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Editorial

Welcome from the Editors

Welcome to the thirty-two (32nd) 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:

Yusuf Latief et al., developed an effective and an efficient institutional framework to support the success of the project. This research is conducted through multi criteria decision analysis and in-depth interviews to select one of four of the best institutional models. The finding shows that there are six influential factors identified which are divided into success and negative factors. The success factors are the high market interest, legitimacy, and commercial freedom while the negative factors are low financial market, the lack of legal framework and policies, and excessive variation of contracts.

Wan Zukri Wan Abdullah et al., presented the supply chain management practices by Industrialised Building System (IBS) manufacturers in Malaysian construction industry. Mixed method was applied in this research which involved questionnaire and interview session to obtain information regarding supply chain management, logistics management and transportation system. The finding shows that most of the manufacturers are making collaborative partnership and the way to improve project performance is through early involvement of manufacturers by applying the new management philosophy originating from the industry.

Norlisa Mili et al., established the application of water pinch technology in minimization of water consumption in palm oil mill in Sarawak. This research used graphical method for both contaminants are solved using Microsoft Excel software and MATLAB software used for mathematical programming. The finding from graphical method has shown the least reduction in the fresh water demand with a reduction of 42.6% for both contaminants while the findings from mathematical programming method, the regeneration recycle approach is proven to be most suitable method whereby it is able to reduce the fresh water demand by 90.7% and 69.5% for BOD and hardness cases respectively.

Nor Hafizah Hussin et al., analysed the influence factors affecting the energy consumption in UTeM's Technology campus. This research applied correlation analysis to measure the strength of relationship between the influenced factors, number of lighting and equipment used, occupancy and temperature in a laboratory building. The findings show that all the factors have strong linear correlation with the energy consumption based on the correlation value.

Sitti Diana Tamjehi et al., determined the level of consciousness in terms of knowledge and implementation level on the current sustainable construction practice in Malaysia. This research adopted mixed methods which involved 142 developers for questionnaire survey and six registered architects from Klang, Selangor for semi-structured interview. The findings show that the level of conceptual knowledge and implementation on sustainable construction is at moderate level. It can be concluded that the consciousness in term of level of knowledge and implementation among developer on the current sustainable construction practice in Malaysia is still low.

Nadia Zaini et al., compared an analysis of Embodied Energy and carbon emission in a building that used IBS and conventional method to achieve sustainable construction in Malaysia. This research used Life Cycle Assessment (LCA) tool which is Carbon Calculator for IBS components of precast concrete wall panel, column, beam and half slab, burn clay bricks, reinforced concrete slab, column and beam. The findings show that the usage of IBS can be regard as a potential in reducing the amount of embodied energy and carbon emission as compared to conventional method.

Afzan Ahmad Zaini and Nurzawani Md Sofwan developed the modelling risk factors and challenges with the implementation of risk management in high rise building construction. This research used questionnaire survey as research method involving 105 experienced and less experienced construction stakeholders dealing with high rise building construction. The analysis used in this research is Factor Analysis and converted into AMOS graphic to analyse the inter-relationship of risk factors and challenges towards risk management. The findings suggested to focus on the performance of construction project in the future.

Siew Ping Yiiong and Jane Labadin presented the three-dimensional incompressible boundary-layer fluid flow passing a complex terrain in Sarawak. This research was aiming to understand the airflow structures involved as the complexity of the terrain is increased. The Navier equations was used to undertake this research. The findings show that there exist regions of flow separation, recirculation, and reattachment at certain critical height of the terrain. The inconsistencies of the appearance and disappearance of flow separation are observed as the height of the terrain becomes relatively large.

Editorial Committee

DEVELOPMENT OF INSTITUTIONAL MODEL ON TOLL ROAD CONSTRUCTION BASED ON LAND LEASE FINANCING SCHEME

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Abstract
One of the reconstruction activities which is very important is the right of way acquisition or land acquisition. Delays on this part may result in delays and conflicts in the overall project. One of the factors that inhibit this activity is the limitation of project funds, meaning that new innovative financing schemes that can provide funding specifically for land acquisition are needed. One such innovative financing scheme is a land lease. The implementation of land lease in Indonesia has never been done, therefore the aim of this research is to obtain an effective and an efficient institutional framework to support the success of the project. The institutional model is developed using a method called multi criteria decision analysis to select one of four best institutional models. The research results concluded that the alternative institutional model 1 is best to be selected with 1 additional institutional factor.

Keywords: *Project financing; institutional framework; toll road; multi criteria analysis; land lease.*

INTRODUCTION

One of the preconstruction activities in highway construction which is very important is the right of way (RoW) acquisition or land acquisition. Delays at this stage may give rise to conflicts and delays in the completion of the project. There are many factors that can affect the timing of the land acquisition, one of which is the limitation of project funding (Sohn et al., 2014).

Based on Indonesia's national development plan (RPJMN), the infrastructure development funding need in 2015-2019 is IDR 4,796 trillion, but the state budget is only able to cover IDR 2,817 trillion. This is an example of the budget limitation described in the above statement, which may cause delays in the land acquisition for toll road projects and lead to conflicts as well as further delays in the completion of the project. Hence, there is a need for new innovative schemes that can specifically and adequately finance land acquisition, one of which is the land lease scheme. This land lease scheme has never been implemented in Indonesia, as such, an effective and efficient institutional arrangement must first be formulated to support the success of the project.

Land lease refers to the toll road project financing model obtained from leasing the land alongside said toll road during the operational phase. The land is leased to utility network companies to generate income that can be used for the RoW acquisition or land acquisition in the next stages (Chen, 2012). The interaction between land leasing, debt and infrastructure investment is illustrated by the construction of the outer-ring circumferential highway in Changsha, capital city of Hunan Province in central China. In order to finance the project, the municipality transferred to a public-private agency, the Ring Road Investment Corporation, leasing rights for strips of land 200 meters wide on both sides of the highway that was to be built, within total of 33 square kilometres of land in all, of which 12 square kilometres were finished land possessing infrastructure access and development approvals. In its original state,

without access to roads or infrastructure, the remaining land had very little market value. However, the plan was to sell off land parcels once the highway was built. The total cost of the second stage of the highway project was estimated at RMB 6 billion (at the time some USD 730 million). Approximately half of this amount was financed directly from sale of leasing rights to the land already having infrastructure service. The other half was financed through lending. The Ring Road Investment Corporation was able to lend against the future anticipated value of the improved land to obtain financing from China Development Bank and commercial banks, pledging to sell off land parcels in the future, after the highway was completed, in order to meet debt service (Peterson, 2006).
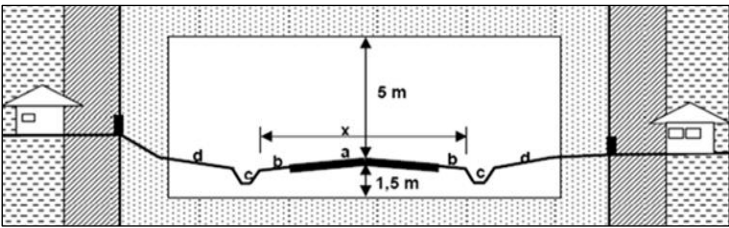
Figure 1. Land Area to be Leased

In Figure 1 the space marked a – d cannot be used for any activities except road utilities, so the area that can be leased is the one outside these marks.

This innovative scheme can provide opportunities for financing activities during the preconstruction stage, namely land acquisition. It has never been applied in Indonesia; hence, an institutional scheme-based model is a prerequisite because the right institutional management, good construction planning and effective cooperation are the keys to success in infrastructure development (Irwanto, 2016). This study is therefore aimed at developing a model of institutional toll road development based on land lease financing scheme.

METHODOLOGY

The instrument used in this qualitative research takes the form of in-depth interview to collect data from stakeholders and relevant authorities, as well as to explore the success factors and negative factors that affect possible models of institutional toll road development based on land lease financing scheme. This data collection using in-depth interview consisted of two phases. Data collection was conducted between January-May 2017. Phase 1 was used to identify the stakeholders and their roles, as well as institutional success factors and negative factors. Data processing on the success factors and the negative factors using the relative importance index (RII) method resulted in a ranking from the largest to smallest. These results can be seen in Table 1.

Table 1. Institutional Success Factors and Negative Factors

Institutional Success Factors	
High Market Interest	Liu et al. (2016)
Commercial Freedom	Tiong (1990)
Legitimacy	Delhi and Mahalinga (2012)
Institutional Negative Factors	
The lack of legal framework and policies	
The low financial market	Hwang et al. (2012)
Excessive variation of contracts	
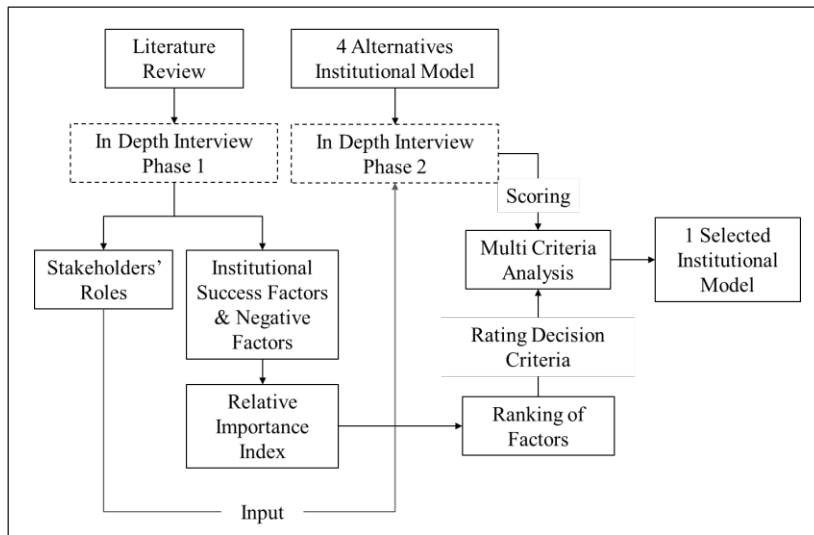
Figure 2. Research Methodology

In-depth interview Phase 2 was used to assess each alternative institutional model obtained by a literature review. It was also used to improve the models in ways that cannot be covered by literature review. The results of Phase 1 are to identify stakeholders and their roles to serve as an input for in-depth interview Phase 2.

The selection to choose one of the four models was carried out using a multi criteria analysis method by taking into consideration the institutional success factors and negative factors. The initial result of sorting the institutional factors using RII was used to do the weighting. The respondents were then asked to do an assessment on each of the alternative institutional models by considering its success factors and negative factors. The subsequent scoring was made by multiplying the average value for a given respondent with weight applied to each factor in order to obtain one alternative with the highest value. The four alternative institutional models can be seen in Table 2.

Table 2 shows the institutional models obtained from a literature review categorized by 3 characteristics: the amount of special purpose vehicle (SPV), the existence of stakeholders State Asset Management Agency (LMAN) & Directorate General of State Assets Management Ministry of Finance (DJKN), and auction scheme. The amount of SPV variations in institutional models with either one SPV or two SPV. One SPV in a project finance structure is common, but the models with two SPV are unique. In the institutional models with two SPV, the first SPV's role is concession agreement while the second SPV plays a role to increase land value using the auction scheme (Lu et al., 2015). This means that models with two SPV will have the auction scheme and models with one SPV will not have the auction scheme.

Table 2. Institutional Alternative Models

	M 1	M 2	M 3	M 4
Amount of SPV	2	2	1	1
Stakeholders of LMAN & DJKN	+	-	+	-
Auction scheme	+	+	-	-

In the category of the existence of LMAN & DJKN stakeholders, the difference between models with and the models without such stakeholders is that the models with these stakeholders will use them to manage land asset while in the models without those stakeholders, land asset management is performed by the SPV.

RESULTS & DISCUSSIONS

Data collection using in-depth interviews was addressed to respondents with experience in the field of project financing, highways, infrastructure development, and the utilisation of state assets.

Stakeholders' Roles in Institutional Model of Toll Road Development Based on Land Lease Funding Scheme

This section will explain about the outcome of the interviews in identifying stakeholders' roles in an institutional model of toll road development based on land lease financing scheme. The questions regarding stakeholders' roles and the development of alternative institutional models is based on literature study. Within the process, the respondents were provided the initial model and then they provided input related role required based on land lease. In addition, the respondents also provided additional information and corrections in case of shortages on stakeholders compiled in the institutional models based on literature review. The following are stakeholders who are into alternative institutional models: Toll Road Authority Agency (BPJT), toll road SPV, State Asset Management Agency (LMAN), DJKN, and National Land Agency (BPN).

Table 3. Respondents

Code	Institution	Education	Experience
R1	Ministry of Public Works and Housing	Doctoral	22 Years
R2	KPPIP	Doctoral	35 Years
R3	Indonesia Market Intelligence & Consulting	Master	24 Years
R4	Indonesia's Toll Road Authority Agency	Doctoral	20 Years
R5	State Asset Management Agency	Master	-
R6	PT. Jasa Marga	Master	30 Years
R7	KPPIP	Doctoral	31 Years
R8	PT. Hutama Karya	Master	26 Years

The findings on the Government's role among the stakeholders providing toll road concession agreements showed the emergence of some new stakeholders in the internal public private partnership project authority (PJPK) e.g. the existence of Directorate General of Highway in Ministry of Public Works in the procurement of toll road concession abolished the role of the KPBU node in the form of Directorate General of Construction Service Development in Ministry of Public Works.

With regards to the Government's role, another finding showed that the financing scheme of land lease agreements removed the DJKN. This stakeholder can be removed because the institution of LMAN is a public service that can receive earnings in line with its basic tasks and functions in property management.

Table 4. Stakeholders' Roles

No.	Stakeholder	Role
1	Toll Road Regulatory Agency (BPJT)	Giving Concession Agreement
2	Directorate General of Highway	Monitoring, evaluating, and making policy of toll road development
3	State Asset Management Agency (LMAN)	Funding on RoW acquisition and managing asset on land alongside toll road
4	National Land Agency	Executing RoW acquisition
5	PT. Hutama karya	Special Purpose Vehicle
6	PT. Hutama Karya Realtindo	Second SPV and collaborating with DJKN on managing asset on land alongside toll road

The in-depth interview also identified which stakeholders are involved as well as their roles in the institutional models. There are six stakeholders involved in the development of land lease scheme models such as Toll Road Regulatory Agency, Directorate General of Highway, Asset Management Agency, National Land Agency, PT Hutama Karya, and PT Hutama Karya Realtindo.

Institutional Success Factors and Negative Factor in Land Lease Funding Scheme

This section will present the results of the in-depth interviews associated with institutional success factors and institutional negative factors. Respondents were asked for their opinion on the factors obtained from a literature review. In-depth interviews were used to identify which factors can strengthen and weaken the institutional models of toll road based on land lease funding scheme. After identification, the factors were then assessed using the Relative Importance Index (RII) ranking method. The results of institutional success factors and negative factors are tabulated in Table 5.

