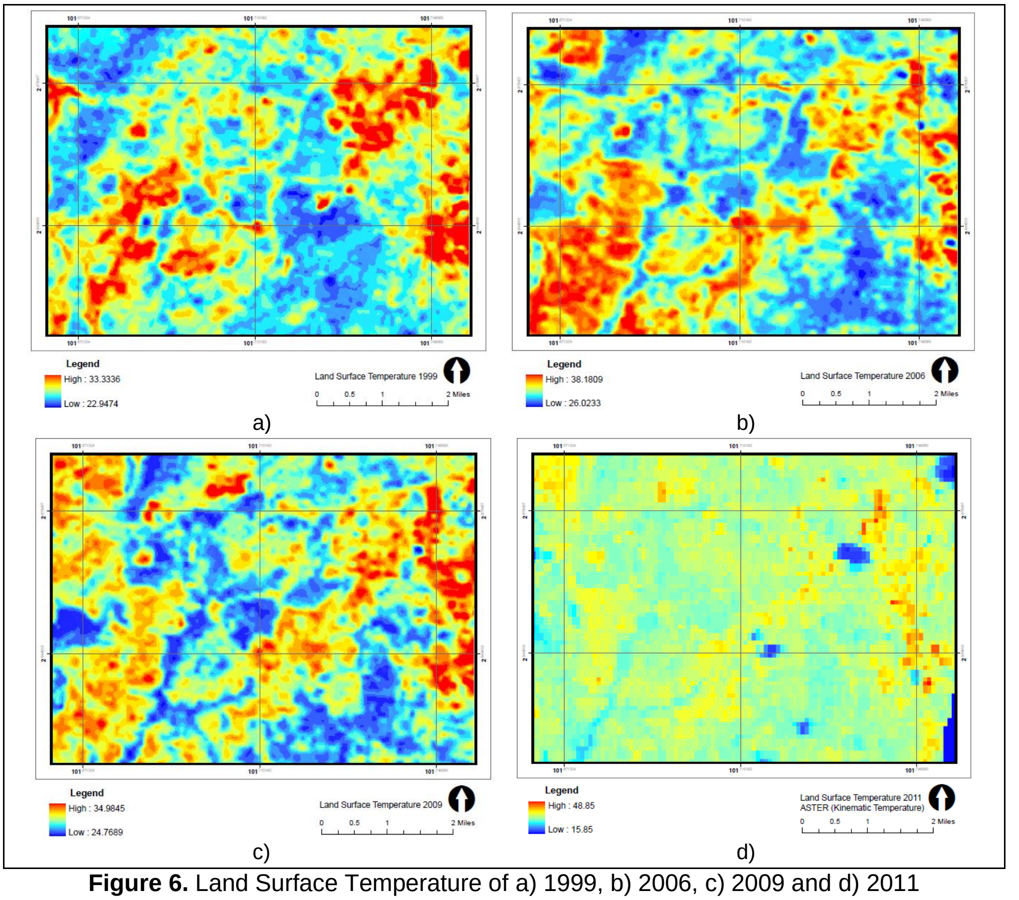

Figure 6. Land Surface Temperature of a) 1999, b) 2006, c) 2009 and d) 2011

RESULTS AND DISCUSSION

The value of LSA can be very surface specific. Using LULC maps generated through remote sensing images, the raster images are converted into point layers. Based on each of these layers, each centre pixel value of land use class and LSA are extracted and tabulated. By using SPSS for Windows software, the following tables show the descriptive land use statistics of the study area for the years 1999, 2006, 2009 and 2011.

The MSE for all years are relatively small throughout the land use and land cover categories (0.0001 – 0.0007). In the year 1999, the highest standard deviation of LSA belongs to the urban built up class (0.0348), while 2006 showed clear land scored the biggest standard deviation at 0.0328. In the LSA values for 2009, the largest deviation occurs to LSA values belonging to clear land (0.0371) and is repeated in 2011 where the standard deviation of LSA for clear land is 0.0644. Tables 3 and 4 represent the mean LSA for all land use land cover classes of the study area. Further to this, Tables 5 and 6 show the derived land surface temperature according to the 5 (five) land use land cover classes.

From Tables 5 and 6, the mean LST of land use over the study does not deviate very much from each other. From the year 1999 to 2011, the standard deviations of LST are between 0.8 and 3.5, which reveal the highest deviation came from LST depicted from an ASTER image in 2011. The LST standard errors across the land use and land covers classes are also very low comparatively, with the lowest standard error at 0.007 seen in 1999, 2006 and 2009 which all fall into the urban built up land use land cover class. The highest LST standard error is for water bodies in 2011 with 0.04775. Although the standard error and standard deviation are comparatively low throughout the land use and land cover classes, they do have significant differences in terms of the maximum and minimum temperature of LST. In 1999, the maximum urban surface temperature seems to be lower than for vegetative land. This indicates the albedo and evapotranspiration effects. The same pattern is depicted in 2009. It is found to contradict from common knowledge of having the built-up surface warmer than vegetative land. This behaviour is clearly seen in 2006.

Table 7 demonstrates the mean of LSA and LST according to the land use and land cover classes of the study area. Evidently, both the LSA and LST are generally lower over forested land than over greenery grassland. Clear land has considerably higher albedo than urban areas. Water bodies obviously possesses the lowest surface albedo values. Land surface albedo retrieved from remotely sensed data requires an understanding towards the land use land cover conversion and ecosystem disturbance affected the surface energy balance (Shuai et al., 2011). Therefore, pattern recognition of LSA and LST in accordance with land use and land cover is importance.

Table 3. LSA According to Land Use (1999 and 2006)

Land use Type		1999 N	1999 Min	1999 Max	1999 Mean		1999 Std. D	1999 Var	2006 N	2006 Min	2006 Max	2006 Mean		2006 Std. D	2006 Var.
		Statistic			Stat	Std. E	Statistic		Statistic			Stat	Std. E	Statistic	
Clear Land	Land Surface Albedo	8336	.1208	.3691	.2175	.0004	.0315	.001	6693	.1203	.3280	.2166	.0004	.0328	.001
	Valid N (listwise)	8336							6693						
Forest	Land Surface Albedo	19594	.0769	.2326	.1610	.0001	.0160	.000	8885	.0945	.2117	.1330	.0001	.0114	.000
	Valid N (listwise)	19594							8885						
Greenery Grassland	Land Surface Albedo	20185	.0673	.2875	.1884	.0002	.0228	.001	17793	.1090	.2466	.1676	.0002	.0199	.000
	Valid N (listwise)	20185							17793						
Urban Built-Up	Land Surface Albedo	39226	.0498	.4691	.1883	.0002	.0348	.001	51740	.0435	.3476	.1699	.0001	.0291	.001
	Valid N (listwise)	39226							51740						
Water Bodies	Land Surface Albedo	1232	.0573	.1622	.0757	.0003	.0111	.000	1086	.0414	.1823	.0728	.0005	.0161	.000
	Valid N (listwise)	1232							1086						

Table 4. LSA According to Land Use (2009 and 2011)

Land use Type		2009 N	2009 Min	2009 Max	2009 Mean		2009 Std. D	2009 Var	2011 N	2011 Min	2011 Max	2011 Mean		2011 Std. D	2011 Var.
		Statistic			Stat	Std. E	Statistic		Statistic			Stat	Std. E	Statistic	
Clear Land	Land Surface Albedo	4367	.1160	.4360	.2160	.0006	.0371	.001	8681	.1843	.5263	.3032	.0007	.0644	.004
	Valid N (listwise)	4367							8681						
Forest	Land Surface Albedo	4539	.0891	.2065	.1315	.0002	.0142	.000	32536	.1316	.2880	.1963	.0001	.0135	.000
	Valid N (listwise)	4539							32536						
Greenery Grassland	Land Surface Albedo	21456	.0332	.2321	.1406	.0002	.0269	.001	67828	.1540	.3403	.2191	.0001	.0165	.000
	Valid N (listwise)	21456							67828						
Urban Built-Up	Land Surface Albedo	57228	.0327	.5355	.1576	.0001	.0275	.001	93267	.1185	.5655	.2289	.0002	.0517	.003
	Valid N (listwise)	57228							93267						
Water Bodies	Land Surface Albedo	1168	.0282	.1086	.0393	.0002	.0075	.000	4764	.1295	.2243	.1576	.0002	.0123	.000
	Valid N (listwise)	1168							4764						

Table 5. Derived Land Surface Temperature for Each Land Use Type 1999 and 2006

Land use Type		1999 N	1999 Min	1999 Max	1999 Mean Stat	1999 Mean Std. E	1999 Std. D	1999 Var	2006 N	2006 Min	2006 Max	2006 Mean Stat	2006 Mean Std. E	2006 Std. D	2006 Var.
			Statistic		Stat	Std. E	Statistic			Statistic		Stat	Std. E	Statistic	
Clear Land	LST	8302	23.0202	31.7546	26.0439	.0146	1.3323	.775	6766	27.6587	35.5987	30.8499	.0162	1.3281	1.764
	Valid N (listwise)	8302							6766						
Forest	LST	19471	23.3947	31.7478	26.2441	.0098	1.3599	1.849	8885	26.9972	34.4483	29.1872	.0085	.8044	.647
	Valid N (listwise)	19471							8885						
Greenery Grassland	LST	20072	23.3970	33.3336	26.2159	.0101	1.4350	2.059	17832	27.5065	35.5309	30.0050	.0088	1.1680	1.364
	Valid N (listwise)	20072							17832						
Urban Built-Up	LST	39080	22.9474	32.2834	26.1592	.0070	1.3920	1.938	53256	26.0233	38.1809	31.9620	.0072	1.6717	2.795
	Valid N (listwise)	39080							53256						
Water Bodies	LST	1234	22.9666	29.0674	25.2789	.0333	1.1705	1.370	1837	27.5994	33.0019	29.4405	.0187	.8032	.645
	Valid N (listwise)	1234							1837						

Table 6. Derived Land Surface Temperature for Each Land Use Type 2009 and 2011

Land use Type		2009 N	2009 Min	2009 Max	2009 Mean Stat	2009 Mean Std. E	2009 Std. D	2009 Var	2011 N	2011 Min	2011 Max	2011 Mean Stat	2011 Mean Std. E	2011 Std. D	2011 Var.
			Statistic		Stat	Std. E	Statistic			Statistic		Stat	Std. E	Statistic	
Clear Land	LST	4294	24.7783	33.9391	28.6876	.0262	1.7192	.956	8672	16.8500	45.8500	33.3644	.0366	3.4065	11.604
	Valid N (listwise)	4294							8672						
Forest	LST	4502	25.3324	34.9845	28.8336	.02647	1.7758	.153	32527	16.8500	47.8500	32.8179	.0141	2.5407	6.455
	Valid N (listwise)	4502							32527						
Greenery Grassland	LST	21212	25.1724	34.9463	28.7169	.0106	1.5445	.386	67771	15.8500	47.8500	32.8992	.0116	3.0179	9.108
	Valid N (listwise)	21212							67771						
Urban Built-Up	LST	56994	24.7689	34.9666	28.9337	.0070	1.6739	.802	93069	15.8500	47.8500	33.1324	.0117	3.5628	12.693
	Valid N (listwise)	56994							93069						
Water Bodies	LST	1157	25.1673	32.3484	28.0430	.0410	1.3948	.946	4748	16.8500	47.8500	32.0975	.0477446	3.2899	10.823
	Valid N (listwise)	1157							4748						

Table 7. Mean LSA and LST (°C)

Land Cover	Land Surface Albedo			
	1999	2006	2009	2011
Water bodies	0.07582	0.06762	0.039278	0.15764
Clearland	0.21750	0.21777	0.216108	0.30321
Urban	0.18831	0.16929	0.157541	.228922
Forest	0.16102	0.13295	0.131428	0.19630
Greenery Grass Land	0.18839	0.16769	0.140647	0.21912
Land Cover	**Land Surface Temperature (°C)**			
	1999	**2006**	**2009**	**2011**
Water bodies	25.27888	29.44054	28.04295	32.09747
Clearland	26.04394	30.84987	28.68758	33.36441
Urban	26.15916	31.96199	28.93368	33.13239
Forest	26.24409	29.18722	28.83363	32.81793
Greenery Grass Land	26.21590	30.00504	28.71689	32.89924

Land surface temperatures across different land cover in 1999 appear to be the lowest, ranging from 25°C to 27°C. The variations of land cover land surface temperature in 2006 are noticeably larger as compared to the years 1999, 2009 and 2011. Forested land appears to have the lowest temperature (29.19°C) while the surface temperature of urban areas is the highest (31.96°C). Smaller variances of land surface temperature between 28°C – 29°C and 32°C - 33°C are depicted in 2009 and 2011 respectively. Such variations are probably due to the seasonal local heterogeneity of specific dates when the images are being captured (Shuai et al., 2011), surface soil texture and geological characteristics like albedo and emissivity are evidently related in terms of their spatial pattern and magnitude (Zhou et al., 2003) and also the process of extracting LSA from satellite images, such as the overly corrected atmospheric effects. The fluctuations of LSA with respect to LST are illustrated in Figure 7.

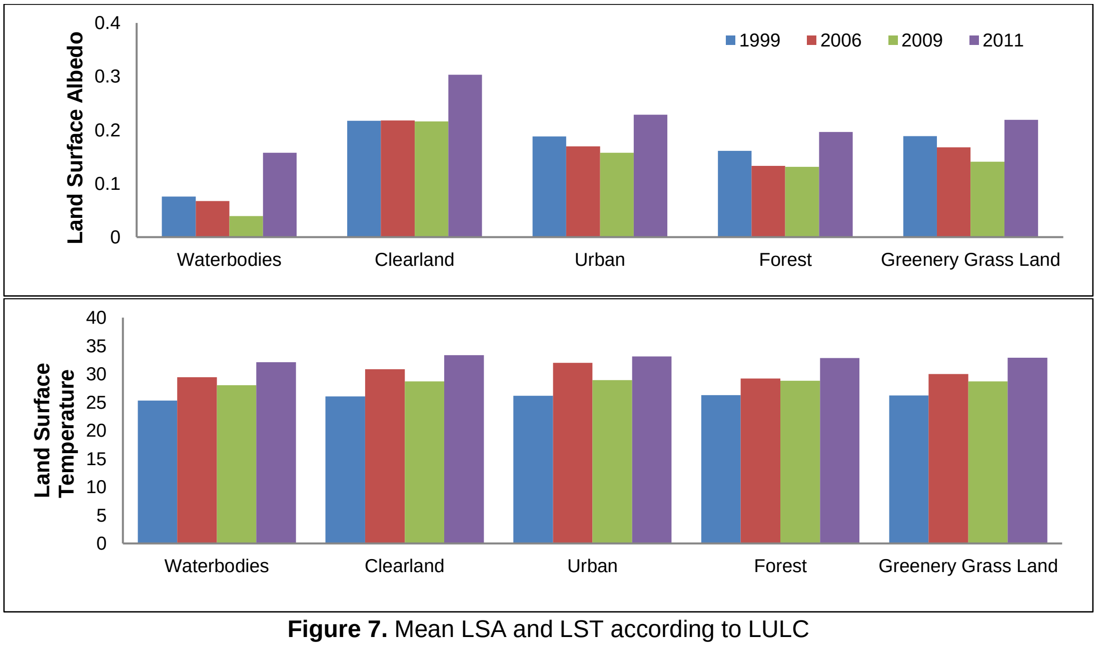

Figure 7. Mean LSA and LST according to LULC

A single factor ANOVA with post-hoc Tukey's HSD test is executed to see if any significant differences of LSA are present across the land covers. In order to test for significant difference between the albedo and temperature values associated with the land covers within and between each image, the Tukey's honesty significant difference (HSD) test is executed using a 0.00048 significance level in order to minimise the experiment wise error rate. There are 25 pairings for each land cover within an image performed. The significant difference of LST and LSA across LULC will be able to calibrate many weather and climate simulation studies. Especially at local scale where LULC may have been largely generalised. LSA is also capable in supressing the air and land surface temperature, thus, this finding may change perception towards the use of high albedo (reflective) material for built up area. The physical behaviour of high reflective materials can also help reducing the impacts of climate change especially with respect to surface heat and global warming (Hamoodi et al., 2019).

All of the land covers in image 1999 have significantly different ($p < 0.00048$) land surface albedo and surface temperature values, except when comparing Group 3 (Urban) and Group 5 (Greenery Grass Land) albedo values where $p = 0.998$ ($\pm$ 0.0000758), $p < 0.00048$, and Group 4 (forest) and Group 5 (Greenery Grass Land) land surface temperature values with $p = 0.256$ ($\pm$0.0281855), $p < 0.00048$. Table 8 demonstrates the Single way ANOVA for year 1999. All of the land covers in image 2006 have statistically significant different ($p <$ 0.00048) land surface albedo and surface temperature values. While in 2009, all land covers have significantly different ($p < 0.00048$) land surface albedo, except when comparing the land surface temperature values of Group 2 (Clear Land) and Group 5 (Greenery Grass Land) where $p = 0.826$ ($\pm$0.0293095), $p < 0.00048$, and Group 3 (Urban) and Group 4 (forest) where $p = 0.001$ ($\pm$0.1000526), $p < 0.00048$. Tables 8 and 9 show the single-way ANOVA for years 2006 and 2009 respectively.

All of the land covers in image 2011 have significantly different ($p < 0.00048$) land surface albedo and surface temperature values, except when comparing the land surface temperature of Group 4 (Forest) and Group 5 (Greenery Grass Land) where $p = 0.002$ ($\pm$0.0813049), $p < 0.00048$. Table 9 presents the single-way ANOVA for year 2011.

Table 11. Single ANOVA Tukey’ s HSD Year 1999 and 2006

		1999					2006				
		SS	df	MS	F	Sig.	SS	df	MS	F	Sig.
LSA	Between Groups	35.125	4	8.781	10880.274	.000	46.170	4	11.542	12756.681	.000
	Within Groups	71.148	88154	.001			80.140	88571	.001		
	Total	106.274	88158				126.310	88575			
LST	Between Groups	1265.106	4	316.276	164.512	.000	98695.968	4	24673.992	11381.346	.000
	Within Groups	169476.688	88154	1.923			192015.959	88571	2.168		
	Total	170741.794	88158				290711.928	88575			

Table 12. Single ANOVA Tukey’ s HSD Year 2009 and 2011

		2009					2011				
		SS	df	MS	F	Sig.	SS	df	MS	F	Sig.
LSA	Between Groups	38.554	4	9.639	13048.092	.000	103.367	4	25.842	17264.202	.000
	Within Groups	65.119	88154	.001			309.519	206782	.001		
	Total	103.673	88158				412.886	206786			
LST	Between Groups	1642.324	4	410.581	151.179	.000	8405.003	4	2101.251	201.107	.000
	Within Groups	239414.248	88154	2.716			2160543.893	206782	10.448		
	Total	241056.572	88158				2168948.896	206786			

With respect to the above discussions, the image for 2006 is found to have LSA and LST values across the land use land covers scoring statistical significance and the image for 2011 has good statistical significance consistency of its LSA across the land use and land covers. Figure 8 shows the relationships between LSA and LST mean values with regards to the LULC in 2006.

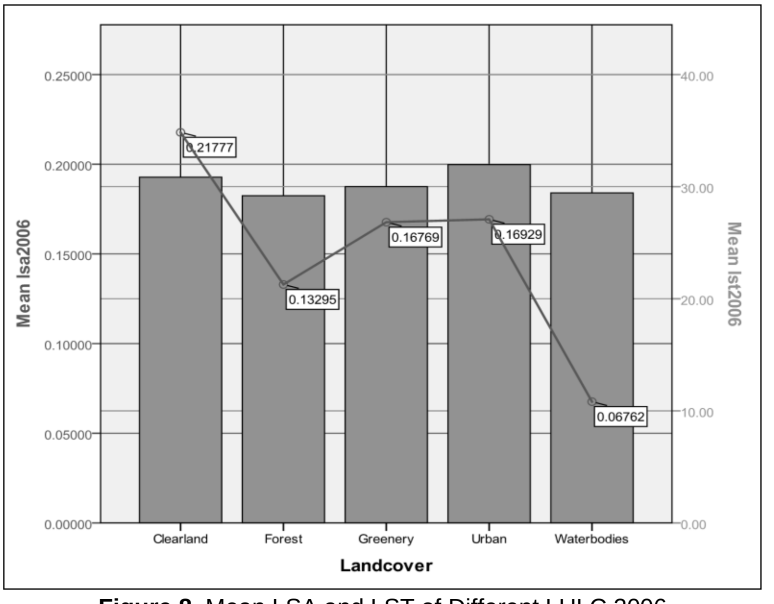

Figure 8. Mean LSA and LST of Different LULC 2006

The highest LSA is captured in clear land areas, followed by the urban area. Water bodies has the lowest mean LSA (0.06762 ± .0003975), with LSA increasing over mixed greenery grassland. Even with two of the highest mean shortwave (SW) albedos, the clear land and built-up land covers also has two of the highest average surface temperatures (30.84987 ± .0161457 °C and 31.96199 ± .0072439 °C). Here, the exterior factors that influenced the values of LST and LSA can be inferred as the LST and LSA relate contradictory (increased in LST decreased in LSA). Figure 8 illustrated that the land use may moderating the fluctuation of LSA and LST values.

CONCLUSION

The study focused in determining the significant difference of LSA and LST based on different land use land cover. A single factor ANOVA with Tukey's HSD test is executed to see if any significant differences of LSA and LST are present between the land covers. It is identified that there are significant differences in term of values of LSA and LST across the LULC. In the year 1999, the LSA of Groups 3 and 5 are not statistically significant (mean difference of ±0.0000756) and the LST of Groups 4 and 5 differences were also not statistically significant (mean difference of ±0.0281855). For the year 2009, the LST of Groups 2 and 5, and 3 and 4 are not statistically significant with mean differences of ±0.0293095 and ±0.1000526 respectively. As for 2006, the LSA and LST of all groups of land cover appeared to be statistically significant while in 2011 only one LST comparison (Groups 4 and 5) appeared to be statistically not significant with a mean difference of

±0.0813049. These findings exhibits that the land surface albedo quantification is important not only to the snow-covered region but also snow-free region, specifically referred to this study at the subtropical region such as Malaysia. Therefore, it is crucial to capture the actual values of LSA especially when this biophysical variable is been classified as an Essential Climate Variable (ECV). However, it is also recommended to justify the important of this finding by conducting relevant climate simulation that involve with LSA in order to be able to quantify the impacts and magnitude of which these statistically significant difference to the climate modelling and simulation results. A new approach of extracting land surface albedo data via google earth engine can also be explored to furnish the climate researcher with more accessible information about land surface albedo (Capolupo et al., 2021).

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MOVING TOWARDS SMART CITIES: ASSESSMENT OF RESIDENTIAL SATISFACTION IN NEWLY DESIGNED FOR PUBLIC HOUSING IN MALAYSIA

Natasha Dzulkalnine[1*], Zuhairi Abd. Hamid[2], Ihfasuziella Ibrahim[2], Maria Zura Mohd. Zain[2], Nurulhuda Mat Kilau[2], Intan Diyana Musa[2], Mohammad Faedzwan Abdul Rahman[2] and Syarifah Mastura Syed Abu Bakar[1]

[1]Faculty of Business and Management, Universiti Teknologi MARA (UiTM), 42300, Puncak Alam, Selangor.

[2]Construction Research Institute of Malaysia (CREAM).

Abstract

The issue of public housing has become so prevalent not only in Malaysia but also globally including Indonesia, Australia and United States of America (USA). The Malaysian government has initiated the 11th Malaysian Plan which aims to increase access towards affordable housing for targeted group, strengthening planning and implementation for better management of public housing as well as encouraging environment friendly facilities to enhance liveability. Past researchers highlighted that the global issues and challenges in the development of public housing are financial issue to build the public housing and poor maintenance of the public housing. A survey has been conducted to 600 residents of public housing in Klang Valley to analyse the residential satisfaction on the physical aspects of the house. The findings show that the main issues of public housing in term of physical aspect are limited area for washing area, inadequate size of kitchen and poor quality of interior construction. It was found that majority of the residents satisfied with garbage disposal, accessibility to city centre and types of houses occupied.