Table 5. Institutional Success Factors and Negative Factors

Institutional Success Factor	Code	RII	Rank
High Market Interest	K1	1	1
Commercial Freedom	K2	0.43	3
Legitimacy	K3	0.95	2
Institutional Negative Factors	**Code**	**RII**	**Rank**
The lack of legal framework and policies	K4	0.95	2
The low financial market	K5	1	1
Excessive variation of contracts	K6	0.67	3

In the institutional success factors as seen in Table 5, high market interest becomes the most important factor, because the success of this institutional model depends on the high interest from the utility network company leasing the land alongside the toll road. These network utility companies provide, among others, fibre optic, gas pipes, drains, etc. Moreover, the space can also be rented for transportation such as trains. The second important factor is legitimacy, which refers to the existence of basic laws supporting the authority of all the stakeholders involved in the institutional models. This factor is influential for State Asset Agency & National Land Agency because these stakeholders have both the task and the authority on Land Lease funding schemes based on such laws. Lastly, commercial freedom is the least important factor to strengthen the institutional models. This factor refers to the SPV authorization in managing the land asset utilization to be leased to the utility network company. Commercial freedom is given by the government to SPV during their concessions

to refer to the institutional scheme without the presence of State Asset Management and the National Land Agency because the utilization right during the concession period is entirely performed by the Government.

On the other hand, the negative factor that weakens the institutional models the most is a low financial market. This is in contrast with the high market interest factor, i.e. low interest paid by the other party to lease the land alongside the highway. The second negative factor that affects the institutional models is the lack of legal framework and policies to base the selection of institutional models on clear rules, i.e. all project finance activities are not hampered by applicable rules and laws. The least weakening factor is excessive variation of contracts, which refers to the large number of contracts between each stakeholder involved in alternative institutional models. An example is in an institutional model with two contracts, namely Land Lease Agreement and Concession Agreement, while there are also institutional models with only a single Concession Agreement.

An additional factor was found to greatly influence the institutional models: the purpose of land use on the land that will be leased. When the lease is given to public interest organizations, the Government as landowner can lease it without a fee because the goal is of public interest. This is because the Government-owned asset utilization should prioritize public interests, meaning that the land can be utilized for other infrastructure needs other than the highway itself.

Institutional Land Lease Funding Models of Trans Sumatera Toll Road

This section will present the results of the in-depth interviews associated with institutional models on toll road development based on land lease financing scheme. The respondents were asked for their opinions about 4 alternative institutional models obtained from the literature study.

After the in-depth interview identified the roles of stakeholders and institutional success factors and negative factors, the institutional models were assessed using the multi criteria analysis method. A further institutional model was also developed using the in-depth Interview to further explore the four alternative institutional models produced from the literature study. The results of the data processing using multi criteria analysis can be seen in Table 6.

Table 6. The result of Multi Criteria Decision Analysis

Code	Rating	Mean Score				Combined Weight Score			
		M.1	M.2	M.3	M.4	M.1	M.2	M.3	M.4
K1	50%	3	3	2	1	1.5	1.5	1	0.5
K2	17%	1.57	2.86	1.57	2.57	0.26	0.48	0.26	0.43
K3	33%	2.71	1.14	2.71	2.71	0.9	0.38	0.9	0.9
K4	33%	1	2.43	1.29	2.86	0.33	0.81	0.43	0.95
K5	50%	3	3	2	1	1.5	1.5	1	0.5
K6	17%	1.57	1	1.57	1.57	0.26	0.17	0.26	0.26
Sum-Combined Weight						0.57	-0.112	0.48	0.112

The mean score values are obtained from the average of the assessment results from the respondents on each alternative institutional model. The value of the combined weight is obtained from the value of the mean score multiplied with the rating. The rating was obtained

by weighting the RII results according to the ranking of all factors. The sum combined weight value is derived from the value of the combined weight of the institutional success factors (K1, K2, and K3) reduced by the combined weight of the institutional negative factors (K4, K5, and K6). Based on this calculation model, we then identified an institutional model with more institutional success factors than institutional negative factors, which took us to alternative 1 (M1) institutional model with a value of 0.57.

The multi criteria decision analysis method on institutional models and in-depth interviews which resulted in a selected institutional model of toll road development based on the land lease financing scheme is shown in Figure 3.
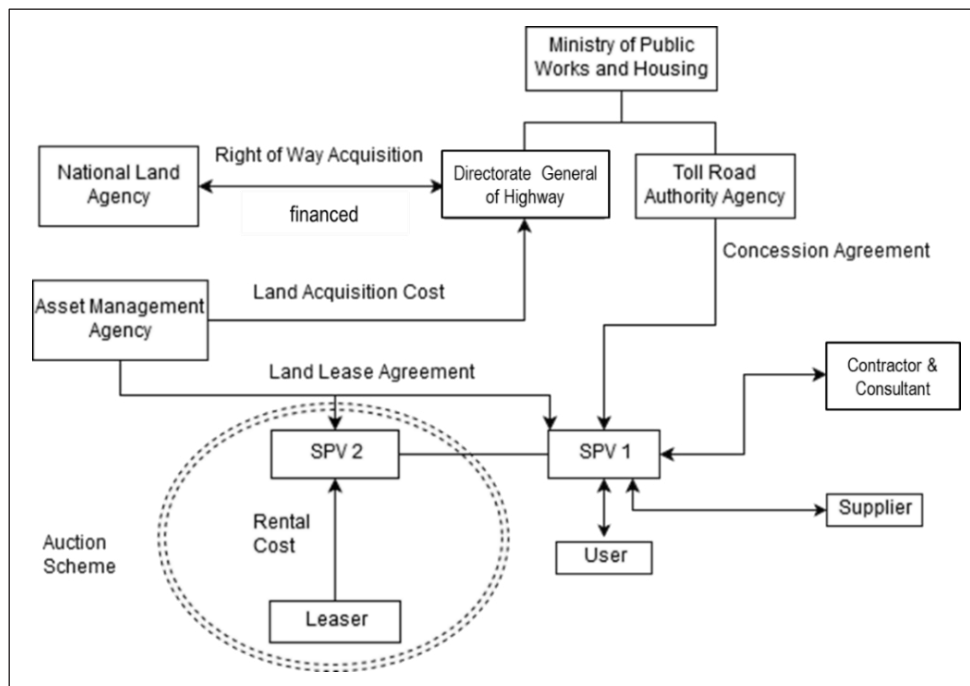
Figure 3. Institutional Models of Toll Road Development Based on Land Lease Financing Scheme

The findings from the in-depth interview showed new processes within the Directorate General of Highway (DGH). As the party who needs land, DGH gives the execution of RoW acquisition to the National Land Agency (BPN) before forming a land unit tasked with paying the costs of the land provision to the National Land Agency (BPN), paying compensation to land owners and charging to the LMAN because the cost of acquiring land for projects falls into the category of national priority project funded by the LMAN. LMAN's service in the financial costs of land acquisition reflects the process relation between LMAN and DGH. In addition, the auction scheme is not required in this case because of the unique nature of the rent, which requires special technical aspect assessment. The opinion voiced by 4 respondents against the auction scheme was also supported by respondent 5 who compared the auction to a beauty contest. The respondents also argued that the scheme 8 auctions are not conducted given that the nature of the rent is intended for unique items. On the other hand, other respondents stated that that auctions are necessary because nowadays there are many utility networks companies with interests in leasing the land alongside the toll road.

As seen in Figure 3, the Ministry of Public Works form the Toll Road Regulatory Agency to give concession to SPV 1, the additionally formed DGH to give the location of the assigned land acquisition for toll roads to the national land agency. The land acquisition cost is financed by business entity (SPV 1).

The State Asset Management Agency corresponds to its role in financing the land acquisition for toll road, then giving the funds to the Directorate General of Highway which would then give it to the business entity (SPV 1). SPV 1 formed SPV 2, which is aimed at increasing the value of land use revenue through the auction scheme. SPV 2 also cooperates with the State Asset Management Agency in providing the utility box or by sharing trench for network utilities. SPV 1 as the project company in general does the toll road contracts with contractors and consultants, then perform the contract with the suppliers with regards to the provision of material and facilities for toll road users.

CONCLUSION

Based on the result of data processing and analysis, there are six stakeholders involved in the institutional models that are Toll Road Regulatory Agency, Directorate General of Highway, Asset Management Agency, National Land Agency, SPV 1, and SPV 2. In addition, six influential factors were identified: three success factors (i.e. high market interest, legitimacy and commercial freedom) and three negative factors (i.e. the low financial market, the lack of legal framework and policies, and excessive variation of contracts). The selected institutional model is the M1 model enhanced with in-depth interviews to confirm the obtained institutional model on toll road development based on land lease financing scheme.

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SUPPLY CHAIN MANAGEMENT PRACTICES BY INDUSTRIALISED BUILDING SYSTEM (IBS) MANUFACTURERS IN MALAYSIAN CONSTRUCTION INDUSTRY

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Abstract
This paper presents the interesting outcomes which include the supply chain management practices in general, the logistics management and transportation performance by Malaysian IBS manufacturers. The main method adopted is by using the questionnaire and interview session to obtain information regarding to a) supply chain management; b) logistics management and c) transportation system. The findings indicated that most of the manufacturers are making collaborative partnership because firms commonly take either a strategic or reactive approach and trying to migrate from a reactive approach to more of a strategic approach to establishing supplier partnerships. More than 50% of the respondents also have a separate logistics department for the delivery system and transportation. One of the main approaches to improve project performance through early involvement of manufacturer by applying the new management philosophy originating from other industries. The findings could make a headway in improving IBS supply chain management practices and a way forward to provide new insights on the supply chain performance in an appropriate procurement method selection. This research may produce a framework that involves all key players in IBS strengthen the effectiveness of the relationship between all parties to monitor and deal with any problems relating to the construction work.

Keywords: *Industrialized Building System (IBS); Malaysian manufacturer; performance; supply chain practices; system.*

INTRODUCTION

Industrialised Building System (IBS) is not new to the construction industry. Only it has now emerged worldwide in the 21st century as a plausible solution to improve construction image and performance. The method will enable cost saving and quality improvement through the reduction of labour intensity and construction standardization. Apart from this, it offers minimal wastage, less site materials, cleaner and neater environment, controlled quality, and lower total construction costs. Successful IBS implementations in the world are Sekisui Home (Japan), Living Solution (United Kingdom), Open House (Sweden) and Wenswonen (Netherlands) (Oostra, 2007).

The current Malaysian government report, Construction Industry Master Plan (CIMP 2006-2015), the requirement for quality and execution upgrade in the Malaysia development industry was examined. CIMP recognized innovative methodologies through Industrialized Building Systems (IBS) and its supply chains as having vital parts in enhancing the profitability and the nature of the construction development process. Various case studies have demonstrated that dealing with the whole supply chain has turned into a noteworthy achievement component in conveying successful IBS approach (Wan Zukri et al., 2017; Zulhumadi et al., 2013; Oyegoke et al., 2012; Blismas et al., 2006; Faizul, 2006) with the

procurement system arrangement plan being used as a go between tool and as the method for controlling integration between players (Gibb & Isack, 2001; Pan et al., 2008).

Investigation by some researchers identified that the authority should consider the requirement of early integration and collaboration of specialist and knowledge holders such as contractors, manufacturers and suppliers to deliberate the design process at an earlier stage. It is because the Malaysian current practice is still based on the traditional approach in the project delivery process. Integrating construction knowledge into design processes greatly improves the chances of achieving a better-quality project, able to complete in a safe manner, within schedule, and for the least cost.

The purpose of this paper is to identify the factors affecting the IBS supply chain integration that focuses on the IBS manufacturer's perspective with regard to existing logistics and procurement practices. The findings reveal the current practices and performance regarding to supply chain Management by manufacturer in IBS Projects. In the other hand, this paper can determine the tool or system being used by them to support Supply Chain Management. By identifying this, the author can propose the framework of supply chain integration for successful collaboration.

IBS MANUFACTURER PERSPECTIVE

The contribution of manufacturer in IBS project not only limited to manufacture the product but also involved with the whole processes including planning, design, project management and implementation. Taking the experience of Setia Precast Sdn. Bhd. As an established precast concrete manufacturer, the first thing to do is converting the conventional design into more comprehensive design needed for precast construction. Then only productive work will take place and followed by transporting, erecting, and joining the elements. That means, even though they are manufacturer, the scope of work being covered is really wide compared to manufacturer for conventional construction method who's only responsible to supply materials for contractor.

Transformation from on-site to off-site environment just moves, more often than not, the challenges and difficulties in the factory environment. This scenario permits the IBS manufacturer to manage difficult activities more effectively (Gibb, 1999). Quantitatively analysed perception among supply chains revealed that there is a range of procurement stages that have prominent problems, making it difficult to integrate the supply chains (Abd Shukor et al., 2010). To achieve effective integration, an assessment of the challenges faced by manufacturers in supply chain integration has to be conducted in the context of the Malaysian IBS construction project delivery.

Table 1. IBS Manufacturer in Malaysia (CIDB, 2016)

IBS Type	Total Manufacturer
Pre-cast concrete	62
On-site precast concrete	13
Formwork system	27
Steel framing system	14
Metal Roof Truss System	22
Timber Framing System	5
Blockwork System	31
Innovative Product System	40
Total	**214**

The total registered IBS manufacture in Malaysia until May 2016 is 214 which produce IBS products available in the market shown in Table 1.

RESEARCH METHODOLOGY

This paper is part of an on-going research on the supply chain issue that affect the implementation of IBS construction in Malaysia. Multiple approaches have been employed in order to ensure that the data is gathered comprehensively and accurately. The approaches used include literature review as the first phase that considered by many as part of the research methodology. Through the literature review, the definition, concept, application, and related issues of supply chain management in IBS construction industry is examined and highlighted.

All the data and information are gathered directly from books, articles and other printed materials sourced from national and international journals, proceeding and bulletin. This literature review is very important and helpful in the process of developing the theoretical sections of the actual research. There are few journals has been reviewed such as Journal in Science and Technology, Journal in Business & Logistics and European Journal of Purchasing & Supply Management. It might give a new interpretation of old material or combine new with old interpretations that might trace the intellectual progression of the field, including major debates. The literature review may evaluate the sources and advise the reader on the most pertinent or relevant.

Collection of primary data is the second phase, where the information was collected through questionnaires (mail and online system). The questionnaires were distributed to the IBS manufacturers in Malaysia from a different category of IBS main product. In this study, there are 38 completed questionnaires were successfully collected out of 115 forms of distribution.

The third phase of gathering information is from semi-structured interviews. The interviews were conducted in order to support and verify the previous preliminary questionnaires and to supplement new insights and deeper understanding of the issues that are being explored. The respondents of these preliminary qualitative semi-structured interviews were selected from the respondents in the preliminary questionnaires as a sampling that gives the detail information regarding the issue.