Keywords: *residential satisfaction; public housing; residents; interior construction quality.*

INTRODUCTION

The growing numbers of the population in Malaysia emerge the needs of public housing. Government has initiated many schemes and plans towards the development of affordable housing in Malaysia including public housing. Public house schemes are perceived by the government as the way for low-income groups to live under better housing conditions by ensuring the provisions of minimum acceptable standards, amenities, and facilities within and outsides the dwelling units. This will contribute to an improvement in the quality of life for residents (Wahi and Zin, 2018). The Malaysia government always tries to identify clearly the target groups entitled to public housing. Over the year, the target group has continued to expand in accordance with the higher aspirations of the people, often matched by a corresponding increase in the capacity for delivery. The low-cost housing has relatively low selling prices or rentals so as to maintain high levels of affordability by the low-income group (Abdullahi et al., 2017). The government is actively promoting policies to ensure quality and affordability of houses to all nations. Thus, this scenario shows that sustainability is becoming prominent in Malaysian housing industry (Goh, Seow and Goh, 2009).

The scheme of affordable housing in Malaysia has started in 1961 with the objective to encourage the house ownership among civil servants. This phase also encouraged private sector involvement in affordable housing. 11th Malaysia Plan (11th MP) encourage the private sectors to participate in the affordable housing construction. The objective of 11th MP related to affordable housing are to increase access to affordable housing for targeted group, to provide financial assistance for home buyers, to strengthen planning and implementation for better management for affordable housing and to encourage environment-friendly facilities for enhanced liveability. As part of affordable housing, government has initiated the public housing known as People's Housing Program (PPR) focusing on low to middle income group of RM 2,500.00 and below. Table 1 shows the government's initiatives to promotes the affordable housing.

Table 1. Affordable Housing Scheme in Malaysia

No.	Program	Objective	Price	Income Group
1.	Skim Perumahan Rakyat 1Malaysia (PR1MA)	To build affordable housing in urban areas for Malaysians, especially middle classes	RM 100,000.00 – RM 400,000.00	RM 2,500.00 – RM 10,000.00
2.	Skim Perumahan Mampu Milik Swasta (MyHome)	Scheme by the Malaysian government to encourage more affordable housing by the private sector	Peninsular: MyHome 1: RM 50,000.00 – RM 90,000.00 MyHome 2: RM 90,001.00 – RM 170,000.00 Sabah & Sarawak: MyHome 1: RM 60,000.00 – RM 90,000.00 MyHome 2: RM 90,001.00 – RM 220,000.00	MyHome 1: RM 3,000.00 – RM 4,000.00 MyHome 2: RM 4,001.00 – RM 6,000.00
3.	Perumahan Penjawat Awam 1 Malaysia (PPA1M)	Aims to provide quality and affordable homes for civil servants	RM 150,000.00 – RM 300,000.00	Below RM 10,000.00
4.	Program Perumahan Rakyat (PPR)	Increase the quality of life to those with low incomes	Peninsular: RM 30,000.00 – RM 35,000.00 Sabah & Sarawak: RM 40,500.00	Below RM 2,500.00
5.	Rumah Mesra Rakyat 1Malaysia (RMR1M)	To provide a comfortable home to low-income land owners such as farmers and fishermen	RM 45,000.00 to RM 65,000.00	RM 750.00 to RM 3,000.00
6.	Rumah Mampu Milik Wilayah Persekutuan (RUMAWIP)	To provide affordable housing to middle-income earners, living and working in federal territory	RM 52,000.00 to RM 300,000.00	Below RM 15,000.00
7.	Rumah Selangorku	To provide affordable housing to middle-income earners, living in Selangor.	RM 42,000.00 to RM 250,000.00	RM 3,000.00 – RM 10,000.00
8.	Rumah Idaman Rakyat (RIR)	To provide affordable housing to middle-income earners.	Below RM 300,000.00	1. Monthly income below RM 10,000.00 2. Monthly Personal income below RM 7,500.00
9.	Transit Home	To provide housing for married couples aged 30 and under.	RM 250.00 monthly	Below RM 3,000.00.00

As reported by Bank Negara Malaysia (BNM) in 2016, Malaysian still have an issue of ownership of affordable housing. Three main issues related to the housing affordability are the supply and demand of affordable housing, high price of affordable housing and the rate of home price increases exceeds the rate of increase in household income (Ling, Almeida and Wei, 2017). Table 2 shows the number of rent and own People's Housing Program (PPR). The number of own units is higher than the rent units showing the desire of Malaysian to own a home.

Table 2. Number of Rent and Own PPR

PPR Program	Total Project		Completed Project		Ongoing Project		Planned Project	
	Project	Unit	Project	Unit	Project	Unit	Project	Unit
Rent	84	73,439	83	72,439	1	1,000	0	0
Own	126	44,871	46	14,108	48	19,101	32	11,662
TOTAL	**210**	**118,310**	**129**	**86,547**	**49**	**21,101**	**32**	**11,662**

Source: Housing Planning Division, National Housing Department (2016)

Apart from the issue of housing affordability, there are another of main issue of public housing which are related to the residential satisfaction of one the main affordable and liveable housing scheme in Malaysia which is People's Housing Program (PPR). Thus, to align with the objectives of the 11^{th} MP to increase better management for public housing and encourage environment-friendly to enhance liveability, a study on the residential satisfaction towards low income of public housing is conducted.

Previous studied conducted by Salleh, Yusof, Salleh, & Johari (2011) studied four (4) main level of tenant satisfaction which are building features, building quality, neighbourhood aspect and public housing management. The building features includes location of staircase, location of living room, location of kitchen, location of dining area, size of living room, size of kitchen, size of bedroom, size of bathroom, size of study area, size of children's play space, number of bedrooms, level of privacy and overall size of house.

Definition of Residential Satisfaction

Life satisfaction can be influences by many factors especially housing factor. Residential satisfaction is considered as a part of life satisfaction and most studied topics in the field of residential environment. Azemati, Pourbagher, & Rostami (2017) defined housing satisfaction as the feeling of contentment when one person achieved to what his needs or desires in a house. Residential satisfaction related to the environment which refers not only physical aspect of residential setting but also including social, economic and organisational settings (Francescato, S. and J., 1986). Galster & Garry W. Hesser (1981) defined theories of residential satisfaction as measurement the differences between household actual and desired housing and neighbourhood situations.

Sam, Zain, & Saadatian (2012) studied the residential satisfaction into four (4) perspectives which are urban planners and designers, architects, environmental psychologists and policy makers. The perspective from the urban planners and designers as been mentioned by Berkoz, Turk, & Kellekci (2009), six parts that can determine the residential satisfaction are accessibility to various function, environmental features, facilities in the inhabited environment, environmental security, neighbour relationships and housing environment. Architects emphasize on three (3) parts of the residential satisfaction involving dwelling units, services provided by the developers and neighbourhood facilities and finally environment (Salleh, 2008). The environmental psychologists focus on two main areas that contributes to the residential satisfaction including centrality and socio-psychology characteristics of the residential area. Apart from that, the policy makers defined the residential satisfaction as a neighbourhood satisfaction and a residence which more than physical structure. Policy makers also take income location of residence as part of importance factors of residential satisfaction.

METHODOLOGY

This survey involved 600 respondents for People's Housing Program (PPR) residents in Klang Valley. The questionnaire is distributed by face-to-face interview to fourteen (14) PPR housing in the Klang Valley. The list of PPR involved in the survey are as follows:

i. PPR Bukit Jalil I
ii. PPR Bukit Jalil II
iii. PPR Cochrane
iv. PPR Intan Baiduri
v. PPR Kerinchi
vi. PPR Kg. Baru Air Panas
vii. PPR Kg. Batu Muda
viii. PPR Kg. Muhibbah
ix. PPR Lembah Subang
x. PPR Pantai Ria
xi. PPR Permai
xii. PPR Serendah
xiii. PPR Seri Semarak
xiv. PPR Taman Wahyu

Questionnaire Design

The questionnaire design sources are from literature review approach. The questionnaire in this study divided into two main parts. A questionnaire is utilised as it is an efficient data collection mechanism to collect the required data of the variable of interest. Sekaran & Bougie (2010) defined questionnaire as reformulated written set of questions to which respondents record their answers, usually within rather closely defined alternatives. Table 3 shows the parts in the questionnaire which include 31 number of items in the questionnaire. The respondent's demographic profile is collected in this part. Part A consists of 11 items which contains the gender, marital status, race, age, occupation, education, length of residency, family size, monthly family income, vehicle owned and working wife while Part B consists of the Likert scale questions about the resident's satisfaction on physical aspect of PPR housing.

Table 3. Description of Part in Questionnaire

Part	Description	No. of Item
Part A	Respondent's Demographic Profile	11
Part B	Resident's Satisfaction on Physical Aspect of PPR Housing	20
TOTAL		**31**

Reliability Test

Nunnally & Bernstein(1994) and Bland & Altman (1997) stated that there are different reports about the acceptable values of alpha, ranging from 0.70 to 0.95. A low value of alpha could be due to a low number of questions, poor interrelatedness between items or heterogeneous constructs. George & Mallery (2003) provide the rules of thumb as shown in Table 4.

Table 4. Indication of Cronbach's Alpha Value

Cronbach's Alpha Value	Indication
> 0.90	Excellent
> 0.80 – 0.90	Good
> 0.70 – 0.80	Acceptable
> 0.60 – 0.70	Questionable
> 0.50 – 0.60	Poor
< 0.50	Unacceptable

Since the Cronbach's Alpha value in this study is 0.815 as seen in Table 5, it is indicated that the content of the questionnaire reliable as rated as "Good". This statistic proves that the sampling in this study reflects the population.

Table 5. Cronbach's Alpha Value of the Study

Cronbach's Alpha	N of Items
.815	31

Table 6 shows the value of Cronbach's alpha for resident's satisfaction on physical aspect of PPR Housing. The value of 0.900 indicated the content of the questionnaire focusing on the resident's satisfaction on Physical Aspect of PPR Housing is "Good".

Table 6. Cronbach's Alpha for Resident's Satisfaction on Physical Aspect of PPR Housing

Cronbach's Alpha	N of Items
.900	20

RESULTS AND DISCUSSION

The analysis undertaken in this study are descriptive statistics for respondent's demographic profile and physical aspect of the PPR housing. The data were analysed to achieve the aims of the research which are to identify the level of satisfaction of PPR residents in term of physical aspect. Findings of the research are as follows:

Respondent's Demographic Profile

In this section, eleven (11) related questions were asked to the respondents such as gender, marital status, race, age, occupation, education, length of residency, family size, monthly income, vehicle owned and whether their wife is working or not. The findings are shown as in Table 7.

Table 7. Analysis on Respondent's Demographic Profile

Respondent's Demographic	Details	Frequency	Percentage (%)
Gender	Male	276	46
	Female	324	54
Marital Status	Single	99	16.5
	Married	501	83.5
Race	Malay	326	54.3
	Chinese	108	18.0
	Indian	156	26.0
	Others	10	1.7
Age	<25 years old	55	9.2
	25 - 40 years old	256	42.7
	41 - 60 years	241	40.2
	>60 years old	48	8
Occupation	Unemployed	144	24.0
	Government Sector	87	14.5
	Private Sector	271	45.2
	Business	98	16.3
Education	SPM and below	293	48.8
	Certificate	132	22.0
	Diploma	109	18.2
	Degree	60	10.0
	Master & PhD	6	1.0
Length of Residency	< 2 years	29	4.8
	2 - 3 years	86	14.3
	3 - 4 years	122	20.3
	4 - 5 years	99	16.5
	> 5 years	264	44.0
Family Size	2 - 4	261	43.5
	5 - 7	245	40.8
	8 - 10	86	14.3
	11 and above	8	1.3
Monthly Income	< RM 750	21	3.5
	RM 750 - RM 1000	39	6.5
	RM 1000 - RM 1200	62	10.3
	RM 1200 - RM 1500	126	21.0
	RM 1500 - RM 3000	245	40.8
	> RM 3000	107	17.8
Vehicle	Motorcycle	143	23.8
	Car	223	37.2
	Motorcycle and Car	207	34.5
	None	26	4.3
Working Wife	Yes	262	43.7
	None	336	56.0

The findings show that majority (54.0%) of the respondents are female and 83.5% of the respondents are married. Malay is the main (54.3%) resident's in the PPR followed by Indian (26.0%), Chinese (18.0%) and another race with 1.7%. Most (42.7%) of the respondents age between 25 years old to 40 years old followed by respondents (40.2%) between 41 years old to 60 years old.