SURVEY ANALYSIS AND DISCUSSION

Thirty-eight questionnaires were successfully collected from the respondents that involved in Supply Chain Management and logistics practices. Figure 1 shows the analysis from the 38 respondents. The survey revealed that, in general, the most popular and widely used by the manufacturer in managing supply chain is developing collaborative supplier partnerships (86.84%).

This is the technique that customers and suppliers develop such a close and long-term relationship that the two work together as partners. The result followed by just in time (JIT) supply (76.32%), which is receiving goods only as when needed in the production process and plan strategically (65.79%), that combines aspects of business-strategy formulation with aspects of tactical supply-chain planning that can make each far more valuable. The other

management technique is few suppliers (57.89%), e-procurement (55.26%), outsourcing (52.63%), many suppliers (42.11%), vertical integration (13.16%) and supply chain benchmarking (2.63%). There is no technique applied by manufacturer for electronic data interchange (EDI) and holding safety stock.

Most of the manufacturers are making collaborative partnership because firms commonly take either a strategic or reactive approach. In addition, most firms are trying to migrate from a reactive approach to more of a strategic approach in establishing supplier partnerships.

Organization-level arguments specify that factors such as communication quality, cooperativeness, risk sharing and reward sharing, and top-management commitment on both sides contribute to partnership-like behaviour (Hartley et al., 1997; McCutcheon et al., 1997; Ragatz et al., 1997). On the other hand, strong buyer-supplier collaboration in the design and development of significant product components enables the buyer members and the supplier members of the project to openly share relevant information (Ancona & Caldwell, 1990; Brown & Eisenhardt, 1995; Littler et al., 1998; Ragatz et al., 2002; Ragatz et al., 1997; Takeishi, 2001).

When developing the IBS components, it will always have related to the logistics management. Logistics management is one of the concepts and tools that can achieve competitive advantage by providing costs reduction and better customer satisfaction (Rushton et al., 2000). Smith, 1977 also mentioned that the implementation of logistics management with just-in-time (JIT) delivery may also be useful in reducing warehouse and storage cost, reducing lead time, improving productivity, and improving quality.

Based on the survey that related to logistics management, 22 manufacturers (57.89%) from 38 respondents have separate logistics department for better management of delivery system and transportation. Logistics management and supply chain management (SCM) is closely related to lean supply (Lamming, 1996). On the other hand, there are some indications that bad logistics management may become the basis to evaluate the effectiveness of logistics management of a firm. These indications included the non-punctuality in materials and components deliveries, inability in foreseeing with accuracy the periods of activities execution, large storage on site, etc. (Bertelsen & Nielsen, 1997; da Silva & Cardoso, 1999). The reasons behind most of these indications are insufficient planning of work and delivery, errors in specification, and other human errors (Bertelsen & Nielsen, 1997).

Table 2. Method for Best Logistics Practices by Manufacturers

Method	Mean
Using Performance Metrics extensively and systematically to measure the performance of logistics activities.	3.92
Developing a clear, transparent set of practices to finance supply chain management.	3.95
Creating a logistics/ supply chain leader, to allocate resources among supply chain functions, to optimize trades-off between functions.	4.11
Employing a logistics centre that can give many functions	4.13
Integrating logistic activities into one department or developing procedures to coordinate activities.	4.26
Recognizing logistics and supply chain management as a strategically important set of activities, and developing a mission statement that defines their roles, goals and vision.	4.05

Referring to Table 2 and based on the IBS manufacturers' point of view based on the degree of importance of each success factors from scale 1 to 5 (1 - Not Important, 2 - Limited Important, 3 - Somewhat Important, 4 - Important and 5 - Very Important), integrating logistics activities into one department or developing procedures to coordinate logistics activities across the supply chain is the highest priority method to be considered practicing logistic management with a mean value of 4.26. This is followed by employing a logistics centre that can give many functions including the quality with a mean value of 4.13, creating a logistics and supply-chain leader, to allocate resources among supply-chain functions, to optimize trade-offs between functions is the third important factor to be considered ranked by the IBS manufacturers with the mean value of 4.11. The other methods are recognizing logistics and supply-chain management as a strategically important set of activities, developing a clear, transparent set of practices to finance supply-chain management and using performance metrics extensively and systematically to measure the performance of logistics activities with the mean value of 4.05, 3.95 and 3.92 respectively.

In most companies, the logistics are divided among a number of departments, including purchasing, operations, and marketing. However, best practice firms typically integrate the operations of these functions, either formally within a "logistics" department, or, less formally, such as through regular interdepartmental managerial meetings, project teams, or shared-reward systems. By integrating logistics functions, firms can faster integrate within the organization and avoid setting up conflicting goals between departments and managers.

In the perspective of transportation management, there are several methods had been applied by the manufacturer in order to perform effectively so that all the IBS component will deliver in good condition and available when needed. Table 3 shows the 38 respondents point of view based on the degree of importance of each success factors from scale 1 to 5 (1 - Not Important, 2 - Limited Important, 3 - Somewhat Important, 4 - Important and 5 - Very Important). Based on statistical analysis, the mean value for all factors is calculated more than 3.0 (>3.0) which indicates that all of the factors listed are important to the implementation of IBS.

The highest mean value of the method of transportation management is making transportation as a customer service instead of cost, followed by making a responsive transportation network begins with end-to-end network visibility that allows the business to centralize production operations to lower-cost areas without impacting customer service levels with mean value 4.79 and 4.50 respectively. Communication skills, an economical transportation network and effective security monitoring are also gaining significant importance to the manufacturer with a mean value of 4.26, 4.18 and 4.00 respectively. The other three factors which are < 4.00 but still in the area of important factors are effective planning of logistics, coordinate with design professionals and understand the traffic flows with mean value 3.95, 3.92 and 3.68 respectively.

In supply chain management, logistics and transportation plays an important part in conducting all the products that will ensure the sustainability and performance of the IBS project. According to Tseng et al., 2005, transport system makes goods and products movable and provides timely and regional efficacy to promote value-added under the least cost principle. Transport affects the results of logistics activities and influences production and sale. In the logistics system, transportation cost could be regarded as a restriction of the

objective market. In addition, the role that transportation plays in logistics system is more complex than carrying goods for the proprietors. Its complexity can take effect only through high quality management.

By means of well-handled transport system, goods could be sent to the right place at the right time in order to satisfy customers' demands. It brings efficacy, and also it builds a bridge between manufacturers and consumers. Therefore, transportation is the base of efficiency and economy in business logistics and expands other functions of logistics system. In addition, a good transport system performing in logistics activities brings benefits not only to service quality but also to company competitiveness.

Table 3. Method of Transportation Management by Manufacturer

Method	Mean
Make a transportation as a customer service instead of cost	4.79
Make a responsive transportation network begins with end-to-end network visibility that allows the business to centralize production operations to lower-cost areas without impacting customer service levels	4.50
Make an economical transportation network that begins with a shift in attitude	4.18
Make an effective planning of logistics efforts that will help to co-ordinate the customers and delivery schedule	3.95
Make an effective security monitoring that will monitor all the vehicles, where they have been and whether or not they are on time for deliveries	4.00
Coordinate with Design Professionals; A bill of materials should be created to show the flow of materials needed on a project and ways of minimizing hold on the material	3.92
Communication; ensure you have open communications with all your key manufactures, suppliers and distributors	4.26
Understand Traffic Flows; Peak hour	3.68

CONCLUSIONS

This paper has briefly studied the IBS supply chain practices in our Malaysian Manufacturer in IBS construction industry. This finding lead to a broader exploration of the other region, particularly in the achievement and hindrances variables of coordinating the supply chain players with the fitting courses of action of procurement method and strategy. This better approach for administration and working must be connected and be in line to the Malaysian construction industry current pattern particularly in IBS.

The research presented in this paper is a part of an ongoing PhD research, which will eventually attempt to further enhance the practices and implementation of the Supply Chain Integration in relation to procurement systems, particularly in the IBS project delivery by IBS manufacturers in Malaysia. The results of the main research will hopefully provide and form the basis of a valuable in order to support the Malaysian Construction Industry Master Plan and strengthen the value chain in the Malaysian construction industry.

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APPLICATION OF WATER PINCH TECHNOLOGY IN MINIMIZATION OF WATER CONSUMPTION IN PALM OIL MILL

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Abstract
This research proposes to establish property integration technique, in graphical targeting and mathematical modelling by using reuse, regeneration reuse, and regeneration recycle in order come up with the accurate targets for maximum direct recycle of process resources, with the minimum effluent produced and minimum fresh water consumption at a palm oil mill in Sarawak. The problems are treated as single contaminant problems where the contaminants are the biochemical oxygen demand (BOD) and the hardness properties of the process streams. Graphical method for both contaminants is solved using Microsoft Excel software, meanwhile mathematical programming is executed using MATLAB software. The results show a fresh water demand reduction by 42.6% for both contaminants for graphical targeting; mathematical modelling by using reuse approach shows a reduction 63.1% and 60.3% for BOD and hardness properties respectively; regeneration reuse approach shows a reduction of 78.1% and 64.7% for BOD and hardness respectively; lastly, regeneration recycle approach shows a reduction of 90.7% and 69.5% for BOD and hardness respectively. Thus, regeneration recycle process is the best choice to be implemented in the palm oil mill to reduce the consumption of fresh water.

Keywords: *Water Pinch Technology; Graphical Method; Mathematical Modelling; Single Contaminant; Regeneration Recycle*

INTRODUCTION

Any large-scale industrial processes are known for their high demand of water. However, one cannot defy the theory of conservation of mass where high water consumption leads to ramification of high amount of effluent produced. Besides high amount of effluent, another matter to be concerned of is the shortage of raw water for the process. On that account, insufficient water supply is a stumbling block for a large-scale process which case in point is the palm oil milling process in Malaysia where our country herself is known as the preeminent producer and exporter of crude palm oil (Vijaya et al., 2008). This particular problem is faced by Lambir Palm Oil Mill in 2016 due to the drought brought by El Nino from February to the end of April. The extreme weather has caused most of the reservoir ponds to subside to critical level, and the only mitigation available is to pump water from a river located far from the mill. Therefore, it is paramount to find a panacea for the water shortage problem. This is when pinch analysis comes into light as a process integration tool.

Process integration serves the purpose of material and energy integration and minimizing the emissions and wastes produced from an industrial plant (Mann, 1999). It is branched into two approaches which are the pinch technology for energy and mass integration, and mathematical optimisation comprises of linear and nonlinear programming (Mann, 1999; Zhelev et al., 2002). Figure 1 shows the process integration tools.
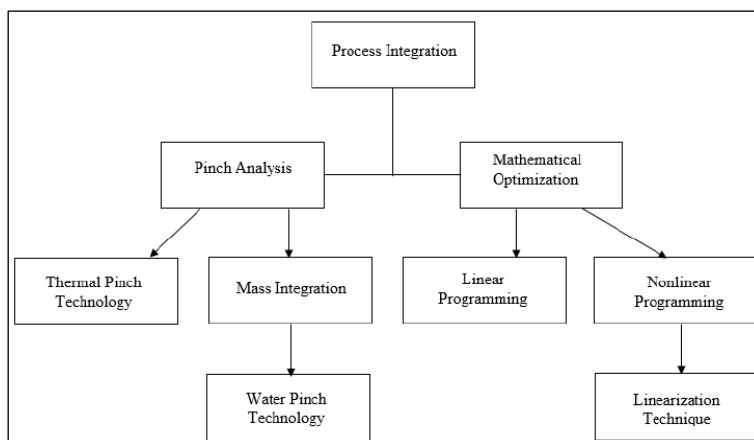
Figure 1. Process integration tools

Pinch analysis method is originally introduced as heat recovery systems design back in the 70's which implementing the similitude between heat transfer and mass transfer (Linnhoff & Flower, 1978; Linnhoff, 1993). This is the basis that bring forth water pinch analysis. It is a systematic method as a tool to reduce the water consumption and wastewater generation by mass integration for an example, the water pinch analysis and water pinch synthesis. Nonetheless, the effluents from a process comprise of different qualities influenced by contaminants such as biochemical oxygen demand (BOD) and hardness properties. These qualities will determine the availability of the effluents or streams to be reused or recycled into the processes. By depending to the number of the contaminants, water-using operations at a plant can be divided into simple and complex models.

METHODOLOGY

The methods that have been implemented in this project corresponds to the research conducted by Mughees and Al- Ahmad (2015) on their application of pinch technology on an industrial process. However, their case study is on Tehran Oil Recovery and by far no research has been done on a palm oil mill in Sarawak. The chosen methods that have been applied in this case study are the graphical targeting (Material Recovery Pinch Diagram) and the mathematical modelling of reuse, regeneration reuse, and regeneration recycle for single contaminants.

The water pinch study has been carried out in three phases which are the data collection or site visits, the water pinch analysis, and finally, the project identification and road map. However, only the first two phases have been conducted due to the limitation of time and the scope of this research only focuses on the application of water pinch technology in the industrial process.

Site Visits and Data Collection

Several site visits are conducted by the researcher for the first two weeks in order to analyse the milling process for further comprehension. Generally, the milling process produces two main outputs which are the CPO and palm kernels with different stations located systematically within the mill to convert the raw material FFB to the end products.

Certain unit operations require a huge amount of water such as at the sterilization process, the boilers station, and the oil clarification station. However, some of the processes are not practical to apply water pinch study because the restrictions in terms of piping, narrow space, or even a huge distance between two processes for the water pinch implementation. Therefore, the researcher and the assistant mill engineer have surveyed and analysed the process mill to identity several processes that have high potential and at the same time do not have too much restriction in order to make the water pinch study easier. Next, the data needed for the pinch study such as the BOD and hardness of the targeted process streams are collected from the laboratory which is also located next to the mill. The workers in the laboratory extracted the data based on the sample obtained from the mill for several weeks. The final data is handed to the researcher at the end of week seven. The data is used as constraints for the next water pinch analysis phase.

Water Pinch Analysis

Water pinch analysis involves two different method where both BOD and hardness are treated as contaminants. The first method would the graphical method where the development of the Property Based Recycle Pinch Diagram is constructed in Microsoft Excel environment. First and foremost, the chosen sites' streams are divided into sinks and sources streams. All of the sinks and sources identified within the process are utilised fully in determining the minimum amount of fresh water required. First, the sinks and sources are arranged in an ascending order of their maximum property loads. Second, the property load of a sink is calculated. Refer to Equation (1).

$$M_J^{sink, \, max} = G_J \times z_J^{max} \tag{1}$$

Where G_J is flow rate, M_J^{sink}, max is admissible maximum load, z_J^{max} is maximum property value for sink steam. Third, the source's maximum property is calculated. Refer to Equation (2).

$$M_i^{Source, \, max} = W_i \times y_i^{max} \tag{2}$$

Where W_i is the flow$_i$ rate, $M_i^{Source, \, max}$ is admissible maximum load, y_i^{max} is maximum property value for source stream. Fourth, the sink and source composite curves are constructed in Microsoft Excel where the y-axis is the property load and the x-axis are the corresponding flow rate. Fifth, the minimum fresh water demand is obtained by shifting the source composite curve on the fresh line depicting on the x-axis to the right and below sink composite curve where the source composite curve has touched the sink composite curve at one point. This particular point is called Property Based Recycle Pinch Point and can be seen in Figure 2.

For the construction of the Property these guidelines or golden rules are followed, to determine the minimum fresh water and wastewater requirements (Kazantzi and El-Halwagi, 2005). First, the property load that must not pass through the pinch point or in other words, both sink and source composited curve must touch one another at one point. Second, the utilisation of the fresh water is not allowed for any sink unit that is higher that the pinch point established. Third, the discharge of wastewater is not allowed for any source unit that is below the pinch point established.
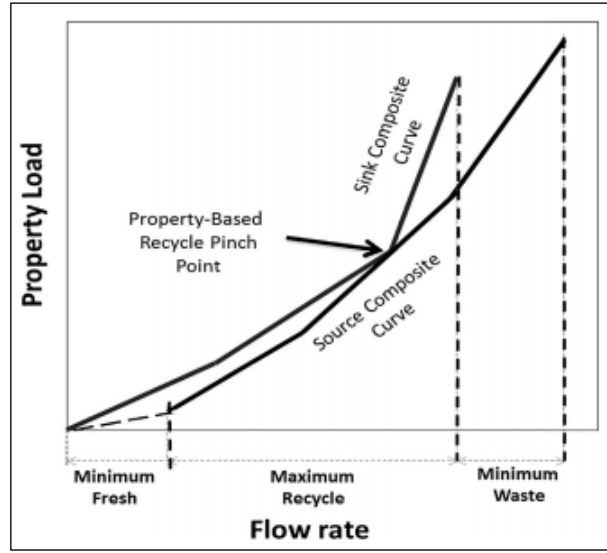
Figure 2. Property composite curve pinch point (Equation 7)

For mathematical modelling, there are three different approaches that have been applied for this water pinch study: reuse, regeneration reuse, and regeneration recycle. First, the algorithm to solve minimum fresh water requirement for reuse process for both BOD and hardness contaminants which acted as single contaminant are developed as the following (El-Halwagi, 2012; Swain, 2010; Mann et al., 1999). First, the input inserted for the coding is the limiting flow rate of every process stream in m³/hr, the inlet and outlet contaminants in ppm. Second, the highest contamination existed among the process streams is determined. Third, several intervals with different concentration is established. Fourth, the limiting flow rates for every interval is added up and is established as a single value. Fifth, the calculated for every interval's mass load is determined. Refer to Equation (3).

$$mass\_load_l = \frac{C_{l+1}-C_l}{1000} \times \sum_l f_{n,lim\_}int \tag{3}$$

Where, $mass\_load_l$ is the mass load at l^{th} interval in kg/hr, C_{l+1} is the interval outlet contamination concentration in ppm, Ck is the interval inlet contamination concentration in ppm, and $f_{n,lim\_}int$ is the limiting flow rate of interval at n^{th} operation in kg/hr. Sixth, then the cumulative mass load is determined. Refer to Equation (4).

$$cumulative = \sum_{n=1}^{l} mass\_load \tag{4}$$

Seventh, every interval boundary's flowrate is obtained. Refer to Equation (5).

$$f_l = \frac{cumulative}{c_l} \times 1000 \tag{5}$$

Eighth, the minimum fresh water demand is determined to be the interval with the highest flow rate.

The second method is the regeneration reuse process where the algorithm for the MATLAB coding is as following (Wang and Smith, 1994; Swain, 2010): first, the input inserted for the coding is the limiting flow rate of every process stream in m³/hr, the inlet and outlet contaminants in ppm, and the outlet regeneration concentration in ppm. Second, the steps in reuse method from step 2 until step 7 is repeated. Third, the interval with the highest flow rate is established as the fresh water pinch point. Fourth, the minimum fresh water flow rate is determined where the fresh water demand is equals to the regenerated water flow rate. Refer to Equation (6).

$$f_{min}\left(\frac{m^3}{hr}\right) = \frac{\Delta m_{pinch}\left(\frac{kg^3}{hr}\right)}{[2C_{pinch}-C_0](ppm)} \times 1000 \qquad (6)$$

Fifth, the outlet concentration after the regeneration process is calculated. Refer to Equation (7).

$$C_{out}(ppm) = C_{pinch}(ppm) + \frac{[\Delta m_{total}-\Delta m_{pinch}]\left(\frac{kg^3}{hr}\right)}{f_{min}\left(\frac{m^3}{hr}\right)} \times 1000 \qquad (7)$$

The last method would be the regeneration recycle process for single contaminants. The algorithm is outlined as follow (Wang and Smith, 1994; Swain, 2010): first, the input inserted for the coding is the limiting flow rate of every process stream in m³/hr, the inlet and outlet contaminants in ppm, and the outlet regeneration concentration in ppm. Second, the steps in reuse method from 2 until 7 is repeated. Third, the minimum fresh water demand is obtained by taking the value of flow rate that corresponded to the outlet regeneration concentration interval boundary. Fourth, the interval with the highest flow rate is established as the fresh water pinch point. Fifth, the regenerated water flow rate is calculated. Refer to Equation (8).

$$f_{regen}\left(\frac{m^3}{hr}\right) = \frac{\Delta m_{regen}\left(\frac{kg}{hr}\right)-[\frac{f_{min}\left(\frac{m^3}{hr}\right)C_{pinch}(ppm)}{1000}]}{(C_{pinch}-C_0)(ppm)} \times 1000 \qquad (8)$$

Sixth, the recycled water flow rate is obtained. Refer to Equation (9).

$$f_{recycle} = f_{min} + f_{regen} \qquad (9)$$

RESULTS AND DISCUSSION

Site visits are conducted for the first two weeks where the author and the assistant mill engineers work together to survey and analyse the mill process that requires a lot of fresh water and the possibility for the targeted site to use water pinch technology. Based on the data collected over time, the average of fresh water required by the mill in order to run in a smooth operation is approximately 120.8 m³/h and during the draught season, the fresh water supplied is 19.7% lower at 97 m³/h. Next, it is found that certain unit operations such as the decanter distribution tank, the separator distribution tank, and the crude oil holding tank have high demand of fresh water (a total of 60.3 m³/hr) which have the potential to be the sinks; while outlet streams from separator, hydro cyclone, and cooling water is

discovered to have high potential to be considered as sources of either recycle, reuse, regen-reuse, or regen-recycle to reduce the usage of fresh water and directly reducing the amount of waste water produced. Once the targeted site has been acquired, the data required for the water pinch analysis such as the stream flow rates and the contaminants in terms of BOD and hardness have been provided by the assistant mill engineers and the laboratory workers respectively.

Graphical Method (Recycle Method)

The processes taken into consideration are the separator, the hydrocyclone, the cooling water, the decanter distribution tank, the separator distribution tank, and the crude oil holding tank with the labelling of S1, S2, S3, S4, S5, and S6 respectively. Table 1 shows the process flow rates and the constraints. Meanwhile Table 2 and Table 3 shows the cumulative loads for the sinks and the sources for the same contamination respectively after computing the results by using equation (1) and equation (2) that have been mentioned previously. The data are reconstructed in Microsoft Excel where the Property Based Recycled Pinch Diagram for BOD the x-axis and cumulative load acting as the y-axis.

Table 1. Process Flow Rates and Constraints

Process Number	Limiting Water Flow Rate (m³/h)	Stream Constraints (ppm)			
		BOD		Hardness	
		In	Out	In	Out
S1	18.0	7010	7400	40	75
S2	30.0	1220	4740	8	24
S3	15.5	2	2	2	20
S4	8.2	6880	6910	30	32
S5	9.1	6950	7050	30	40
S6	11.6	5640	6320	24	36

Table 2. Cumulative sinks data-BOD case

Sinks	Flow Rate G(m³/h)	Cumulative Load (m³/h)
S6	11.6	0.065424
S4	19.8	0.121840
S5	28.9	0.185085

Table 3. Cumulative sources data-BOD case

Sinks	Flow Rate W(m³/h)	Cumulative Load (m³/h)
S3	15.5	0.000031
S1	45.5	0.142231
S2	63.5	0.275431
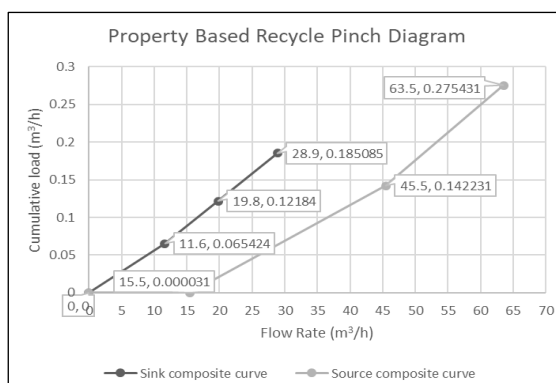
Figure 3. Final property-based pinch recycle pinch diagram

The same procedure goes for the hardness case as a contamination. By using the cumulated loads and flow rates of sinks from Table 4 and sources from Table 5, a Property Based Recycle Pinch Diagram for hardness case is obtained as shown in Figure 4.

Table 4. Cumulative sinks data-hardness case

Sinks	Flow Rate G(m³/h)	Cumulative Load (m³/h)
S6	11.6	0.000278
S4	19.8	0.000524
S5	28.9	0.000797

Table 5. Cumulative sources data-hardness case

Sources	Flow Rate W(m³/h)	Cumulative Load (m³/h)
S3	15.5	0.00031
S2	45.5	0.00103
S1	63.5	0.00238
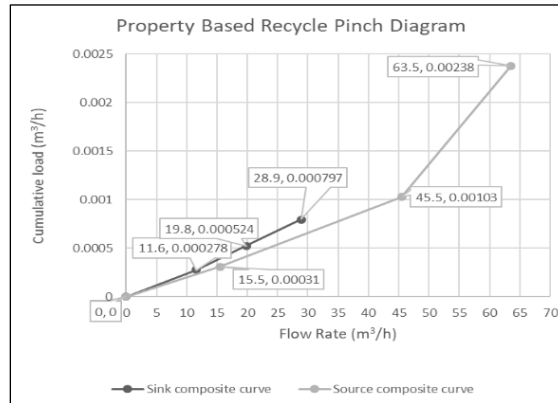
Figure 4. Final property-based pinch recycles pinch diagram

Mathematical programming method

The input for the MATLAB coding is based on Table 1 for reuse method for BOD contamination problem. The inputs are BOD_{in} = [7010,1220,2,6880,6950,5640], BOD_{out} = [7400,4740,2,6910,7050,6320] and flim= [18,30,15.5,8.2,9.1,11.6], where the output is f_{lmin_fw} = [22.2785]. Where, BOD_{in} and BOD_{out} is the inlet and outlet contaminations (ppm) respectively, f_{lim} is the limiting flowrate (m³/h) for each process, and f_{min_fw} is the fresh water demand (m³/h).

The input for the MATLAB coding for regeneration reuse is similar to reuse method with an additional of BOD_0 = [1500]. The outputs are f_{min_regen} = [13.2331], max = [7400], and cout = [5954]. Where, BOD_0 is the outlet regeneration concentration (ppm) that can be vary and is set based on the requirement of the mill, max is the pinch contamination concentration (ppm), and cout is the outlet wastewater contamination (ppm).

With the same inputs of previous method for the MATLAB coding, the outputs for regeneration recycle methods are $f_{min\_fw\_no\_regen}$ = [5.6], f_{regen} = [24.4], $f_{recycle}$ = [30], and cout = [7609]. Where, $f_{min\_fw\_no\_regen}$ is the fresh water demand after recycling (m³/h), f_{regen} is the regenerated water flow rate (m³/h), and $f_{recycle}$ is the flow rate of recycled water (m³/h).

The same procedures are conducted for hardness case as single contaminants. The output for reuse method is f_{min_fw} = [31.95], the output for regeneration reuse is f_{min_regen} = [21.3]. max = [75], and cout = [66.9], and finally the output for regeneration recycle method is $f_{min\_fw\_no\_regen}$ = [18.4], $f_{\_regen}$ = [27.1], and $f_{\_recycle}$ = [45.5].

Analysis of Results

Based on the data obtained, it is clearly shown that the graphical method (recycle) has the least reduction of fresh water demand standing at the value of 42.6% for both BOD and hardness as contaminations, meanwhile regeneration recycle has the highest reduction in fresh water requirement with 90.7% for BOD's case, and a 69.5% reduction for hardness case. Therefore, the total fresh water required for the process mill will be only 3.624 m³/h and 36.844 m³/h for BOD and hardness case respectively-a significant decrease in terms of the amount. The ascending order of the methods from the least reduction to the highest reduction is graphical method (recycle), reuse method, regeneration reuse method, and regeneration recycle method. All the data obtained for all methods are tabulated in Table 6.

Table 6. A comparison of graphical and mathematical programming method

Process		BOD contaminants		Hardness contaminants	
		Fresh water required (m³/h)	Fresh water reduction (%)	Fresh water demand (m³/h)	Fresh water reduction (%)
Graphical Method (Recycle)		34.6	42.6	34.6	42.6
Mathematical Programming	Reuse	22.3	63.1	32.0	60.3
	Regen Reuse	13.2	78.1	21.3	64.7
	Regen	5.6	90.7	18.4	69.5

However, graphical method obtained the same reductions in the demand of fresh water for both BOD and hardness cases which shows the method is only intuitive despite easy to use. Nonetheless, the outcome for every method varies depends on the cases since different methods have their own advantages and disadvantages (Mehrdadi et al., 2009). Moreover, the results obtained by using the mathematical programming are shown to be as consistence as the analytical solution conducted by Wang and Smith (1994). Last but not least, regeneration recycle process method is proven to be most effective way to reduce the fresh water requirement in this case study, thus, this method should be implemented for the network designing.

CONCLUSION

Water shortage, extreme climate, increasing fresh water consumption due to the large-scale industries have motivated researchers to come up with several options to optimise the fresh water requirement and minimisation of wastewater production in plants. One of the approaches would be water pinch technology which comprises of different methods such as the graphical method and mathematical programming. These two methods are chosen to be applied in a palm oil mill in order to minimise the fresh water demand and the wastewater production. The process site which has the potential for the water pinch study is chosen based on the amount of the fresh water consumed and also the ability to produce sink streams and source streams. The contaminants that have been provided to this case study is BOD and hardness which have acted as constraints for both graphical and mathematical programming methods. After the application of both chosen methods onto the process site, it

is found that graphical method has shown the least reduction in the fresh water demand with a reduction of 42.6% for both contaminants. This is due to the limitation of this particular approach which only gives insight of water pinch problem. Meanwhile, for mathematical programming method, the regeneration recycle approach is proven to be the most suitable method whereby it is able to reduce the fresh water demand by 90.7% and 69.5% for BOD and hardness cases respectively. Reuse method shows a reduction of fresh water requirement by 63.1% and 60.3% for BOD and hardness cases respectively, while regeneration reuse shows a reduction of 78.1 and 64.7 respectively. However, the disadvantage of regeneration reuse and regeneration recycle would their vulnerability.