45.2% of the respondents working in the private sector, 16.3% is venturing in the business and the least (14.5%) percentage is respondents works in the government sector. Surprisingly, big percentage (24.5%) of the respondents is unemployed which open the opportunities to unhealthy activities such as theft and robbery.

Majority (48.8%) of the respondents have certification of SPM and below following by 22.0% of the respondents who have certificate in technical and non-technical education. 1.0% of the respondents which is the least have Master and PhD. The length of the residency more than 5 years is the highest percentage with 44.0% followed by 20.3% of respondents who stay about 3 years to 4 years.

43.5% of the respondents mentioned that the family size is 2 to 4 persons in a house while about 40.8% of the respondents have 5 to 7 persons in a house. Surprisingly, there are quite a number for 8 persons and above in a house.

40.8% of the respondents have monthly income ranging from RM1,500.00 to RM3,000.00 followed by 21.0% of the respondents who have monthly income of RM 1,200.00 to RM1,500.00. About 17.8% of the respondents have monthly income more than RM3,000.00 and least (3.5%) have monthly income less than RM750.00.

The findings revealed that 37.2% of the respondents have their own vehicle which is car, 34.5% respondents have both car and motorcycle. Only 4.3% of the respondents did not own any vehicle. Majority (56.0%) of the respondents are not working wives and 43.7% are working wives.

Resident's Satisfaction on Physical Aspect of PPR Housing

Table 8 shows mean score and standard error of resident's satisfaction towards physical aspect at PPR housing. Mean score of resident's satisfactions towards physical aspect was between 3.60 (washing room area) and 4.37 (garbage disposal) at a Likert's scale of 1 to 5. The meaning of higher score of mean score portray the higher level of resident's satisfaction of physical aspect. According to Ginsberg & Churchman (1984), the physical characteristics of housing influence the level of resident satisfaction towards their housing. The housing characteristics as mentioned by Mohit & Al-KhanbashiRaja (2014) includes number of bedrooms and toilets, size and location of kitchen, living room, quality of housing unit which affect the residential satisfaction differently at cross-cultural levels.

The findings show almost all physical aspect of PPR Housing achieved a moderate to high resident's satisfaction mean score value. This study supports the study done by Salleh et al. (2011) in Ipoh, Perak, Malaysia found that resident's of MBI public housing were satisfied with the building features of the houses they were residing on mean score of 3.42. Contradict with the study done by Sulaiman & Yahaya (1987) which shown that major of the residents was dissatisfied with the characteristics of their dwelling units. This study shows the three (3) physical aspect achieved a low mean score are washing room area (3.60), size of kitchen (3.72) and the quality of the interior construction (3.72). This finding was supported by study done by Salleh et al. (2011) which received low mean score of size of kitchen (3.17) and internal construction quality (3.54).

The highest mean score is garbage disposal (4.37) followed by near to city centre (4.31) and types of houses (4.17). Ibem, Adeboye, & Alagbe (2015) support the findings that location of residence in the housing estate is the importance factors of the residential satisfaction through the measurement of mean satisfaction score (MSS) with score of 3.43. Sam et al. (2012) supported this statement which the location characteristics of house is important to the architects, urban planners and designers and also policy makers. The researcher also mentioned that the garbage line is important in the residential satisfaction in term of architect's perspective. However, it is contradict with the study done by Alden Speare (1974) which mentioned that the distance from work, schools and shopping mall are moderately important to the respondents.

Table 8. Physical Aspect of PPR Housing

No.	Physical Aspect	Mean	
		Statistic	Standard Error
1	Garbage disposal	4.37	0.024
2	Near to city centre	4.31	0.029
3	Types of house: terrace and apartment	4.17	0.025
4	Food stall	4.13	0.033
5	Ventilation of the house	4.13	0.028
6	Size of house	4.07	0.029
7	Location of stairs	4.06	0.03
8	Prayer hall	4.01	0.031
9	Size of living room	4.01	0.033
10	Number of bedrooms	4.00	0.03
11	Size of bedrooms	3.98	0.034
12	Size of bathrooms	3.95	0.033
13	Number of bathrooms	3.93	0.032
14	Size of dining room	3.93	0.035
15	The quality of exterior construction	3.90	0.039
16	Community hall	3.84	0.038
17	Number of sockets	3.82	0.081
18	The quality of the interior construction	3.73	0.043
19	Size of kitchen	3.72	0.044
20	Washing room area	3.60	0.046

Analysis of Variance (ANOVA)

Table 9 shows the output of the ANOVA analysis and whether there is a statistically significant difference between group means. It can see that the significance value for Physical_1 (Near to city centre), is 0.001, Physical_7 (Food stall), is 0.003, Physical_13 (Number of socket), is 0.003, Physical_14 (size of kitchen), is 0.044, Physical_16 (size of dining room), is 0.007 and Physical_17 (size of living room) is 0.027, which is below 0.05. and, therefore, there is a statistically significant difference in types of physical aspects between the different monthly family income.

Table 9. Analysis of Variance (ANOVA) Results of Physical Aspects and Monthly Family Income

		Sum of Squares	df	Mean Square	F	Sig.
Physical_1 Near to city centre	Between Groups	10.476	5	2.095	4.201	.001
	Within Groups	296.242	594	.499		
	Total	306.718	599			
Physical_2 Types of house: terrace and apartment	Between Groups	3.664	5	.733	1.958	.083
	Within Groups	222.334	594	.374		
	Total	225.998	599			
Physical_3 Size of house	Between Groups	.816	5	.163	.323	.899
	Within Groups	300.517	594	.506		
	Total	301.333	599			
Physical_4 Garbage disposal	Between Groups	1.426	5	.285	.806	.546
	Within Groups	210.172	594	.354		
	Total	211.598	599			
Physical_5 Community hall	Between Groups	7.189	5	1.438	1.636	.148
	Within Groups	522.129	594	.879		
	Total	529.318	599			
Physical_6 Prayer hall	Between Groups	6.110	5	1.222	2.136	.060
	Within Groups	339.830	594	.572		
	Total	345.940	599			
Physical_7 Food stall	Between Groups	11.393	5	2.279	3.571	.003
	Within Groups	378.981	594	.638		
	Total	390.373	599			
Physical_8 Number of bathroom	Between Groups	3.808	5	.762	1.232	.292
	Within Groups	367.252	594	.618		
	Total	371.060	599			
Physical_9 Size of bathroom	Between Groups	5.620	5	1.124	1.688	.136
	Within Groups	395.565	594	.666		
	Total	401.185	599			
Physical_10 Number of bedrooms	Between Groups	2.413	5	.483	.906	.477
	Within Groups	316.585	594	.533		
	Total	318.998	599			
Physical_11 Size of bedrooms	Between Groups	5.413	5	1.083	1.583	.163
	Within Groups	406.261	594	.684		
	Total	411.673	599			
Physical_12 Washing room area	Between Groups	11.691	5	2.338	1.892	.094
	Within Groups	733.903	594	1.236		
	Total	745.593	599			
Physical_13 Number of socket	Between Groups	48.239	5	9.648	2.489	.030
	Within Groups	2302.226	594	3.876		
	Total	2350.465	599			
Physical_14 Size of kitchen	Between Groups	12.993	5	2.599	2.293	.044
	Within Groups	673.272	594	1.133		
	Total	686.265	599			
Physical_15 Location of stairs	Between Groups	5.244	5	1.049	2.025	.073
	Within Groups	307.714	594	.518		
	Total	312.958	599			
Physical_16 Size of dining room	Between Groups	11.409	5	2.282	3.217	.007
	Within Groups	421.364	594	.709		
	Total	432.773	599			

		Sum of Squares	df	Mean Square	F	Sig.
Physical_17 Size of living room	Between Groups	8.457	5	1.691	2.554	.027
	Within Groups	393.436	594	.662		
	Total	401.893	599			
Physical_18 The quality of the interior construction	Between Groups	8.575	5	1.715	1.546	.174
	Within Groups	659.050	594	1.110		
	Total	667.625	599			
Physical_19 The quality of exterior construction	Between Groups	7.468	5	1.494	1.677	.138
	Within Groups	528.917	594	.890		
	Total	536.385	599			
Physical_20 Ventilation of the house	Between Groups	4.449	5	.890	1.857	.100
	Within Groups	284.669	594	.479		
	Total	289.118	599			

Post Hoc Tests

Post hoc test using Tukey HSD was done to find the difference for specific income group for variables that are significant. Six (6) variables were identified as significant and Table 10 shows which income group is significant.

Table 10. Post Hoc Tests within Income Group

(i) Monthly Income	(j) Monthly Income	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Physical 1: Near to city centre						
RM 1000 – RM 1200	RM 1500 – RM 3000	0.336	0.100	0.011	0.05	0.62
	> RM 3000	0.324	0.113	0.048	0.00	0.65
RM 1200 – RM 1500	RM 1500 – RM 3000	0.224	0.077	0.045	0.00	0.45
Physical 7: Food Stall						
RM 1200 – RM 1500	RM 1500 – RM 3000	0.270	0.088	0.026	0.02	0.52
Physical 13: Number of Socket						
RM 750 – RM 1000	RM 1500 – RM 3000	1.138	0.339	0.011	0.17	2.11
Physical 14: Size of Kitchen						
RM 1500 – RM 3000	RM 1200 – RM 1500	-0.350	0.117	0.034	-0.68	-0.02
Physical 16: Size of Dining Room						
< RM 750	>RM 3000	-0.579	0.201	0.047	-1.15	0.00
RM 1500 – RM 3000	>RM 3000	-0.282	0.098	0.045	-0.56	0.00

A Tukey post hoc test revealed that the physical aspect of near to city centre is statistically significant different on monthly income group of RM1500 to RM3000 (mean = 4.21, Sd = 0.727, p = 0.011 < 0.05) and group of greater than RM3000 (mean = 4.22, Sd = 0.718, p = 0.048 < 0.05) compared to monthly income group between RM1000 to RM1200 (mean = 4.55, Sd = 0.563). Likewise, there is statistically significant different on monthly income of RM1500 to RM3000 (mean = 4.21, Sd = 0.727, p = 0.045 < 0.05) compared to monthly income group between RM1200 to RM1500 (mean = 4.44, Sd = 0.687). The other groups of monthly income are not statistically significant different since p-value > 0.05.

Likewise for Physical 7 (Food stall), the test show that this variable is statistically significant different on monthly income group of RM1500 to RM3000 (mean = 3.98, Sd =

0.844, p = 0.026 < 0.05) compared to monthly income group between RM1200 to RM1500 (mean = 4.25, Sd = 0.769). The other groups of monthly income are not statistically significant different since p-value > 0.05. A Tukey post hoc test for Physical 13 (Number of socket) revealed that the physical aspect of number of sockets is statistically significant different on monthly income group of RM1500 to RM3000 (mean = 3.58, Sd = 1.055, p = 0.011 < 0.05) compared to monthly income group between RM750 to RM1000 (mean = 4.72, Sd = 6.724). The other groups of monthly income are not statistically significant different since p-value > 0.05.

A Tukey post hoc test for Physical 14 (size of kitchen) revealed that the physical aspect of kitchen's size is statistically significant different on monthly income group of RM1500 to RM3000 (mean = 3.55, Sd = 1.038, p = 0.034 < 0.05) compared to monthly income group between RM1200 to RM1500 (mean = 3.90, Sd = 1.003). The other groups of monthly income are not statistically significant different since p-value > 0.05. while for Physical 14 (Size of Dining Room), a Tukey post hoc test revealed that the physical aspect of dining room's size is statistically significant different on monthly income group of greater than RM3000 (mean = 4.10, Sd = 0.752, p = 0.047 < 0.05) compared to monthly income group less than RM750 (mean = 3.52, Sd = 0.873). Likewise, there is statistically significant different on monthly income of greater than RM3000 (mean = 4.10, Sd = 0.752, p = 0.045 < 0.05) compared to monthly income group between RM1500 to RM3000 (mean = 3.82, Sd = 0.805). The other groups of monthly income are not statistically significant different since p-value > 0.05.

However, a Tukey post hoc test for Physical 17 (Size of Living Room) shows that there is no different on monthly income group and the size of living room since all the p-value > 0.05. Test need to reidentify (Table 11). Due to that, a Least Square Difference (LSD) test is equivalent to multiple t tests between all pairs of groups. This test does not control the overall probability of rejecting the hypotheses that some pairs of means are different, while in fact they are equal. An LSD post hoc test revealed that the physical aspect of living room's size is statistically significant different on monthly income group of RM750 to RM1000 (mean = 4.28, Sd = 0.724, p = 0.010 < 0.05) and group of RM1200 to RM1500 (mean = 4.10, Sd = 0.768, p = 0.043 < 0.05) compared to monthly income group less than RM750 (mean = 3.71, Sd = 0.902). Likewise, there is statistically significant different on monthly income of RM1500 to RM3000 (mean = 3.92, Sd = 0.826, p = 0.010 < 0.05) compared to monthly income group between RM750 to RM1000 (mean = 4.28, Sd = 0.724). While there is also significant different of monthly income between RM1500 to RM3000 (mean = 3.92, Sd = 0.826, p = 0.039 < 0.05) compared to monthly income group of RM1200 to RM1500(mean = 4.10, Sd = 0.768). The other groups of monthly income are not statistically significant different since p-value > 0.05.

Table 11. Post Hoc Test within Income Group using Least Square Difference (LSD)

(i) Monthly Income	(j) Monthly Income	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Physical 17: Size of Living Room						
< RM750	RM 750 – RM 1000	-0.568	0.220	0.010	-1.00	-0.14
	RM 1200 – RM 1500	-0.389	-.192	0.043	-0.77	-0.01
RM 750 – RM 1000	RM 1500 – RM 3000	0.364	0.140	0.010	0.09	0.64
RM 1200 – RM 1500	RM 1500 – RM 3000	0.185	0.089	0.039	0.01	0.36

CONCLUSIONS

This study investigated and analysed the level of residential satisfaction of PPR Housing on physical aspect using data obtained from the survey questionnaire involving 600 residents in 14 PPR housing around Klang Valley. Based on the findings, the following conclusions can be made. It can be concluded that these three items should be taken into more consideration which are washing room area, size of kitchen and the quality of the interior construction. These parameters should be set as principal in the design and planning process of low-cost housing. The factors that received high rate of satisfaction amongst residents should be retained such as near to city centre to allow accessibility to various function areas for daily needs. The findings shows that six (6) variables are significant which are Physical 1 (Near to City Centre), Physical 7 (Food Stall), Physical 13 (Number of Socket), Physical 14 (Size of Kitchen), Physical 16 (Size of Dining Room) and Physical 17 (Size of Living Room). Thus, it can be concluded that, higher group of income (RM 1500 and above) have higher expectation on these variables, while lower income group have higher satisfaction on these variables.

The recommendation to enhance residential satisfaction based on this study are to increase the size of toilet, washing room area, size of kitchen and to establish policy and regulation to check on the quality of interior construction. The improvements in the residential development are necessary to enhance the residential satisfaction towards low-cost housing, thus can drive the ambition towards smart cities.

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THE IMPLEMENTATION OF SUSTAINABLE ENERGY PRACTICES IN THE LOCAL AUTHORITY BUILDINGS

Nasrudin Sharkawi[1,2], Mohamad Sufian Hasim[1], Hamimah Adnan[1], Hikmah Kamarudin[1] and Rostam Yaman[1]

[1]Faculty of Architecture, Planning and Surveying, Universiti Teknologi MARA Shah Alam, Selangor, Malaysia.

[2]Faculty of Engineering and Built Environment, Universiti Sains Islam Malaysia, Negeri Sembilan, Malaysia.

Abstract

Globally, the local authority organisations have an important trend toward focusing on energy efficiency and sustainability in managing physical assets and facilities. As an asset owner, they own huge assets and infrastructure such as office buildings, kiosks, community halls and gardens. These assets consume high energy and potentially negatively impact the environment. Thus, sustainability adopted in energy practices is essential for achieving sustainability goals. This paper investigated the commitments of the local authority organisations in Malaysia toward implementing sustainable energy practices. The objectives were to identify the sustainable energy initiatives implemented at eight selected local authorities from City Hall and Municipal Council categories. The participants from eight key practitioners with facilities management (FM) experiences were observed via a semi-structured interview. The study found that the commitment of the local authority organisations towards implementing sustainable energy practices was still at an initial stage, with seven initiatives found. The most significant initiatives identified were the practices such as introducing energy-saving techniques, installing energy-saving technology and energy-saving equipment, and encouraging the involvement of officers and staff in energy-saving. Therefore, the study suggested that local authorities' proactive roles are needed for higher sustainable energy implementation practices. Indeed, these organisations have to lead toward achieving energy sustainability goals as they have a huge asset in their jurisdiction.

Keywords: *sustainability; sustainable energy; sustainable facilities management; local authorities.*

INTRODUCTION

Sustainable energy practices are one of the crucial actions toward achieving sustainability goals. Facilities management units should adopt this approach in every local authority organisation to deal with the energy consumption of their buildings and assets. Over the last ten years, there has been increasing awareness globally about sustainability practices due to development's detrimental impact, especially concerning environmental degradation (Woodruff & Mankoff, 2009). However, the commitment among local authorities in Malaysia is still unknown, especially concerning sustainable energy practices in managing their buildings and assets. Currently, energy consumption has become a vital agenda leading to a growing commitment among organisations worldwide. Thus, urgent actions and solutions are required to minimise the environmental challenges due to high energy consumption, such as ozone depletion, pollution, soil degradation, and deforestation (Banerjee, 2002; Hansen, 2006). Indeed, implementing sustainable energy practices is essential to meet the challenges of energy supply adequacy and overcome the impact of carbon emissions.

Sustainable energy practices are any methods of managing and using energy to meet present human demands without jeopardising the future generations' ability to satisfy their desires (Abdelkader, 2020; Delponte et al., 2017; Frederiks et al., 2015). Azis (2021) asserted that adopting sustainable energy practices initiatives on various buildings and institutions has brought numerous benefits, not only from an economic perspective but also provided benefits to the social and environmental sectors. Some of the initiatives that are commonly classified as sustainable energy practices include implementing energy-saving initiatives both inside and outside the building's perimeter, replacing older electrical equipment, installing more energy-efficient equipment and LED lighting, solar PV installation, and passive design planning. To conserve energy, including the use of energy-efficient air conditioning equipment and numerous additional measures that have been put in place to accomplish this goal (Azis, 2021; Dzulkifli et al., 2021). All measures to establish sustainable energy practices must be planned and implemented systematically by building owners who are accountable for their properties. When building owners take responsibility for thoroughly implementing sustainable energy on their properties, the issue of energy supply and the impact of carbon dioxide emissions will be able to be addressed (Berawi et al., 2020). Indeed, sustainability in energy management practice is potentially driving local authorities' progress towards a sustainable city.

The local authority is regarded as one of the vital research settings and can play a fundamental role in achieving sustainability goals. Local authorities have a crucial role in the transition to more sustainable ways of living. These organisations have significant power and influence to determine whether policies and programs under their authority create sustainable or unsustainable conditions. Generally, the local authority is a government agency that can promote success and serve as a catalyst for implementing sustainable energy practices throughout Malaysian society (Juhari et al., 2019). As an asset owner, they own huge assets and infrastructure such as residential buildings, commercial buildings, office buildings, public libraries, kiosks, community halls, gardens, recreational parks and other public facilities provided in their territory. For example, local authorities in Malaysia own and essentially control many buildings and assets such as buildings, gardens, kiosks, and shop complexes. Therefore, their performance in implementing sustainable energy practices on their assets should be evaluated. According to the Local Government Department of Malaysia (Local Government Department, 2021), currently, there are 150 local authority offices in Malaysia. Although there is no published study on the true worth of assets owned by local governments in Malaysia, an examination of the annual reports of several local governments reveals an increasing trend in the number of local government assets in line with population growth around their territory. Therefore, local governments must implement sustainable energy practices on all buildings and assets under their management as an asset and building owners.

This paper focuses on the importance of sustainability adoption in the facilities management of local authorities' buildings in Malaysia that focus on sustainable energy practices. This paper investigated the commitments of local authority organisations in Malaysia toward implementing sustainable energy practices. This preliminary study engaged only a few selected local authorities as a sample of studies. The objectives were to identify the sustainable energy initiatives implemented, and the findings may stimulate global discussion, which may impact sustainable practices.

This paper is broken down into five sections. This introduction will review the literature on local authorities' commitment to sustainable energy practices, methodology, result in analysis and discussion, and finally, the outcomes and interpretation of those findings. At the end of the discussion, conclusions are reached that are linked to the broader topic.

LOCAL AUTHORITIES' COMMITMENTS TOWARDS SUSTAINABLE ENERGY PRACTICES

Local authorities are an essential organisation in driving and promoting the successful implementation of the sustainability agenda (Amundsen et al., 2018; Smedby & Quitzau, 2016). This is because local authorities can influence climate change impacts by adaptation and mitigation of land use planning, waste management, health care services, infrastructure, and community development. Furthermore, according to Fudge et al. (2016), local authorities can act as change facilitators for all organisations embracing sustainable energy, reducing the adverse effects of climate change and, as a result, lowering carbon emissions. The local authorities' commitment to sustainability agenda is demonstrated by the existence of The European Covenant of Mayors Movement. It unites over 7600 signatory local authorities committed to reducing CO_2 emissions by at least 20% in 2020 or 40% by 2030 by implementing a climate action plan dubbed the Sustainable Energy Action Plan (SEAP) (Melica et al., 2018). Malaysia has also responded to this call by asking several local authorities to hold a Low Carbon Cities Framework (LCCF) in line with the commitment promised by the Prime Minister of Malaysia at the 15th United Nations Framework Convention on Climate Change (COP15) 2009 in Copenhagen, Denmark to reduce its carbon dioxide emission intensity based on GDP by 40 per cent by 2020 (Juhari et al., 2019). Therefore, it is clear here that local authorities are essential organisations in driving the successful implementation of the sustainability agenda.

Furthermore, local authorities need to implement sustainable energy practices because they are among the institutions that have a wide range of assets to contribute to the global effort. In the Malaysian context, local authorities are a government entity that owns a substantial portion of Malaysia's immovable assets, split into three categories: buildings, civil infrastructure and land. Immovable assets of the Local Authority's buildings are split into a community hall, public transport terminal, public market, food establishments and toilets (Mong et al., 2021; Norhidayah et al., 2015). Parking, road, sewerage, drainage, pedestrian bridge and bus stop, street, traffic, and decorative lights and signage are all types of civil infrastructure. In addition, there are two types of landscapes which are soft and hard. These immovable assets of local authorities contribute to Malaysia's final electricity consumption, which continues to rise year after year (Aldhshan et al., 2021; Hassan et al., 2014; Latif et al., 2021). In addition, data shows that final electricity consumption increased from 7,968 ktoe to 13,099 ktoe from 2008 to 2018 (Malaysia Energy Information Hub, 2011). The development of this local authority's immovable assets also contributed to the growth statistics from the same source, which revealed an increase in Malaysia's final energy demand through the residential and commercial sectors, which increased from 6,205 ktoe in 2008 to 7,774 ktoe in 2018. Using the acquired data the above, it is highly crucial for local authorities, as one of the prominent asset owners in Malaysia, to embrace sustainable energy practices to manage all their own assets.

Sustainable energy practices by the local authorities must be implemented systematically and guided by the best practices that have been implemented (Akinyele & Rayudu, 2016; Asian Development Bank, 2018; Manan et al., 2010). As a consequence of the direction provided by best practices, it will be able to serve as a model for local authorities to follow in order to fulfil their objectives and create beneficial outcomes. Notably, the local authority needs to prepare a baseline and objectives, which represents the starting point for their

Sustainable Energy Action Plan (SEAPs) and allows for identifying the most potential sectors and the priority areas for action (Akinyele & Rayudu, 2016; Tan et al., 2017). With these objectives and baselines, local authorities will have a clear direction in implementing sustainable energy. In addition, practices and awareness on energy saving on the premises also need to be advertised to be disseminated to all assets owned (Alam et al., 2019). Furthermore, Polzin et al. (2018) reported that one of the best practices established by municipal governments in Germany is retrofitting all electrical equipment on their property. The execution of this retrofit has benefited the local governments' economies. Furthermore, Italy's local governments have established a green public procurement strategy that has a good influence on their environment (Testa et al., 2016). Therefore, with the guidelines from the best practices to implement sustainable energy, local authorities will be able to implement sustainable energy on their assets systematically and effectively.