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ANALYSIS OF INFLUENCE FACTORS AFFECTING THE ENERGY CONSUMPTION IN TECHNOLOGY CAMPUS, UTEM

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Abstract
Energy resources utilisation is a necessity for human civilisation to survive and progress. However, inefficient use of energy will not just affect the economy as it will also contributes substantially to climate change. To improve the energy saving, the influence factors that contribute to high energy consumption must be studied and analysed. The objectives of this research are to analyse the influence factors that affect the energy consumption for energy savings in Technology Campus, UTeM. The correlation analysis was performed using Pearson's Correlation Coefficient to measure the strength of relationship between the influenced factors; number of lighting and equipment used, occupancy and temperature in a laboratory building. The results show that all the factors have strong linear correlation with the energy consumption and proven by the hypothesis testing for testing the population correlation coefficient. This study has an advantage to be used in modelling the most influenced factors in forecasting the future energy consumption.

Keywords: *Influence factors; energy consumption; correlation analysis; Pearson's Correlation Coefficient.*

INTRODUCTION

Building energy efficiency has come to the forefront of political debates due to high energy prices and climate change concerns. Energy consumption in commercial buildings accounts for a significant proportion of worldwide energy consumption. In Malaysia, energy saving campaign has been very crucial due to the intense energy use. Inefficient use of energy or electricity contributes substantially to climate change. This will contribute to the greenhouse gas emissions and can caused global warming (Labriet et al., 2015; Zhang et al., 2017). Hence it is important to give awareness on the influence factors that affect the energy consumption. A study conducted by Dintchev et al. (2000) showed that there is significant influence on the energy efficient behaviour and awareness with the education of electricity saving.

There are few factors that affect the energy consumption. Many researchers are devoted to study on analysing the factors that influenced the energy consumption of a public building. Wei conducted a research on the analysis of energy consumption data of office building in Changsha, China (Wei et al., 2015). While He Xiao studied about the office building energy consumption pattern in Beijing and Hong Kong (Xiao, 2011). The result shows that occupant behaviour has a large impact on the energy consumption.

A research carried by Yuan et al. (2016) on studying the energy consumption characteristics of the buildings in Qingdao found that there are five factors selected for a correlation analysis which is age of the construction, number of building stories, the occupancy density, and the form of cooling source and heating source. The study found that

the type of cooling system and occupancy density give a larger contribution on the energy consumption influence factors. While based on the study conducted by Mora et al. (2015), the result reveals that floor area and climate are the most significant influence factor for electricity consumption. Other factors affecting the energy consumptions as proven in the research conducted by Chen (2017) are equipment used and lighting system in the building.

Correlation analysis is a method that is used to investigate the relationship between two variables. Many studies have been using this method to develop relationship between the independent and dependent variable (Jifri et al., 2017; Tangon et al., 2018). A study conducted by Xiao (2011) use a pearson's correlation coefficient to measure the strength of relationship between influence factors and the energy consumption. Jifri et al. (2017) use Pearson correlation to analyse the macro factors affecting the load demand in power system. A study on factors affecting electricity consumption intensity of hotel buildings in Thailand carried by Tangon et al. (2018) use a Pearson correlation in analysing the hotel parameters that affects the electricity consumption of the hotel.

METHODOLOGY

Technology Campus, UTeM consist of several building that includes an administrative building and laboratory building. This project will be focused on auditing the laboratory building since the usage of the building will be high when the semester starts. The laboratory session will be held every day from 8 a.m. to 5 pm and sometimes will extend to 9 p.m. if there is an extra class needed. There are few factors that can affect the energy usage in a building such as the number of lighting used (kW), the temperature (^0C) of the surrounding especially the usage of air-conditioning, the equipment used in the laboratory (kW) and also the occupancy in that particular building. All these factors are used in data collection as the explanatory variable and the energy consumption (kWh) as the response variable. The objective of the study is to investigate the correlation between the factors that affect the energy used and energy consumption in Technology Campus, UTeM.

The analysis in this project is divided into two part which is first will be correlation analysis which is to investigate the relationship between the energy consumption and all the factors that affect the energy consumption using the Pearson's Correlation Coefficient. Followed by making a hypothesis testing for the significance of the correlation coefficient in order to decide whether the linear relationship between all the influence factors and energy consumption is strong enough to be used in modelling the relationship in the population.

Correlation Analysis

The correlation analysis is developed using Pearson's Correlation Coefficient method since it is the most appropriate method in determining the dependency of the response variable, y and the explanatory variable, x. In this study, the total energy consumption will be the response variable, y and all the factors affecting the energy consumption which is number of lighting used, temperature in the building and the occupancy in the building will be the explanatory variable, x. The degree of correlation between the influenced factors and the total energy consumption will be calculated using the Pearson's Correlation Coefficient, r and the formula is;

$$r = \frac{n\sum xy - \sum x \sum y}{\sqrt{\left(n\sum x^2 - \left(\sum x\right)^2\right)\left(n\sum y^2 - \left(\sum y\right)^2\right)}}$$

(1)

The value of r is in the range between -1 to 1 where if r is between -1 to 0, it shows a negative linear correlation while if r is between 0 to 1, this indicates a positive linear correlation. When the value of r is 0, it means that there is no linear correlation between the variable. The scatter plot can also help in giving an overview on the linear correlation between the variable. Figure below shows two types of correlation.
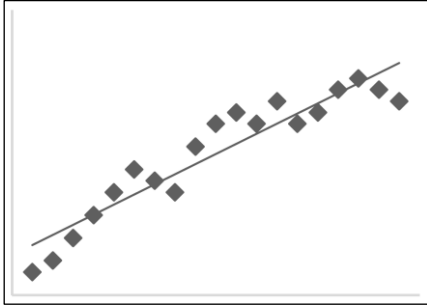
Figure 1. Positive Linear Correlation
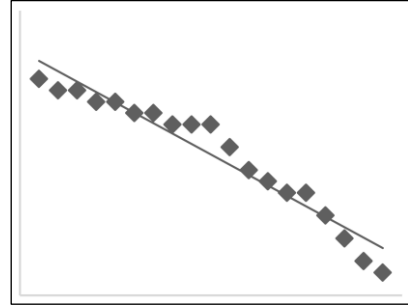
Figure 2. Negative Linear Correlation

To fit a linear regression equation, it is known that the coefficient of determination, R^2 is widely used to assess the goodness-of-fit for the equation (Cornell and Berger, 1987). It measures the strength of the linear association between response and explanatory variable. In other words, it represents the percent of the data that is the closest to the line of best fit. For instance, if the regression line passes through every point on the scatter plot, all of the variation in response variable can be explained. This is important since the regression line can be used to predict the response variable. Hence, if the points in the scatter plot is further away from the line, it will be difficult to explain the variation. Equation (2) below shows the formula for coefficient of determination, R^2.

$$r^2 = \frac{\left(n\sum xy - \sum x \sum y\right)^2}{\left(n\sum x^2 - \left(\sum x\right)^2\right)\left(n\sum y^2 - \left(\sum y\right)^2\right)}$$

(2)

The range of R^2 will be always between 0 to 100% where 0% means that the model explains no variability of the response data and 100% indicates that the model explains all the variability of the response variable. This concludes that the higher the value of the data R^2, the better the model fits the data.

Hypothesis Testing

In the correlation analysis, the value of Pearson's Correlation Coefficient, r, indicates the strength of the linear relationship between x and y points on a regression line. Since this study was done on a sample from a large population, we need more evidence to prove that there is linear relationship between the influence factors and energy consumption for the population. Hence, we can use the regression line to model the linear relationship between the influence factors and the energy consumption in order to predict future energy consumption on a larger scale.

This hypothesis test will help to decide whether the value of the population correlation coefficient, ρ is significantly different from 0 or close to zero. If the test concludes that the correlation coefficient is significantly differing from 0, we have enough evidence to conclude that there is significant linear relationship between x and y. Hence, the regression line can be used to model the linear relationship between x and y in the population.

The hypothesis testing that were used is t-test for testing the population correlation coefficient. The first step is to set the null and alternative hypothesis. Null hypothesis will be represented by $\rho = 0$ and alternative is $\rho \neq 0$. Decision making will be based on the critical value approach; hence, the value of test statistic was calculated using the formula below;

$$t = \frac{r\sqrt{n-2}}{\sqrt{1-r^2}} \tag{3}$$

If the value of test statistic, t, falls in the rejection region, then the null hypothesis be rejected. Note that in this study, the significance level was set to be $\alpha = 0.05$.

RESULTS AND DISCUSSION

In this study, the data was obtained by collecting the data every day in a laboratory building in Technology Campus, UTeM for few months including weekend. It is done to investigate the relationship between the energy consumption and the influence factors which is number of lighting and equipment used which is measured using Kilowatt, temperature and the occupancy in the building. The energy consumption were measures using the kilowatt meter reading (kWh).

Correlation Analysis

The first result obtained was the value of r using equation (1) and it is summarized for each factor in the Table 1 below. Followed by constructing a scatterplot as a guideline on determining the straight line or linear correlation exist between two variables. The value of R^2 obtained using equation (2) was calculated to measure the percentage of variation in energy consumption that explained by the relationship with the influence factors.

It is known that the correlation coefficient measures the strength of a relationship between two variables. Based on the result in Table 1, the correlation between lighting used and the energy consumption is 0.877 shows a strong positive linear correlation since it is close to 1. This is supported by the scatterplot in Figure 3 which shows as the lighting used increase, the kilowatt meter reading is decrease. This is due to the power needed to light up the bulb. Hence, the higher the amount of light switched on, the higher it consumed the energy. Value of R^2 77% indicates that 77% of the variation in energy consumption is explained by the relationship with the number of lighting used and the remaining 33% are due to other reason.

Table 1. Correlation between Response Variable and Explanatory Variable

Influence Factors	Pearson's Correlation, r	Coefficient of Determination, R^2
Number of Lighting (kW)	0.877	77%
Surrounding Temperature (^0C)	-0.821	67.5%
Occupancy (people)	0.870	75.6%
Equipment used in the laboratory	0.827	68.4%
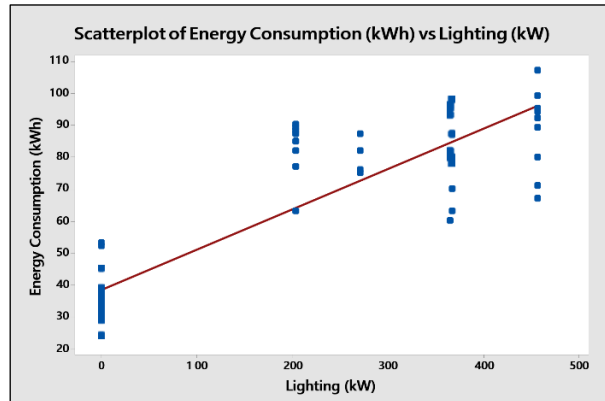
Figure 3. The relationship between Lighting used and energy consumption

The value of correlation coefficient for temperature used is -0.821 shows a strong negative linear correlation since the value is close to -1. Figure 4 support the finding by showing that as the temperature increase, the energy consumption is decrease. This is due to the temperature in the laboratory building is obtained with the use of air-conditioner. The lower the temperature of air-conditioner, the higher the energy used and kilowatt meter reading to maintain the cold temperature. Since the data was obtained also on the weekend, the surrounding temperature was a bit high, hence, the energy used are lower. The value of R^2 is 67.5% indicates that only 67.5% of the variation in the reading of energy consumption is explained by the relationship with the surrounding temperature and the remaining 32.5% is due to other reason.
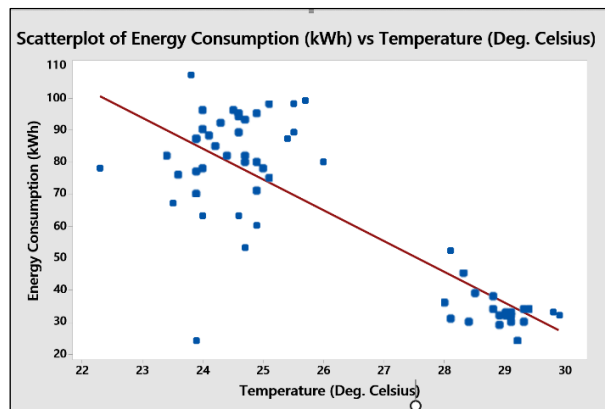
Figure 4. The relationship between Temperature used and energy consumption

The strength of relationship between occupancy and energy consumption is 0.870 shows a strong positive linear correlation. This is supported by the result in Figure 5 showing that as the number of people in the laboratory building increase, the kilowatt meter that measure the

energy consumption tends to increase. This is due to the reason relating with the surrounding temperature. Heat from the surrounding will increase the power needed by the air- conditioner to maintain a cool temperature. Besides that, the occupant will use more light if more laboratory is used as well as the number of equipment in the lab. All these reasons will contribute to the increase of energy consumption. To strengthen the results, the value of R^2 shows that 75.6% of the total variation in energy consumption is explained by the relationship with the occupancy in the building.
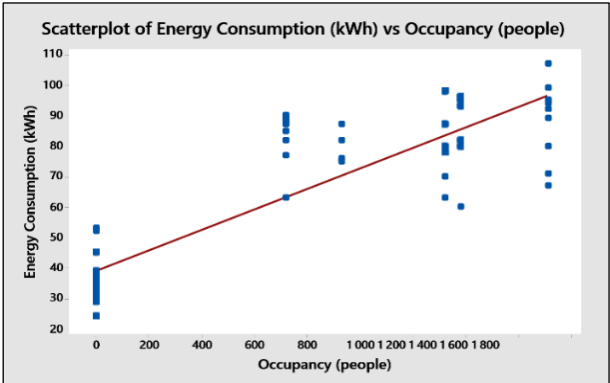
Figure 5. The relationship between occupancy and energy consumption

Last but not least, the correlation between the equipment used and the energy consumption is 0.827 means that it is a strong positive linear correlation. Figure 6 also shows that as the number of equipment increase, the kilowatt meter will also high be making the energy consumption increase. This factor has a relationship with the occupancy since the equipment were used by the students in the lab. The value of R^2 shows that 68.4% of the total variation in energy consumption is explained by the relationship with the equipment used in the building.
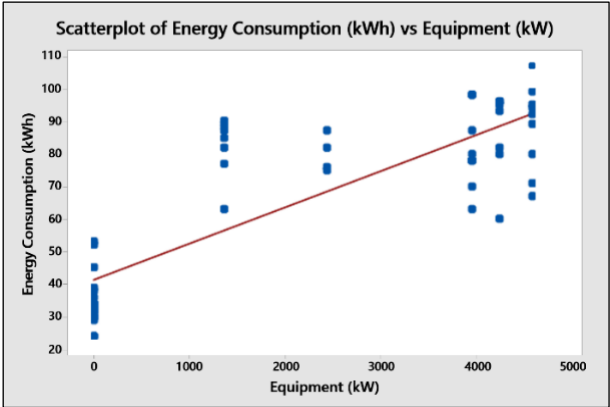
Figure 6. The relationship between equipment used and energy consumption

Hypothesis Testing

The hypothesis testing t-test for testing the population correlation coefficient was run for all the influence factor to determine if there is a significant linear relationship between the energy consumption and all the influence factors. The result is shown in Table 2 below.