METHODOLOGY

The face-to-face and online semi-structured interviews were conducted for this study. Thus, in achieving the study objective, which is to identify the sustainable energy initiatives implemented, eight (8) participants represented eight various selected local authorities in Malaysia were invited as participants for this study. These participants worked in senior positions (technical and professional) in their respective departments, which were actively involved in planning, design, procurement, engineering, maintenance and operational operations for their assets and facilities. Therefore, this study believed the participants were knowledgeable about activities undertaken and who were responsible persons handling energy management in their organisation. Ivanka and Wingo (Ivankova & Wingo, 2018) stated many advantages in conducting interviews to obtain information or data that are still lacking and difficult to obtain. Using this method, researchers can elicit detailed responses from respondents, offer extensive interview questions, reduce the respondent's fear of being evaluated, and preserve criticality in the data analysis process. In addition, this approach is an efficient way to gain direct responses from informants in connection to practical difficulties and the development of instruments (Nusbaum et al., 2017). Creswell (Creswell, 2009) asserted that it was decided to employ the nonprobability deliberate maximum variation sampling strategy to identify key informants for the study since it would capture a greater diversity of opinions.

The Population for The Study and Sampling Size

There are 154 local authorities in Malaysia, and this survey only focuses on the background of local authorities, as referred to by the Local Government Department of Malaysia (Local Government Department, 2021). For the qualitative method, the analysis is only limited to 56 populations of the City and Municipal Councils. For the 56 city and municipal councils, the focus is given to the eight (8) municipal councils that have already dedicated themselves to smart cities and reducing carbon emissions by 2020 (Abdul Rahman, 2020). Guest et al. (Guest et al., 2006) suggested that a range between six (6) and twelve (12) participants for interviews was adequate for developing meaningful themes and achieving research objectives. With a total number of eight interviewees, this study conformed to this suggestion. Indeed, the sample size determined plays a significant role in endorsing the researchers' results before generalising the study findings is completed and published. The following Figure 1 illustrates the population for the study and sampling size.

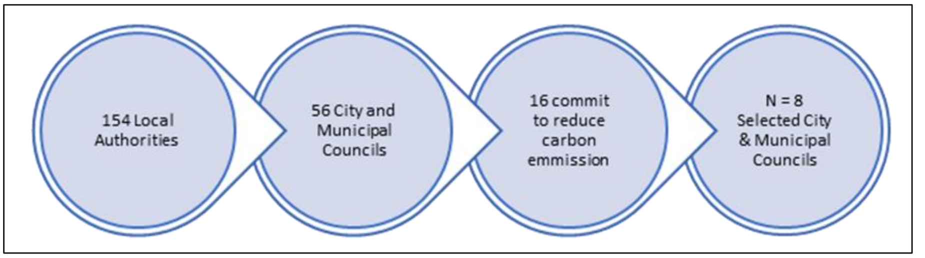

Figure 1. Population for The Study and Sampling Size

The participant represents their local authorities who have taken part in this study presented below, and their data resources are obtained.

Table 1. List of Participant Profiles and Information

No	Position	Ref	Organisation
1	Assistant Planning Officer	A1	Majlis Perbandaran Seberang Perai MPSP)
2	Quantity Surveyor	B1	Majlis Perbandaran Ampang Jaya (MPAJ)
3	Assistant Director	C1	Majlis Bandaraya Petaling Jaya (MBPJ)
4	Assistant Engineer	D1	Majlis Perbandaran Hang Tuah Jaya (MPHTJ)
5	Assistant Director	E1	Majlis Bandaraya Shah Alam (MBSA)
6	Director	F1	Majlis Perbandaran Klang (MPKlang)
7	Director	G1	Majlis Perbandaran Subang Jaya (MPSJ)
8	Principal Assistant Director	H1	Dewan Bandaraya Kuala Lumpur (DBKL)

Data Collection, Analysis & Interview Procedures

This study used interviews face-to-face, participants required thorough expertise in interview methods, and the analysis had to be broken down into parts and carefully recorded and organised according to the steps shown below:

Step 1: After the interview session, the recorded voice must be shifted into the corresponding folder designated in the written template for each participant. It takes time to listen to and write an interview from the beginning to the end of the session to transcribe the voice recorded in the written document. Then the researcher will make a phone call to notify the arrival to let the participant prepare for the interview session. The researcher had established a timeline and period to collect the data to ensure the primary function of collecting data's results was completed on time. The researcher needs to remind the participants once the researcher arrives at the interview location, as agreed previously during the interview. Before the interview begins, the researcher will introduce and briefly explain the study's objective to the participants. At the end of the interview session, the researcher will end the session with closing and appreciation remarks.

Step 2: Williamson et al. (2018) asserted that data analysis transfers raw data and converts the data into proven evidence to convince a specific type or a particular phenomenon of knowledge. Thus, there are five-step to analyse the data, as followed by Creswell (Creswell 2009):

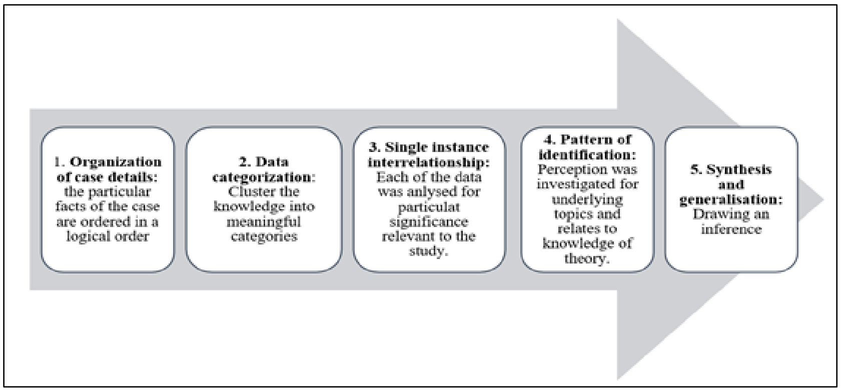

Figure 2. Five steps of The Data Analysation Approach According to Creswell (Creswell, 2009)

Interview Questions Type

The interview questions script focused on two key themes based on the participants' context, awareness, understanding of the subject and sustainable energy initiatives. This focus was created to illustrate research concerns and goals. The first theme was related to participants' background, where they were employed and worked. The second topic was to determine the participant's knowledge and understanding of sustainable energy practice and individual perspectives on particular issues. The participants also asked how the existing buildings can sustain their performance and include them in their office buildings in sustainable energy initiatives. In addition, participants were also asked about the effectiveness of implementing sustainable energy in their offices.

Table 2. Interview Questions

Themes	Questions
Participant background and knowledge	1. Please introduce yourself. 2. How long have you been working in this position? 3. What is your job scope? 4. What do you understand about sustainable energy? 5. Explain the differences between sustainable energy and a sustainable environment?
Current sustainable energy practice and its effectiveness	6. Do you implement sustainable energy in your workplace? 7. What type of sustainable energy has been implemented in your workplace? 8. How effective is sustainable energy implementation? 9. Which initiative in sustainable energy is mostly considered? 10. How and why it was implemented?

RESULTS ANALYSIS AND DISCUSSION

When all participants were asked about their understanding of sustainable energy, most participants understood the meaning of sustainable energy. All participants were also able to explain the objectives of sustainable energy implementation in their workplace. Three (3) main keywords can be planned concerning their views on sustainable energy, energy saving, operating cost savings, and the need to save energy consumption for future needs. They all understand the basic concept of sustainable energy: implementing energy-saving measures and using the current energy without affecting energy consumption in the future. In addition, participants also understand the main elements of sustainable energy by using renewable energy from natural sources such as solar energy, wind, water and biomass.

Current Sustainable Energy Practices

The study conducted found that local authorities in Malaysia have implemented sustainable energy practices as practised in the best practices by local authorities in foreign countries that are much more developed; however, the implementation has not been fully implemented. Table 3 shows the current sustainable energy practices implemented in their respective office buildings.

Table 3. Participant's Feedback About Sustainable Energy Practices Implemented in Their Office Building

Type of Sustainable Energy Initiatives	A1	B1	C1	D1	E1	F1	G1	H1
Introduction of energy-saving techniques and energy-saving technology and equipment for local authorities' offices to reduce energy consumption	√	√	√	√	√	√	√	√
Installation of meters/equipment to monitor energy consumption			√	√	√			√
Encourage the involvement of officers and staff in energy saving	√	√	√	√	√	√	√	√
Efficient lighting, such as installing LED lighting	√		√		√		√	√
'Make a green choice' is programmed for awareness of environmental issues to explain to all officers and staff	√		√	√	√		√	√
Install solar photovoltaic roof panels	√		√		√	√		

Table 3 above has clearly stated that all participants agreed that they are implementing and introducing energy-saving techniques, energy-saving technology, and equipment to reduce energy consumption in their office building and encourage the involvement of officers and staff in energy saving. Participant D1 gave feedback that they implement one particular method to encourage the building occupants to maintain then save energy policy implementation in their office:

"We appointed 3 Green Ambassadors from each department in our organisation to specifically monitor the energy-saving implementation in their respective department. They are also key persons to announce and distribute any related and latest information or technology about the energy-saving method in their department". (Participant D1)

Participant E1 also mentioned that they have a special committee meeting annually to monitor and implement the energy audit in their building to take action and further plan how to reduce the energy if they find the electric consumption is high. Table 3 also stated that participants' feedback regarding their office is not equipped with an air conditioning system with energy efficiency characteristics. They also know that the air conditioning system used contributes to high energy consumption to provide comfort to the occupants building. However, participant D1 mentioned:

"We are planning to implement the air condition retrofitting project, in which we will replace the conventional chiller and a cooling tower with a green marked chiller and cooling tower. This is one of our strategies to reduce energy consumption and reduce our monthly electric bill". (Participant D1)

From the questions that have been asked, all the participants are aware that the use of LED lights contributes a lot to saving electricity. However, many respondents still use conventional lighting systems, such as participants B1 and A1. In addition, not all participant buildings are also equipped with solar panels or any other alternative energy source to supply electricity. Most participants are aware of the benefits of solar panels and renewable energy as one alternative to electricity. However, most participants still do not have the ability in terms of expertise and finance to use renewable energy resources fully. However, participant H1 informed that they had installed some solar panels outside the operating building, like in the botanical garden.

"We did not install any solar panel in our operation building (main office), but we installed it in some of our small stalls under our management and some in our botanical garden for the compound lighting". (Participant H1)

The installation of motion sensor lighting systems has also not been widely installed. However, they have a great collaboration potential with suppliers from outside and within the country to install the systems. Next, participants were also asked about the effectiveness of sustainable energy implementation in their buildings. All participants stated that the implementation of sustainable energy that has been implemented is very effective and has successfully reduced the amount of electricity consumption and reduced their electricity bills. Among the respondent who has shared their electric bill reduction cost is participant C1 and D1.

"Since implementing the retrofitting project, we compared the average electric bill annually, which is RM 80k to RM 85k annually, now it has been reduced to RM 69k to RM 68k". (Participant C1)

"We measured the effectiveness of our program by achieving the reduction of our electric bill annually from RM 30k to RM 15k". (Participant D1)

Among all initiatives implemented, the most straightforward initiatives are to conduct a campaign explaining the energy-saving method, encouraging staff involvement and 'make a green choice' program for awareness of environmental issues to explain to all officers and staff, as stated in Table 4 below.

Table 4. Top Three Ranking of Mostly Considered Sustainable Energy Initiatives

Sustainable Energy Initiatives Mostly Considered	Frequency of Statement	Percentage (%)	Rank
Introduction of energy-saving techniques and energy-saving technology and equipment for local authorities' offices to reduce energy consumption.	8	100	1
Encourage the involvement of officers and staff in energy saving.	8	100	2
'Make a green choice' is programmed for awareness of environmental issues to explain to all officers and staff.	6	72.5	3

CONCLUSION

In a nutshell, various sustainable energy initiatives were detected in the selected organisations. Through this study, the researchers found that local authorities in Malaysia are committed to implementing sustainable energy; however, the commitment is still in its infancy. Total commitment is unable to gain due to several obstacles that need to be further clarified in future studies.

The data obtained through this study has comprehensively explained the level of commitment to implementing sustainable energy in the local authorities in Malaysia, but the data obtained is limited to a few local authorities. Moreover, it was established only by a single approach via semi-structured interviews. As a result, additional evaluation may be beneficial to confirm the findings, and complementary research utilising other approaches, such as quantitative methods, is proposed to provide data validation and strengthen the overall conclusions.

In enhancing the desired commitments from the management team for sustainable energy practices in the local authorities, the top management should support financial, personnel, and other relevant resources to accomplish their planned strategies. Moreover, the energy management teams should establish a firm energy policy for setting goals and integrating energy management planning in the organisation.

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WORK DEVELOPMENT PLAN FOR INTERIOR DESIGN PROJECT DELIVERY PROCESS AND PRACTICE USING GUTTMAN APPROACH

Arniatul Aiza Mustapha and Nur Maizura Ahmad Noorhani
Centre of Studies in Interior Architecture, Faculty of Architecture, Planning and Surveying, Universiti Teknologi MARA Selangor, Puncak Alam Campus, 42300 Bandar Puncak Alam, Selangor.

Abstract
Work process and flow is crucial in interior design project delivery process. Within the balance of time, cost and quality, interior design process involves the execution of the designing, beginning to end, as well as the subsequent phases of construction and completion. Popularity of interior design nowadays amongst people around the world, demand interior design businesses aggressively in action. And this helps the interior designer self-interpret the ways, processes and flows without having uniform way of work in delivering project. This study intends to affirm the process, flow and order of interior design project delivery process in establishing interior design work development plan (IDWDP). This study is merely narrowed to the earlier phase of interior design project delivery process, where it will be discussing until the design stage (pre-contract phase). The establishment of IDWDP, it may give positive exercise for interior design professional in practicing the interior project by contributing to the sustainable economic growth, productive employment as well as decent work stated in SDG 8.

Keywords: *interior design work development plan; interior design scope of work; interior design project delivery.*

INTRODUCTION

Every job has its own set of steps, procedures, and processes for achieving the desired results. When it comes to project delivery, the interior design industry is not immune to these issues. Despite the fact that interior design is supposed to play a minor part in architecture and the construction industry, it plays a vivacious role in fulfilling people's preferred spatial environments for their own business purposes. Interior design project delivery, like other streams, entails planning, scheduling, monitoring, coordinating, directing, documenting, concluding a project, and conducting follow-up with the client after move-in, all of which are part of project coordination and management (Caporale and Tiffany, 2021) within the balance of time, cost, and quality. This is where the scope of work must be incorporated into the interior design project delivery process so that the process and sequence can be clearly defined.

Interior design is starting to emerge from its deep roots, as in Malaysia at the moment, people are beginning to appreciate functional spaces in addition to the value of aesthetics. For example, Malaysians, perhaps due to the pandemic, are spending most of their time in their homes exploring sustainable interiors by importing greens inside of their houses Wong (2020). This corresponds to the direction of Sustainable Design Goal 3 (SDG 3)**,** which promotes healthy lives and well-being at all ages within and inside our own spaces and surroundings. The season, too, makes people keep on adjusting their homes with additional areas for workstation/s. There is an insatiable demand for interior design, therefore, which drives up the quality of the project delivery. This study intends to affirm the process, flow, and order of the interior design project delivery process in establishing an interior design work development plan (IDWDP).

Interior Design Project Process

Interior design process and management of the project has been interpreted in many ways and flows by the interior design practitioners. Although project management is a widely used management tool in the construction industry, interior design continues to advance by incorporating project management knowledge and skills into project delivery practices.

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With improved briefing processes, interior design project procurement accommodates a continuous cycle of projects for renovation, refurbishment, or new work. It recognizes the stages that must be accomplished sequentially until the project is successfully completed (Mustapha, 2019) In comparison to the construction industry, interior design is slightly less complicated in terms of procurement, contracting, and project delivery than architecture and construction (Mustapha, 2019). Traditionally, there are three sequences of construction project delivery, which are similar to interior design project delivery, such as planning, design and construction (McCarthy, 2014).

The breadth of interior design work is not restricted to design. Despite being limited to a restricted area, it requires a variety of complicated tasks and procedures akin to architecture. The interior design process involves the execution of the design from beginning to end, as well as the subsequent phases of construction and completion Mustapha, 2019).

RIBA Plan of Work 2020 (RIBA, 2020) states of eight, starting with stage ‘0’ Strategic Definition, ‘1’ Preparation and Brief, ‘2’ Concept Design, ‘3’ Spatial Coordination, ‘4’ Technical Design, ‘5’ Manufacturing and Construction, ‘6’ Handover, and lastly, ‘7’ Use. According to the RIBA President (2019-2021), the changes and updates to the 2020 Plan of Work are made by adapting the sustainable project strategy, which focuses on trends and innovation (Jones, 2020; Sinclair, 2019).

While the Project Management Body of Knowledge (PMBOK) 7th edition (PMBOK, 2020; PMI, 2021) also states some big changes in the content that will be released in August 2021. Compared to the 6th edition (PMI, 2017), the focus is more towards "process-based project management", which consists of the process of initiating, planning, executing, monitoring and controlling, and closing. The 7th edition will be broader to a "principle-based project delivery" to cover the outcomes of projects by following 12 principles, and no more containing the Knowledge Areas (PMBOK, 2020).

Then, the interior design work stages and process, as mentioned in the research (Mustapha, 2019), involves seven stages of the project development process. The interior design project development process starts from the project initial, programming, schematic design, design development, contract documentation and implementation, construction/installation, completion and handover. This management tool framework (interior design project development process) consists of seven stages of work process and has been tailored to the RIBA Plan of Work 2020 as well as to the sixth project process of

PMBOK 6th Edition, together with the interior design literature sources and practices (Mustapha, 2019).

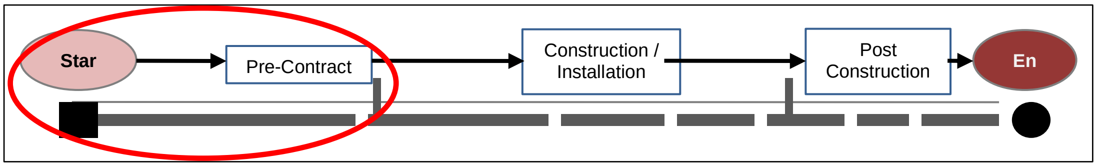

Figure 1. Interior Design Project Delivery Phase (Mustapha, 2019)

The interior design project delivery phase, as in Figure 1, consists of five orders, including the embarkation of the project. Between the start of the project and the pre-contract phase, programming, schematic design, design development, contract documentation, and implementation are supposed to occur in sequence prior to the construction or installation phase. While it is possible to have project completion and handover at the end of the project, during the post-construction phase.

The orders, flows, processes, and scope of work established throughout the project development phase are critical in the delivery of interior projects because they enable the interior designer to operate the project much more efficiently. Thus, the goal of this study is to examine interior design project delivery during the preliminary period of project development because this stage is quite critical to making it successful before materializing the project.

METHODOLOGY ASPECTS

Ontologically, this study is about excavating the nature and reality (Creswell and Clark, 2009) of the process and order of interior design project delivery. The assumption could refer to the ontology that guides the study (Newman, 2011), which is concerned with what to look at (Thomas, 2009), as well as what constitutes reality and our understanding of its existence (Raddon, 2010). Somehow, this study logically uses deductive reasoning, where it tests the validity of assumptions from generalized to the specific (Saunders, Lewis & Thornbills, 2012) management tool framework of the interior design project development process. Considering the subject's nature will aid in related research processes, such as the selection of a research approach and instruments.

The aim of the research is to help interior designers with the establishment of an interior design work development plan as a management tool framework for interior design project delivery. While the objective is to confirm the order, flow, method, and scope of work for the work process, the emphasis of this paper is on the pre-contract stage, which focuses on the design stage.

Adoption of Guttman Scale

Twenty questions were directed at eleven respondents on the project delivery work phases only in the pre-contract as shown in Figure 1. Purposive sampling was used in selecting respondents to answer the survey. The selected informants were identified as having a high profile because of their vast experience in managing interior design projects, years of experience more than 15 years, position as a decision maker who are the key senior and experts (Table 1). While, the other six respondents' criteria were based on 10 years and above of working experience in conducting and managing interior design project delivery. The samples of information were obtained from the Malaysian Institute of Interior Design (MIID) list of active members.

Using the information from the interview results from the research (Mustapha, 2019), this study quantified the level of demand for an interior design scope of work (IDSOW) for the establishment of IDWDP based on a few parameters extracted from the data. The interview results were composed in a table format, Table 1, which focuses only on the initial until pre-contract phase.

Table 1. IDWDP-SOW for Interior Design Project Delivery Practice, (Mustapha, 2019)

Phase	RIBA PoW	IDWDP		IDSOW		
				SOW	DESCRIPTION	
	0			*Project Initial*		
Pre-Contract					2	Terms of Requirement & ID SOW
				Briefing	3	Client's Brief
				Feasibility Study	4	Site Analysis
					5	Initial Client's Budget & Goal
	2	2.2	Schematic Design	Schematic Design	6	Design Concept
					7	Design Development
	3				8	Design Implementation
		3-4.3	Design Development	Design Development	9	Design Coordination
	4				10	Cost Estimation
					11	Construction Schedule
					12	Client's Approval & Authorities' Approvals
						Design Review & Finalization

The Guttman Scaling method was used in the procedure, which is a simple agree/no unidimensional scaling method (M. Azmi, 2019; Frey, 2018; QuestionPro, 2021). The Guttman scale is used in this research to capture the idea of what and how firmly the respondents believe (Survey Monkey, 2021) the interior project process according to their knowledge and experience. This quantified Guttman scalogram analysis was aimed at validating the flow and process of interior design project delivery at the very early stage of the delivery process.

The questions were based on Table 1 results from the previous study, on the interior design project delivery process. They were composed of an additional set of questions on clarity, which focused on the design phase (pre-contract phase). The Guttman Scaling assisted the study in producing a rising pattern for the need for IDWDP establishment on the selected aspects of the design stage (pre-contract stage) that were posed as agree/no questions. The agree/no responses were then converted into 0 and 1 scores, which will be utilised to generate the expanding pattern based on the cumulative data as shown in Table 2. The respondents did not only answer the content of the questions but needed to review the flow and sequence of the work process.

Table 2. The Questionnaire Survey

Nos.	Questions
1	Do you agree that upon the start/initial phase, ideally there are three more stages of ID project flow in between the start phase and the precontract phase, namely programming – schematic design – design development?
	Stage 1 Start / Initial
2	Is in the initial stage, the client will have the engagement by appointing an ID consultant before taking off the project?
	Stage 2 Programming
3	Do you agree that immediately after the engagement/appointment process, the client should give the design intention by providing the requirements and briefing (in written or verbal)?
4	After having a clear design brief and directions, including the details of the proposed site, ID should state the scope of work. Yes, or no?
5	The ID consultant should go for a site visit after the engagement/appointment.
6	Next step, before the client gives his/her expectations in terms of goals/aims and initial budget, the ID consultant shall execute site analysis and feasibility study for the proposed project.
7	Next, the ID consultant shall prepare for Planning Approval Requirement, for project confirmation.
	Stage 3 Schematic Design
8	Do you agree that it should be stated as a project starts and the design concept should be executed instantly by producing design sketches and preliminary design concepts in several discussions/meetings?
9	Do you agree that in the client confirmation exercise, the ID consultant should provide initial drawings, layout plans and brief specifications?
10	After the Design Concept, the Design Development process should be executed.
11	Do you agree that the work scope in Design Development includes detail development of design?
12	Should ID consultant provide the preliminary cost as well as estimate scheduling at this stage?
13	Consequently, the client should make a selection for the final solution and approve it.
14	Then, Design Implementation should be started by having detailed development of the proposed design.
	Stage 4 Design Development
15	Do you agree that in the Design Development stage, the first process should be the production of design drawings?
16	After a series of production and amendments to design drawings, the design shall be finalized with detailed cost estimation, to produce complete working drawings and specifications.
17	Then, the process of drawing coordination and review will be executed for the client's approval.
18	The ID consultant shall produce drawings for authorities' approval (if any).
19	Simultaneously, the ID consultant shall proceed to final cost estimation and update the implementation schedule.
20	Do you agree that those are the processes and flows in the design development stage, before proceeding to the contracting stage?