Table 2. *t*-test for testing the population correlation coefficient

Influence Factors	Test Statistics, *t*
Number of Lighting (kW)	13.92
Surrounding Temperature (^0C)	-10.96
Occupancy (people)	13.42
Equipment used in the laboratory (kW)	11.21

By referring to the *t*-distribution table for two-tail alpha, the critical value, t_0 for this testing is equal to 2.009. The result in Table 2 shows that the null hypothesis is rejected for all influence factors since the test statistics, *t*, falls in the rejection region. It shows that the correlation coefficient is significantly different from 0. Hence, we have enough evidence to conclude that there is significant linear relationship between energy consumption with the number of lighting, equipment used, occupancy and temperature in the laboratory building at Technology Campus, UTeM. Hence, the regression line as shown in Figure 3, 4, 5, and 6 can be used to predict the energy consumption for energy saving in Technology Campus, UTeM.

CONCLUSION

This study was conducted to analyse the influence factors that affect the energy consumption in Technology Campus, UTeM. Based on the results, all the factors that were considered in this study plays an important role on affecting the energy consumption by having a high correlation value. A hypothesis test that was conducted also proved that all the influence factors have a significant affect with the energy consumption in Technology Campus, UTeM. In future work, the finding can be used in modelling the most influence factors using the multiple linear regression in order to predict the energy consumption for energy saving in Technology Campus, UTeM.

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THE CONSCIOUSNESS IN TERM OF LEVEL OF KNOWLEDGE AND IMPLEMENTATION AMONG DEVELOPER ON THE CURRENT SUSTAINABLE CONSTRUCTION PRACTICE IN MALAYSIA

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Abstract
In Malaysia, sustainable construction concept has been practiced by government since year 2000 to minimize the environmental issues in construction industry. The level of sustainability in construction industry is still low and need to be improved in which it requires responsibility by construction stakeholders particularly developers, who plays the important roles in the development process. This research adopted quantitative and qualitative research methodology to achieve the aim of the research. This research employed questionnaire survey to 142 developers and semi-structured interview to six (6) registered architects from Klang, Selangor to determine the level of consciousness in terms of knowledge and implementation level on the current sustainable construction practice in Malaysia. All selected developers were registered under Jabatan Perumahan Negara. The item studied include background of respondents, developer knowledge and the company implementation on sustainable construction practice. The findings from the questionnaire survey were analysed based descriptive and content analysis. The results indicate that the conceptual knowledge of developer on sustainable construction is at moderate level whereas the social concept is the highest compared to the economy and environment concept. The implementation of the developer on sustainable construction result is also at moderate level. From the research, it can be concluded that the consciousness in term of level of knowledge and implementation among developer on the current sustainable construction practice in Malaysia is still low. However, there is still room for improvement in terms of long-term benefits. Future research may focus on innovation strategy that can give more idea to improve the developer knowledge and better implementation on sustainable construction.

Keywords: *Sustainable; construction; consciousness; developer; survey; Selangor.*

INTRODUCTION

The demand in the construction industry is performing well on the national economy. It can be seen from the report of the Gross Domestic Product (GDP) in the first quarter of 2016, whereas the economic grew by 4.2 per cent and it increased by 1 per cent on average. In the construction industry, the economic increases to 7.9 per cent where the earthworks and piling projects is a major contribution activity (GDP, 2016). Refer to the previous findings by Ibrahim et al. (2010), the future of construction is very interesting and encouraging. Thus, to further improve the performance, the government and all stakeholders should conduct research and development (R&D) as well as educating public education to this field which is moving with sustainable construction practice.

As well as to move forward to the advance of the construction industry, the adaption of sustainable construction is very important since the introduction of philosophy called 'Sustainable development' 1987 in Brundtland Report. This philosophy is about to increase an awareness of sustainability concept in construction in developing a country. According to Kibert (2007), sustainable construction is while making good economic sense, a complete

coverage is prepared in the emerging process of natural environmental conditions. Means that, in produce a construction product, all construction practitioners need to be aware and compromise the environment surrounding.

In Malaysia, the environmental issue still not in a good condition (Passer et al., 2015). On the 10th September 2015, Prime Minister YAB Datuk Seri Najib Tun Razak launched the Construction Industry Transformation Program (CITP) from 2016 to 2020 at Putra World Trade Centre (PWTC) (CIDB, 2015). The program has mentioned that there are three (3) specific issues identified on contribution environmental, social and economic issue which is lack of assessment of buildings and infrastructure are not always resilient to natural disasters, waste of high energy consumption of buildings and increase the amount of construction and demolition waste dumping. From these issues, it shows that the level of sustainability in construction still needs to be improved and review from time to time. It is very important to implement sustainable construction concept progressively to sustain our environment and needs to involve a responsibility by all construction practitioners especially developers, who plays the important roles in the development process. In addition, developer also is the one who initiate the project and have the privilege to influence overall the project direction (Zainul Abidin, 2010).

LITERATURE REVIEW

Sustainable construction interests have long expressed and applied by other countries. According to Harris (2003), the origin of actions and commitments are starting from a discussion that was held in 1968 in Rome called The Club of Rome – Limits to Growth, 1968. The discussion is to examine issues involving the interaction of technical, social, and economic terms political aspects. The report was released through these discussions have resulted so called Meadows-Meadows theory. This theory stated that the investment is needed at the early stage to get more energy and in return will be able to reduce energy costs. A continuation of the commitment to promoting sustainable construction, UN Conference on the Human Environment (UNCHE) was established in 1972. It is responsible for putting the environmental issue which is very important and should be involved in political issues. Next, in 1981, The World Conservation Union has been established that takes into account sustainable development. Then, it becomes a focus in the Brundtland Commission - The World Commission on Environment and Development (WCED), which was published in 1987. In this regard, in 1992, UN Conference on Environment and Development (UNCED) was set up to examine the requirements of sustainable development and taking into account of actions from across the country. Starting from that, many more programs or activities established to encourage a sustainable response to this development Halliday (2008). Through the existing of efforts, it can be seen the importance of sustainable construction in developing sustainable development.

Sustainable construction concept

In line with a country's mission to maintain and stabilize the economical, long-term value of the surrounding environment must be taken into account as enshrined in the concept of sustainable construction (Emas, 2015) which is:

i) **Economy:** A system that is sustainable in economic terms, where demand and supply must be monitored and maintained so the process will continue.
ii) **Environment:** In terms of the environment, the resource base should be maintained in a stable condition to avoid excessive exploitation of natural resources on natural causing wastage of energy sources.
iii) **Social:** In term of the social system, it must be achieved through justice in the distribution of opportunities.

Status of sustainable construction in Malaysia

Malaysian construction industry is an important industry in the national economy, contributing revenue sources. Data obtained from the statistics over the period 1991-2010, there is a strong relationship between the construction sector and economic growth. The construction sector has played an important role in the national economic aggregates in terms of contribution to the generation of revenue, capital formation, job creation that ultimately support the gross domestic product (GDP) and, socio- economic development of Malaysia. Given that the construction sector contributed greatly to the national economy, it is necessary for the government to pay attention and focus on the construction sector to qualify for the title of the developed countries (Ali Khan et al., 2014). It does not only contribute to the development of the industry itself, but the industry is also a contributor to other industries (Grovera & Froesea, 2016).

According to Ibrahim et al. (2010), today, the future of construction is increasingly attractive to invest in the international market economy. The need for innovation in technology and engineering has become a trend in the industry in terms of management of construction projects. In addition, establishing new relationships in the construction work was created for the channel construction. He also suggested that Malaysian construction industry must invest in research and development (R & D) to create opportunities for the advancement of the industry. Public education is also encouraged to study and develop new ways to improve operational performance in the construction.

In advance of the construction industry, Malaysia is no exception to contribute significantly to the environment through the building activities. Criteria during the construction phase of the building are certainly lacking such as pollution control in terms of CO_2 emission, dust, and other pollutants which give a negative impact to the environment surrounding (Bahaudin et al., 2014). Consequently, the government incessantly is trying to handle the situation (Asmah Alia et al., 2015).

The government setting a mission which is to be more sustainable development in all aspects which is enabling environment for green growth, adopting sustainable consumption and production concept, conserving natural resources for present and future generation and strengthen resilience against climate change and natural disaster. These missions showing that Malaysia country is still keep moving towards the sustainability construction. It is supported by Mokhtsim and Salleh (2014) that Malaysian still in an effort to achieve sustainable development concomitant with another country. Ahankoob et al. (2013) stated that the implementation is still infancy. Many people worrying about a major cost green technology in construction. Cost reduction of energy consumption in the long term is often overlooked. In addition, life cycle management, government incentives also have an

important role in eliminating these challenges and move towards sustainable building makes integration between different communities create a stable environment. Taking the law in line with other countries will promote progress in sustainable construction. On 25 September 2015, as a result of the demands of the world who want changes in leadership, poverty, inequality and climate change, Agenda 2030 sustainable development through discussion United Nations in New York have been adopted to all over the world of leaders including Malaysia (UNDP, 2012). More than 170 countries and regions, the United Nations Development Programme (UNDP) has been working to help to achieve the eradication of poverty and reduction of inequality and exclusion.

Developer and consultants' roles in sustainable construction

Each party involved in the construction industry has its own power and influence. According to Nurul Diyana & Zainul Abidin (2013), construction sustainable developed by the developers implemented through various aspects and takes a leadership role in transforming the construction industry towards sustainability. They determine the course of the project and are considered a key decision maker performance construction of the project. Developer position is strategic in ensuring the effective implementation of sustainable construction and because of that they are the most important agents to determine the extent to which this approaches sustainable construction. Developers are also the ones initiating the project and have prevailing influence over the overall project direction (Nurul Diyana & Zainul Abidin, 2013).

In construction, Developer work closes with consultants to produce a good quality of projects. Consultants can better carry out their responsibilities to the owners or developers. With increased awareness and understanding, the developers can benefit from the advantages of having consultants involved in the construction process. Consultants have many roles to play during the construction process. This is because the role of consultants in various kinds of construction projects, and usually involved in this project from the beginning until the project is completed. It is important to fully and consultants understand the need to do so to ensure that the consultant can be fully maximized in each construction project and knows the needs of developers (Samantha, 2009).

Architect especially, their relationships are more often and close. According to Lin (1990) architect very closed with developer because they are related to their work motivation, in work entering business incentive, and their skills that they have possessed. For developer, design world by architect is still maintain the negative view on them but the relationship between the architect and the developer has started to grow in United Kingdom (ArchDaily, 2014). The architect is not only responsible not for the design of the building, they are also act for the performance of their economy to the extent that their designs meet market demand and also play important roles holds the majority of the rewards form developer (Luis Gil & Richard Peiser, 2016). It can be concluded that the responsibilities of Architects play important roles to developer for sustainable development purpose.

METHODOLOGY

This study is about to measure the level of knowledge of Developer on sustainable current practice. The selection of mixed- method approach is suitable for this study because

it is involved in the relationship between dependent and independent variables in which variable and data can be analysed using statistical procedure (Cresswell, 2013). Survey research (Talib, 2011) approaches were selected due to the conformity on this topic to measure the level of awareness and knowledge on a random selection among developer.

Research Design

Survey Research (Quantitative)

Survey research design is one of the non-experimental researches which is different with the others quantitative design which has been explaining briefly before. This is because of survey research design is one of the collection methods in the form of opinion, attitude and perception of the respondent's population to produce a sample (Cresswell, 2013).

The example of survey research such as conducted census to a collection of demography data to population, customer satisfaction, attitude changes and perception (Talib, 2011). This topic of research is linked to the perception of Developer on the consciousness of sustainable construction in Malaysia, so, it is suitable to use this method. According to Talib (2011), there are two (2) types of survey design which are longitudinal and cross-sectional. The use of these types of the survey depends on the aim of research. For this research, the cross-sectional is suitable for the research method due to the short period is needed to collect the data in different respondents. In term of analysis of data, percentage method will be used to obtain the data.

Fenomology Design (Qualitative)

For this study, researcher had recently decided that qualitative research methods approach fenomology. Fenomology describe His research is experiencing a phenomenon of individual experience. Fenomology is interpretive experience of glasses or participant perspective. For more information, interviews will be conducted openly against consultants Architects selected at random who have over 10 years projects involved with developers.

Sampling and Population

Population

Overall individual group to obtain the data on research which is needs in this study. Population needs to have all the information needs. These researches, population taken the area Selangor were the parameter of the population in Malaysia. Based on Jabatan Perumahan Negara for 2015 records, about 890 registered Developer in Klang, Selangor, and for the Architect, there are about 300 registered Professional Architect in Gombak, Selangor area (LAM, 2016). According to Krejcie & Morgan (1970), if the population estimate is about 890, the size of the sample would be 269 numbers for developer.

For Architects, purposive sampling techniques are selected due to the related respondent to the research. Researcher will choose and interview well-experienced Architects and stop until meet the repeat feedback.

Sampling Technique

There are two (2) categories of sampling techniques which is random and not random. For this study, random techniques are selected to pick the sample because it is the best technique compare to non-random technique whereby the random sample is a sample that volunteers the features on the research field (Talib, 2011). Systematic random techniques are selected on this research which uses the systematic easy formula with select the hose sample. The calculation to determine this sampling technique as shown below:

i.   Population: 900 Developers company and 300 Professional Architects addressed in Klang, Selangor
ii. Sample needs: 269 Developer, 6 Professional Architects
iii. Systematic Formula: 900/269 = 3 (n=3) for Developer, 6 or more Registered Architect
iv. Sample number three (3) is selected to get 269 Developers and randomly to get 6 or more Professional Architects for interview session.

Research Instruments

Questionnaire Survey

According to Annum (2016), research instrument is necessary to find strategies. It is included a questionnaire, interviews, observations and Reading. For this study, a questionnaire survey and interview session are an ideal instrument for the design of this study. Questionnaire survey can divide into two (2) types which is (structured) or closed form and unstructured (open ended form). This questionnaire survey for this research is in forms of (structured) or closed form. It is to make an easier respondent to answer the survey and suitable for the firm answer and right choice besides believe that all respondent will answer the entire question (Talib, 2011). The results are justified by using the Statistical Package for the Social Sciences (SPSS) software.