The questions were sent via online using WhatsApp, Telegram and email. This is considering using social media platforms as an instrument for data collection. That is called Netnography, a branch of ethnography using online research techniques. (Karr, 2020; Heinonen and Medberg, 2018). During the Movement Control Order (MCO) in the haunted progressive pandemic situation nowadays, this is the best instrument to deliver and communicate the research needs.

RESULTS

The responses were arranged as a scalogram in accordance with Table 3, and the results for each question were then calculated using the respondents' rows and the questions' columns. Generally, the results of the scalogram show majority agreement and consensus from the eleven selected respondents.

The ideal score for each question is 11, which indicates that all of the respondents were in agreement with the process and flow of the question. The fact that some of the scores were below perfect shows that some respondents believed that there were additional steps and processes that needed to be implemented. Nonetheless, the additional items must be specified in a small note labelled description.

Table 3. The Measurement of IDWDP Establishment for the Flow and Process at Pre-Contract Stage for Interior Design Project Delivery

Respondent	Stage 1			Stage 2				Stage 3							Stage 4					
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20
A	1	1	1	0	1	1	0	1	1	1	1	1	1	1	1	1	0	1	1	1
B	1	1	1	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1
C	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	0
D	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1
E	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1
F	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1
G	1	0	1	1	1	1	0	1	1	1	1	0	1	0	1	1	1	1	1	1
H	0	1	1	1	1	0	1	1	1	1	1	1	1	0	1	1	1	1	1	0
I	1	1	1	0	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1
J	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1
K	0	1	1	0	1	1	1	1	1	1	1	0	1	1	1	1	1	0	1	1
Score	9	0	11	7	11	9	8	11	11	11	11	9	9	9	11	11	11	7	11	9

Score Indicator: 0 = No; 1 = Agree

The agreement of eleven respondents is shown in Table 3 as a result of the survey. The indicator ‘0' indicates disagreement, while ‘1' indicates agreement. The highest point total was 11. The majority of respondents agreed with the procedure and flow of the work in each phase, based on 20 questions that illustrate the process in four stages. While the respondents disagreed on the ratings of 7, 8, and 9, they agreed that some minor aspects of the workflow and process should have been included. However, their opinions differed depending on their own company's practises. As a result, such small components were omitted out from the IDWDP summary.

The flow of IDWDP is composed into a diagrammatic composition of an interior design project process framework, as presented in Figure 2. This framework may clearly show the flow and steps of the interior design project delivery process at the pre-contract phase, which is to be seen as a crucial phase in the design stage.

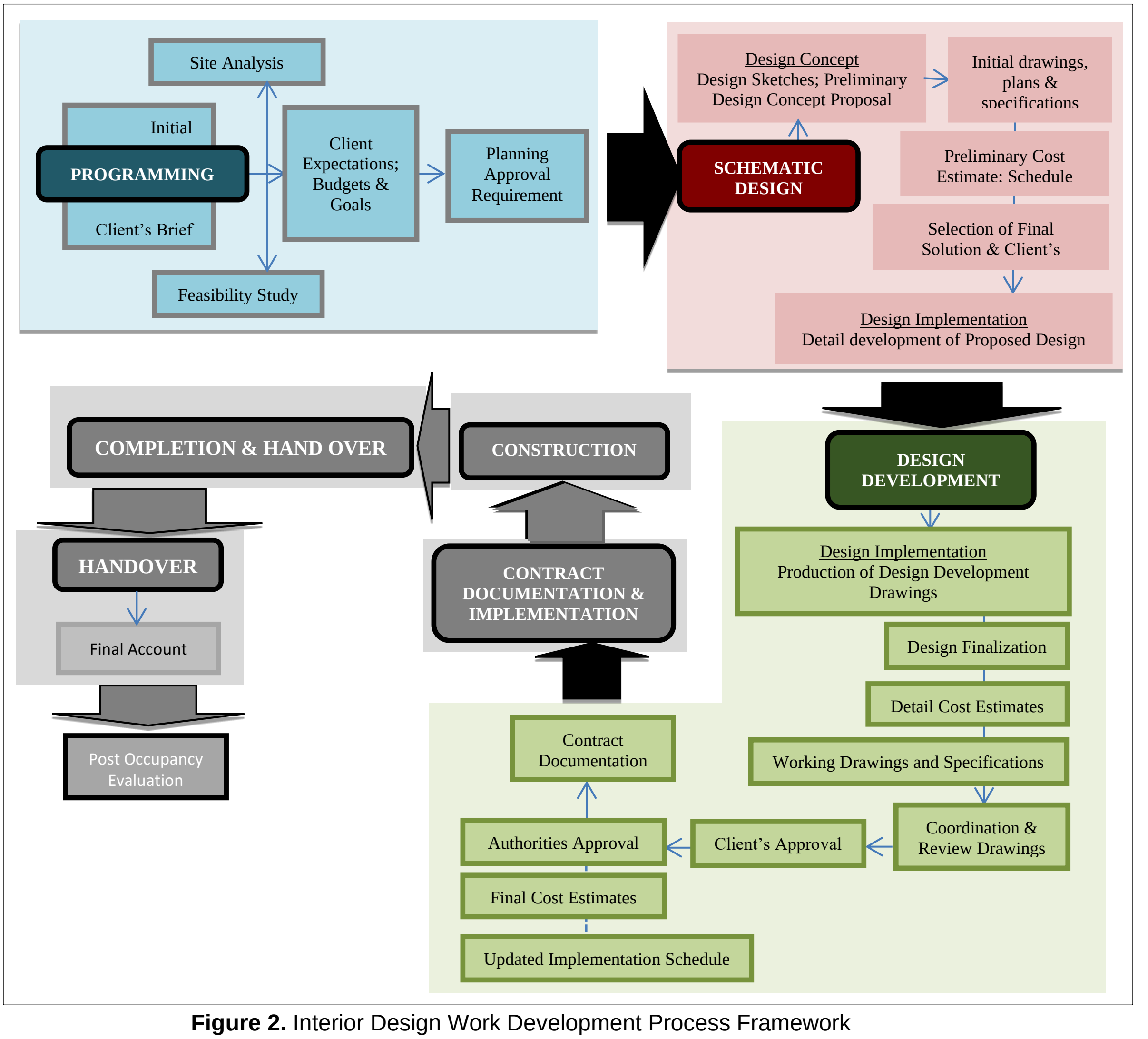

Figure 2. Interior Design Work Development Process Framework

CONCLUSION

The goal of this study, which is the affirmation of the process, flow, and order of the interior design project delivery process in the establishment of IDWDP, has indeed been attained, and that it is depicted in Figure 2 as a result of its composition. When it comes to industry participation, the Interior Design Work Development Plan (IDWDP) is a proactive technique for interior design professionals including a contribution to educational pursuits. The implementation of SDG8 (promote inclusive and sustainable economic growth, employment, and decent work for all) may very well be particularly effective in this regard. Economic growth that is both sustained and inclusive can propel progress, provide decent jobs for all, and raise living standards for everyone. As an initiative action for the interior design industry standard work guideline for interior design project practise, the IDWDP may assist all parties involved, including the client, in establishing a clear procedure and workflow for the project. It also aids in the reduction of conflicts, disagreements, and the definition of a clear scope of work, all of which are critical in the performance of life-cycle projects, particularly in the coordination of work. All of these targets are aligned with the global goal of ensuring decent work and sustainable economic growth, specifically with targets 8.1, 8.2, and 8.3, which are all part of SDG8 (SDG8, 2021), such as sustainable economic growth; diversify, innovate, and upgrade economic productivity; but mostly target 8.3, which promotes policies to support job creation and growing enterprise. For all parties and stakeholders participating in interior design project circles who seek to conduct transparent businesses, the implementation of the IDWDP may be useful.

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GUIDE TO AUTHORS

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CODIFICATION AND APPLICATION OF SEMI-LOOF ELEMENTS FOR COMPLEX STRUCTURES

(FULL NAME) Ahmad Abd Rahman[1,2], Maria Diyana Musa[2] and Sumiana Yusoff[2]
[1]Department of Quantity Surveying, Faculty of Architecture, Planning and Surveying, Universiti Teknologi MARA, Sarawak, Malaysia
[2] Institute of Ocean and Earth Sciences (IOES), University of Malaya, Malaysia

Abstract (Arial Bold, 9pt)
Damage assessment …… ……(Arial, 9pt. Left and right indent 0.64 cm, it should be single paragraph of about 100 – 250 words.)

Keywords:(Arial Bold, 9pt) *Finite Element Analysis; Modal Analysis; Mode Shape; Natural Frequency; Plate Structure (Time New Roman, 9pt)*

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Heading 3 (Arial Italic + Lower Case, 11pt)

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Figures: Figures should be in box with line width 0.5pt. All illustrations and photographs must be numbered consecutively as it appears in the text and accompanied with appropriate captions below them.

Figures caption: Arial Bold + Arial, 9pt. should be written below the figures.

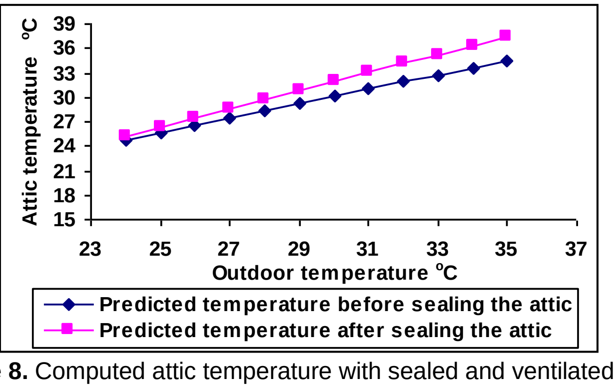

Figure 8. Computed attic temperature with sealed and ventilated attic

Tables: Arial, 8pt. Table should be incorporated in the text.

Table caption: Arial Bold + Arial, 9pt. Caption should be written above the table.

Table Line: 0.5pt.

Table 1. Recommended/Acceptable Physical water quality criteria

Parameter	Raw Water Quality	Drinking Water Quality
Total coliform (MPN/100ml)	500	0
Turbidity (NTU)	1000	5
Color (Hazen)	300	15
pH	5.5-9.0	6.5-9.0

(Source: Twort et al., 1985; MWA,1994)

Units: All units and abbreviations of dimensions should conform to **SI standards.**

Citation:

Passage Type	First reference in text	Next reference in text	Bracket format, first reference in text	Bracket format, next reference marker in text
One author	Walker (2007)	(Walker, 2007)	(Walker, 2007)	(Walker, 2007)
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Three authors	Bradley, Ramirez, and Soo (1999)	Bradley et al. (1999)	(Bradley, Ramirez, & Soo, 1999)	(Bradley et al., 1999)
Four authors	Bradley, Ramirez, Soo, and Walsh (2006)	Bradley et al. (2006)	(Bradley, Ramirez, Soo, & Walsh, 2006)	(Bradley et al., 2006)
Five authors	Walker, Allen, Bradley, Ramirez, and Soo (2008)	Walker et al. (2008)	(Walker, Allen, Bradley, Ramirez, & Soo, 2008)	(Walker et al., 2008)
Six or more authors	Wasserstein et al (2005)	Wasserstein et al. (2005)	(Wasserstein et al., 2005)	(Wasserstein et al., 2005)
Organisation (easily identified by the initials) as the author	Sultan Idris Education University (UPSI, 2013)	UPSI (2013)	(Sultan Idris Education University [UPSI], 2013)	(UPSI, 2013)
Organisation (No abbreviation) as the author	Pittsburgh University (2005)	Pittsburgh University (2005)	(Pittsburgh University, 2005)	(Pittsburgh University, 2005)

(Source: UPSI, 2019)

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Johan, R. (1999) Fire Management Plan for The Peat Swamp Forest Reserve of North Selangor and Pahang. In Chin T.Y. and Havmoller, P. (eds) Sustainable Management of Peat Swamp Forests in Peninsular Malaysia Vol II: Impacts. Kuala Lumpur: Forestry Department Malaysia, 81-147.

Siti Hawa, H., Yong, C. B. and Wan Hamidon W. B. (2004) Butt Joint in Dry Board as Crack Arrester. Proceeding of 22nd Conference of ASEAN Federation of Engineering Organisation (CAFEO 22). Myanmar, 55-64.

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