Semi-Structured Interview

This question is more on the perception of consultants on developer consciousness on sustainable construction. Through the review of research methodology, the instrument of the survey (Talib, 2011) is to obtain and gain the data for analyse to achieve the aim of this study. After the collection of return questionnaire, the data can be analysed and conclude on the next topic.

RESULTS

Quantitative Analysis

A total of 269 questionnaires were distributed to the respondent Klang, Selangor Developer registered under Jabatan Perumahan Negara, and however, 142 respondents were returned to the researcher. Statistical Package for the Social Sciences (SPSS) software is used in justify the results.

Results (Quantitative Analysis)

The overall respondents totalled 142 the respondents are from the director of the company, manager, assistant manager and executive. The companies were established mostly more than 10 years. In terms of experience working respondents, many of whom are more than 10 years in which it may consider knowledgeable in the field of construction. In addition, the respondent also has long attachment in their company of average of 11-15 years. However, the average response is a company that provides 1-100 employees, followed by 100-500 staffs and more than 1000 staffs. It can be concluded that, companies that provide feedback is not too large in capacity of the company. Based on Table 1, on average, the conceptual knowledge of developer on sustainable construction is almost at the level of moderate and high. Among the three concepts of sustainable, social concept is the highest compared to their knowledge on the economy and environment concept. Developer knowledge on the principle of sustainable construction, on average, on moderate level (refer Table 2), similar to the concept of sustainable construction. Principles highest among the other is the focus on quality, followed by the Application life-cycle costing, reduce resources, consumption, protect nature, eliminate toxics, use recyclable resources and reuse resources. This means that the developer is still concerned about the quality of their products even though sustainable construction principle does not reach a satisfactory level.

Table 1. Knowledge on the concept

	N	Minimum	Maximum	Sum	Mean	Std. Deviation
Social	142	2	5	520	3.66	.841
Economy	142	2	5	506	3.56	.803
Environment	142	2	5	486	3.42	.933
Valid N (listwise)	142					
Mean					3.69	

Table 2. Knowledge on the principles

	N	Minimum	Maximum	Sum	Mean	Std. Deviation
Focus on quality	142	2	5	550	3.87	.733
Life-cycle costing	142	3	5	545	3.84	.456
Reduce resource	142	3	5	535	3.77	.471
Protect Nature	142	2	5	507	3.57	.794
Eliminate toxics	142	2	5	506	3.56	.635
Use recyclable resources	142	2	5	503	3.54	.787
Reuse resources	142	2	5	499	3.51	.840
Valid N (listwise)	142					
Mean					3.72	

Table 3. Knowledge on the Significance of Sustainable Construction

	N	Minimum	Maximum	Sum	Mean	Std. Deviation
Friendly accessibility	142	3	5	573	4.04	.688
Available technology	142	1	5	556	3.92	.993
Government intervention	142	3	5	551	3.88	.484
Sustainable design	142	2	4	516	3.63	.679
Organizational commitment	142	2	5	507	3.57	.667
Advanced technologies	142	1	4	506	3.56	.767
Knowledge improvement	142	2	5	501	3.53	.760
Public awareness	142	1	5	487	3.43	.820
Assessment tools	142	2	4	483	3.40	.763
Valid N (listwise)	142					
Mean					3.69	

In terms of knowledge of developers on the significance of sustainable construction, on average, it is surpassed moderate level. But have not yet reached the level of satisfaction. From Table 3, it shows only user accessibility achieve the satisfactory level. Knowledge and implementation of successful factor is very close to the stage as satisfying as available technology, government intervention, sustainable design, organisational commitment, advanced technologies methods, such as knowledge improvement seminars, sharing and discussion, public awareness and market demand, assessment tools. Assessment tools are the lowest among others. The lack of sustainability is likely as they are more concerned with profit-oriented. In terms of implementation of the developer on sustainable construction, the average is still at moderate levels whether in terms of concept, principle and also successful factor (refer Table 4, Table 5 and Table 6). Company implementation of conceptually shows, mostly economic focuses respondent parallel to sustainable construction followed by environment and social. Social is the lowest of all in terms of implementation. In terms of principle, majority developers more on elimination of toxic activity, followed by apply life cycle costing and use recyclable resources. Protect Nature, reduce resource consumption, focus on quality, and reuse resources still at a low level. Similarly, the company factor in successful implementation. Table 6 shows Sustainable design, accessibility friendly, knowledge improvement such as seminars, sharing and discussion, government intervention and assessment tools showed moderate levels. For element organisational commitment, advanced technologies methods, public awareness and market demand and available technology, still shows the low level.

Table 4. Company Implementation – Concept

	N	Minimum	Maximum	Sum	Mean	Std. Deviation
Economy	142	1	5	461	3.25	1.106
Environment	142	1	4	437	3.08	.915
Social	142	1	4	394	2.77	.894
Valid N (listwise) Mean	142				3.10	

Table 5. Company Implementation – Principle

	N	Minimum	Maximum	Sum	Mean	Std. Deviation
Eliminate toxics	142	2	4	450	3.17	.734
Apply life-cycle costing	142	2	4	445	3.13	.727
Use recyclable resources	142	2	4	441	3.11	.760
Protect Nature	142	2	4	423	2.98	.812
Reduce resource consumption	142	2	5	421	2.96	.803
Focus on quality	142	2	4	420	2.96	.617
Reuse resources	142	2	4	416	2.93	.591
Valid N (listwise) Mean	142				3.00	

Table 6. Company Implementation – Successful Factor

	N	Minimum	Maximum	Sum	Mean	Std. Deviation
Sustainable design	142	2	4	465	3.27	.609
Friendly accessibility	142	2	4	456	3.21	.530
Knowledge improvement such as seminar, sharing and discussion	142	2	4	450	3.17	.505
Government intervention	142	2	4	431	3.04	.688
Assessment tools	142	2	4	427	3.01	.625
Organizational commitment	142	2	4	421	2.96	.794
Advanced technologies Methods	142	1	4	412	2.90	.977
Public awareness and market demand	142	1	4	403	2.84	.904
Available technology	142	1	4	388	2.73	.816
Valid N (listwise) Mean	142				3.03	

Qualitative Analysis

The interview session is an open question to the respondents. Only six (6) Registered Architects were interviewed at Klang Valley area to answer the objective of this research. All respondents are 40 years above and have more than 10 years experienced with Developer's project and running their own company. The data analysis which is recorded by tap record is summarized at the end of data collection.

Results (Qualitative Analysis)

Mostly all six (6) respondents mentioned that the most developers are still not aware about sustainable construction currently because there is more profit orientation rather than rather than thinking and looking for sustainable construction. It is impossible to achieve because it is not economical, and the purchasing power of end user is very low compare to other successful country. In terms of implementation is still in the early stage and not balance in term of human comfort and sustainable elements. Only well establish certain developers looking on this and because their policy of construction. But it is still only to get some marketing point to their company to customer well known. To implement the sustainable construction, developer needs to spend a lot of money that sometimes not bring benefit on their company. Cost is the main reason the fail the sustainable construction implementation. They are also mentioned sustainable construction implementation is involved responsible of all parties besides and make sure is that government support plays important roles to the sustainable construction implementation such us strict policy and any intensive for Developer. Other than that, cut cost on unreasonable item especially the submission fee to local authority is very important to give win-win situation or Developer so that they can use for sustainable construction activity.

DISCUSSION

The origin of sustainable construction concept is come from the discussion that was held in 1968 in Rome called The Club of Rome-Limits to Growth 1968 (Halliday, 2008) and were influenced to the whole world including Malaysian's country which began on year 2000 (Abidin, 2009) and been implement about one and half decades. However, Malaysia still infancy with this practice (Ahankoob et al., 2013) and need more innovative strategies in implementation (Zainordin & Carmen, 2015). Through data analysis, the result from questionnaire survey to developer shows that level of consciousness in term of knowledge is slightly on high level. It can be concluded that government effort (Yiing et al., 2013) in helps to improve the understanding of sustainable construction is almost successful. To confirm that developer knowledge is slightly high, the interview session is interpreted. In result, mostly Architects mentioned that developer also maybe know about the sustainable construction concept, but only in the surface only and not in-depth knowledge. It is slightly produced on same results for both parties. According to Zuofa et al. (2014), it is very important to get knowledge to be very strategic resources. It can improve the results of construction projects to reduce unnecessary cost, implementation, and time and improve competitiveness. Therefore, the results of knowledge developer show positive results and will be improving the implementation of sustainable construction.

On the implementation test, the results show the moderate level on that. Construction activity is one of the activities that contribute the environmental issue such us pollution control, dust and others (Bahaudin, 2014). Only well-established companies were active in the implementation of sustainable construction concept (Zainul Abidin et al., 2012). These findings match with the interview session with Architects, they are mostly said that developer is still lacking in sustainable construction concept currently because there is more profit orientation rather than thinking about sustainable construction practice. It is because not economical, less of purchasing power of end user, not balance in term of human comfort and sustainable elements, government roles and win-win situation.

CONCLUSIONS

In conclusion, we can see that the data analysis mostly showing that the knowledge of developer is still in the moderate level. In view of implementation, results showing that, in the implementation averagely low level. Our country still has a chance to improve our weakness and our world safe for the long-term benefit. This is not the perception denied again by the consultants, as an objective to be achieved no.3; they mostly agree that developer knowledge is still in the moderate level and in terms of implementation is still lower. It is supporting the results by developer itself. In addition, the consultants are mostly mentioned that cost is the main issue. Even though the government implement exemption of tax, it is still cannot cover the contribution in sustainable construction. Developer needs to spend a lot of money that sometimes not bring benefit on their company. That is why they do not care about the sustainable concept and it is due to developer's mind-set. They are only caring about profit orientation rather that thinking about sustainable construction process. It is requiring substantial capital and cost of the project is higher than the norm. Developer mind-set does not want to take out things that are not favourable to them and mostly think of profit for their companies. Sustainable construction implementation is involved responsible of all parties besides government to make sure is successful.

It can summarize that developer's knowledge is still in moderate level. Effect on that, the implementation of sustainable construction is very low. This is very worrying because environmental conditions are very worrying and increasingly desperate, sustainable construction is the need for long-term needs. All parties involved must each play an important role in implementing sustainable construction. It should start from the initial warning that continued until the feasibility study in order to drive the future development of the sustainable terms of economic, social and political. Consideration of the government to provide intensive developer within the state must be balanced to achieve a win-win situation between the two sides.

On this research, the results also is strict on the limitation of the data collection which is there is some blacklist developer at Jabatan Perumahan Negara (2015) record that to find out before delivering the questionnaire, possibly the respondents is not the director or well-known person about the company's itself when answer the question, possibly the office address of respondent might be change, possibly the questionnaire would be unreturned within the required time and also limited of time in interview session with registered architects. It may be able to affect the accuracy and consistency of the results.

Therefore, on further research, firstly, it may be able to focus on how to tackle in term of sustainable cost during construction since the main issue of lack implementation of sustainable construction is economical issue and can focus on the types on win- win situation that can be practice for all parties.

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ENERGY CONSUMPTION ASSESSMENT ON INDUSTRIALISED BUILDING SYSTEM (IBS)

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Abstract
Malaysia Government mission towards development of low carbon cities in reducing carbon emission by 40% by year 2020. Therefore, our construction industry plays an important role and gives negative impacts on the environment. Factors of embodied energy and carbon emission are important in selecting construction method by considering the low carbon type of construction material to be used during the construction process. This paper presents an analysis of Embodied Energy and carbon emission in a building that used IBS and conventional method to achieve sustainable construction in Malaysia. All data was recorded and analyse using a commercial Life Cycle Assessment (LCA) tool called Carbon Calculator. The study includes IBS component; precast concrete wall panel, column, beam and half slab and cast in situ components; burn clay bricks, reinforced concrete slab, column, and beam. The results are presented in terms of carbon dioxide equivalent (CO_2E) of construction materials and comparison analysis is made between IBS and Conventional method. The results obtained from Carbon Calculator due to manufacture and installation of components show a that IBS method consumed 26.93 CO_2E/m^2 and conventional method offers 39.57 CO_2E/m^2. By comparing IBS and conventional method, it is found that the average of total energy consumption due to construction materials was 33.25 CO_2E/m^2 and involved 31.94% reduction in comparison with conventional method. Therefore, for further building construction's practice in relation to type of construction method it is recommended to be below the average amount of energy consumption 33.25 CO_2E/m^2 (50%) and any values obtained above the average amount is considered not being able to adopt sustainable building practice. Generally, it can be concluded that implementation of IBS method can be regard as a potential in reducing the amount of embodied energy and carbon emission compared to conventional method.

Keywords: *Embodied energy; carbon emission; Industrialised Building System; conventional method.*

INTRODUCTION

In 21st century, one of the primary roles of construction industry is to generate wealth to the country. However, construction industry is not just concerned about financial return, but also on the long-term impacts of living standards for both present and future (Ding & Shen, 2010). Nowadays, strategies in achieving sustainable building have become a global focus in the world. Thus, the reduction of carbon emissions has become a primary focus of environmental strategies around the world (Farrar & Ceng, 2017). While in Malaysia, carbon emission has to be reduced up by 40% by the year of 2020. Currently, Malaysia is ranked 30th in the world for countries that experience the highest quantity of carbon emission (Rashid & Ismail, 2013). Therefore, our construction industry plays an important role and gives negative impacts on the environment. In order to cope with this challenge, Malaysian construction industry has been urging to use innovative construction technique and to shift from traditional practice to IBS construction method. Nevertheless, studies on the assessment of embodied energy and CO_2 of building projects in Malaysia are scarce. It is necessary to acknowledge embodied energy and carbon emission amongst other factors in selecting construction method for projects.

By responding to these issues, investigation on the benefits gained from the application of IBS compared to the conventional method as well as its impacts towards the environment through assessing embodied energy and carbon emission was carried out. This paper presents an analysis of Embodied Energy and carbon emission in a building that used IBS and conventional method to achieve sustainable construction in Malaysia.

EMBODIED ENERGY AND CARBON EMISSION IN CONSTRUCTION INDUSTRY

Over the years, the construction industry has been stigmatized as the greatest share of energy consumption, high CO_2 emissions and wasteful resources that gave huge negative impacts towards environment (Qarout, 2017). According to Dixit et al. (2010), the construction industry is one of the largest exploiters of natural resources and consumes 40% of total global energy. To cope with these challenges, Malaysian construction industry currently putting serious attention to use innovative construction technique and to shift from conventional method to Industrialised Building System (IBS) construction (Kamar et al., 2010).

One of way to deals with sustainable issue in Malaysia is by using low embodied energy materials. Omar & Doh (2013) has conducted preliminary works on methodology in assessment of embodied energy and CO_2 emission of building and construction processes in Malaysia. They mentioned that embodied energy and carbon emission important to achieve sustainability and demonstrate different methods of tracing energy path. However, more process data are still needed in the literature to enhance the data inputs required for analysis methods, especially on transportation of materials to the construction site. Based on previous studies by other researchers related the embodied energy and carbon emission in construction industry shows in Table 1.

Table 1. Review on significant of embodied energy in construction industry

Authors	Key Findings
Qarout (2017)	The greatest opportunities to reduce EE and CO_2 emissions occur when one material is replaced with a more ecological material. Using wood can reduce EE (10%) and CO_2 emissions (7.5%).
Farrar & Ceng (2017)	The using of Bio-based materials for construction is a good method of providing quality low-rise buildings that reduce embodied energy.
Pomponi & Moncaster (2016)	Reduce, re-use and recover EC-intensive construction materials, such as steel and concrete. Using of materials with lower embodied energy and carbon such as timber, bamboo, and hemp-lime composites. The new tools, methods and methodologies are also needed to facilitate the transition to a low-carbon built environment, as are policies at both government and construction sector levels. Addition is Refurbishment of existing buildings would be 22% more efficient than demolition and rebuild.
Omar & Doh (2013)	Find out that embodied energy and carbon emission important to achieve sustainability and demonstrate that different energy path such as the capital and services affecting a product.
Sattary & Thorpe (2012)	Reducing embodied energy in building materials through processes like selecting suitable materials, recycling materials, balancing the use of materials, selecting materials for durability, localizing the manufacturing process, and similar measures is expected to make a considerable improvement in the efficient lifecycle energy use of buildings. There is considerable potential to achieve very low lifecycle energy use over the coming decades.
Yeen (2012)	Identify the elements of IBS that can contribute to carbon footprint calculated using "Carbon Calculator."

The previous studies, stated that to reducing the embodied energy and CO_2 emission in construction industry by using or replacing the material with are:

i.   More ecological material,
ii. Bio-based materials,
iii. Reduce, re-use and recover EC-intensive construction materials, such as steel and concrete

METHODOLOGY

In order to achieve the aims of this study, all data was recorded and analyse using a commercial LCA tool called Carbon Calculator. These studies choosing two (2) different construction methods which is IBS and conventional method. The items study includes IBS component; precast concrete wall panel, column, beam and half slab and cast in situ components; burn clay bricks, reinforced concrete slab, column, and beam. This study also using Carbon Calculator for Construction Material and Construction Machineries for the instrument to calculated. Figure 1 shows the overview of the Carbon Calculator tools.

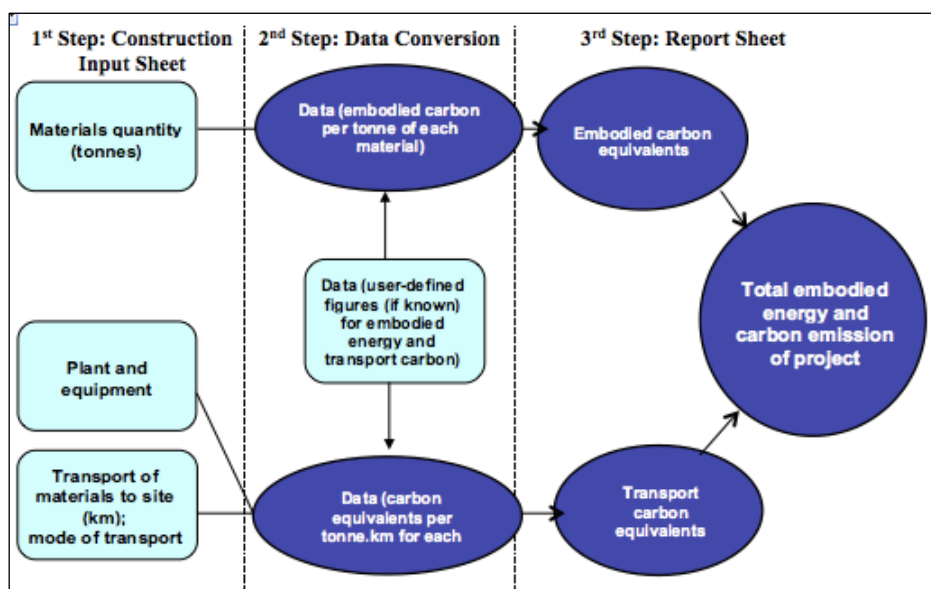**Figure 1.** Overview of the Carbon Calculator Tools (The Environment Agency, 2008)

Carbon calculator for construction material

GHG = Wm × Fe (1)

Where,

GHG = Amount of greenhouse gases in CO_2E (tonne)
Wm = Quantity of materials (tonne)
Fe = Emission factor of material (as recommended by DEFRA)

Carbon calculator for construction machineries

FMC = Do × Er × FMR × 1 litre (2)

Where,

FMC = Mobile plant fuel mass consumption (litre)
Do = Duration usage of operation (hours)
Er = Rating of the engine (kW)
FMR = Fuel Mass Consumption Rates (0.24 kg/kWh as recommended by DEFRA)

RESULT AND DISCUSSIONS

The results are presented in terms of carbon dioxide equivalent (CO_2E) of construction materials and comparison analysis is made between IBS and Conventional method. Figure 2 shows the values are obtained from Project A is 27.00 CO_2E/m^2, while Project C consume 39.76 CO_2E/m^2, with the average of 33.38 CO_2E/m^2. In terms of reduction percentage by comparing both construction methods, it is found that the IBS construction method has a lower carbon emission compared to Project C using conventional system by 32.09 %. Thus, a conventional method emits at least 1.5 times more embodied energy and CO_2 compared to IBS method.

Case Studies	CO_2E per sqm. (CO_2E/m^2)			
	CO_2E per sqm. due to construction materials	CO_2E per sqm. due to fuel consumption	Total CO_2E/m^2	Percentage (%)
Project A (IBS)	26.93	0.070	27.00	40
Project C (conventional)	39.57	0.194	39.76	60

Figure 2. Total Energy Consumption (CO_2E) for IBS and Conventional method

Comparative analysis on embodied energy and carbon emission due to construction material

Figure 3 shows that the Project A (IBS), the value of CO_2E/m^2 is 26.93 CO_2E/m^2 while Project C (conventional) generates 39.57 CO_2E/m^2. The value obtained from the IBS building is less compared to conventional building by 31.94% reduction in comparison. For these values differ because the manufacturing and construction process of IBS is more efficient than conventional method. It can be concluded that for further building construction's practice in relation to type of construction method is recommended to be below red line 50% and any values obtained above the red line is considered not being able to adopt sustainable building practice.
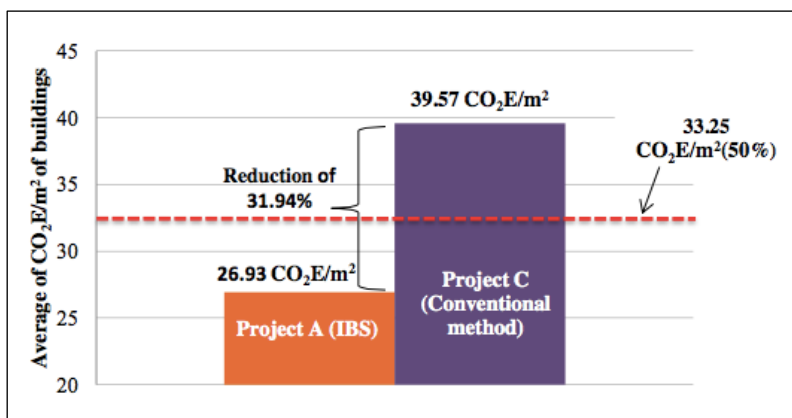
Figure 3. The average CO_2E per square meter of Project A and Project C

Comparative analysis on embodied energy and carbon emission due to construction machineries

Based on the Figure 4 shows that the comparison between Project A (IBS) and Project C (conventional) in terms of CO_2E/m^2 due to fuel consumption. Project A is 0.070 CO_2E/m^2, while Project C consumes 0.194 CO_2E/m^2, with the average of 0.102 CO_2E/m^2 (50%). In comparison, Project A (IBS) consumes less CO_2E/m^2 fuel consumption compared to Project C (conventional). This is due to operation hour of machineries used to manufactured and constructed IBS building is less, and overall time taken to complete IBS building can be reduced compared to conventional building. It can be concluded that for further building construction's practice in relation to type of construction method is recommended to be below red line 0.102 CO_2E/m^2 fuel consumption and any values obtained above the red line is considered not being able to adopt sustainable building practice.
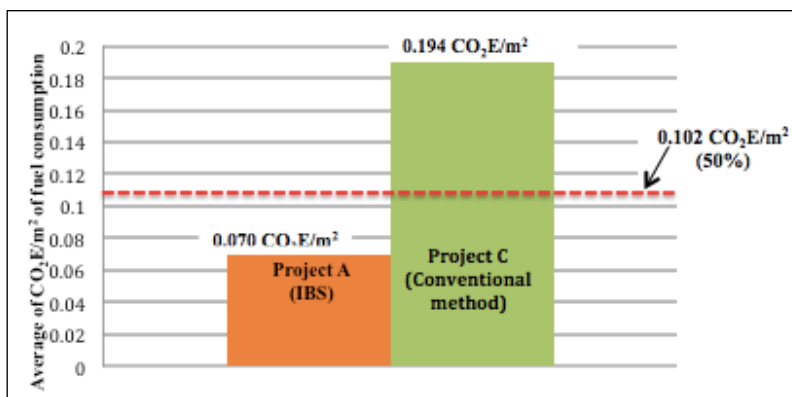
Figure 4. The average CO_2E per square of Project A and Project C

The results of this study obtained are relatively low when compared with the results from researchers Chang et al. (2012) as their results was about 96% for material production and installation whereas transportation comprise 4% of total embodied energy and carbon emission. This is due to high energy used for machineries during construction especially overhead cranes and batching plant which gain its high energy contribution from diesel. The construction machineries used were based on observation and assumption of normal practice

in Malaysia. It was suggested that if a number of cranes used were reduced, a significant reduction would have been noted in energy consumption and emissions during construction.

According to Omar et al. (2014), which have conducted comparative analysis between precast concrete wall panel and conventional wall, revealed that a total emissions reduction of 26.27% is achievable through the selection of a precast concrete wall panel system in the given structure. In addition, Omar et al. (2014) concluded that an equivalent saving of 4.72 million CO_2E can be achieved annually if the entire Malaysia construction industry adopted the IBS construction system.

CONCLUSION

This study has focused on the assessment of embodied energy and carbon emission during manufacturing and construction process. Based on the two case studies with difference methods of construction are IBS and conventional methods. It can be concluded that the awareness towards sustainable construction using IBS method produced less energy consumption compared to conventional method. The Saving on construction materials will result not only in saving of natural resources, but also saving in energy resources, fossil fuels, nuclear and hydroelectric facilities, all used in the mining, manufacturing, transportation and installation of construction materials. Therefore, as the usage of construction materials was reduced when using IBS method, overall construction cost and time taken to construct was reduced as well.

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MODELLING RISK FACTORS AND CHALLENGES WITH THE IMPLEMENTATION OF RISK MANAGEMENT IN HIGH-RISE BUILDING CONSTRUCTION

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Abstract
Construction risks are inherent in every construction project especially high-rise building construction which is complex in nature. It is important to understand the significant risk factors and challenges in high-rise building construction in order to facilitate the construction stakeholders to minimize the negative effect of construction risks. One of the strategies that can be obtained is by the implementation of risk management before any construction project starts. Therefore, this research intends to identify the causal effect of high-rise building construction risk factors and challenges towards the implementation of risk management. This research employed a questionnaire survey of 105 experienced and less experienced construction stakeholders dealing with high rise building construction. The results were analysed using factor analysis and converted into AMOS graphic to analyse the inter-relationship of risk factors and challenges towards risk management. These inter-relationships were modelled based on hypothesis and theoretical framework of the research. The result shows only five (5) hypotheses were supported out of twelve (12) hypotheses that have been tested. A positive relationship between risk factors and challenges towards risk management from this model can be used by construction stakeholders in identifying the major risk factors and challenges and a systematic way to manage the high-rise building construction risks. Based on the findings of this research, it is suggested that future research may focus on inter-relationship of risk management towards the performance of a construction project.

Keywords: *AMOS graphic; construction risks; high rise building; model; survey.*

INTRODUCTION

High-rise building construction is defined as a complex construction project and involves many phases from conceptual design to completion (Zaini & Endut, 2017; Djoen San Santoso & Ogunlana, 2003). The complexity and uncertainty of the construction lifecycle imposed a bad image in the construction industry (Huawang, 2009). The nature of construction project lifecycle such as open space, expose to weather, involving many unskilled labours, tight schedule of short targeted project duration, workers turn over, working at height, confined space and psychologically and physically vulnerable working environment make it one of the dangerous workplaces (Imriyas et al., 2007). Despite the challenges, the construction industry still growing in a developing country likes Malaysia because it acts as an integral part of infrastructure development which gives a tremendous boost to our country's economy. Due to limited and expensive land in a city area, high-rise buildings become one of the favourable options among the developers. Accident causes from machinery and tools always being a major percentage, but acute effect such as permanent disability or death have frequently happened in the high-rise building construction site. In 2017, a total of 4,266 accidents and 183 fatalities were recorded at construction sites, three times higher than those recorded at other workplaces (DOSH, 2018).

The increasing pace of construction accidents has increased the degree of awareness of construction health and safety, thereby involving its inclusion as part of project performance

criteria. The Social Security Organisation (SOCSO) of Malaysia indicated that a worrying increase in the numbers of accidents occurring at the workplace. Despite the awareness focused on construction site injuries in many countries, the rates continue to be frightened. These elements can affect the achievement of project goals. Ministry of Works Malaysia has launched the Construction Industry Transformation Programme 2016 – 2020 which aims to transform the construction industry to be highly productive, environmentally sustainable, with globally competitive players while focused on safety and quality standards (CIDB, 2017). Emphasis is given to inculcate safety climate in the construction site by implementing two initiatives to improve workplace safety and worker's amenities. To prevent accidents, proactive actions have been paid by researchers to explore the possible proactive approach (Zhou et al., 2015). Risk management (RM) has mostly been used in the construction industry for considering and measuring the impact of potential risks on universal project parameters such as time and costs.

Regardless of the increased number of studies on RM, limited studies have strived to reveal the factors that driving and obstructing RM implementation in a high-rise building construction site. The identification of the risk factors and challenges in managing the risk will enable the construction stakeholders to take preventive and corrective actions to reduce their undesirable effect. Hence, this study significantly contributes to the body of knowledge relating to RM particularly in the high-rise building construction.

LITERATURE REVIEW

Construction Risk Factors

Safety risk factors can influence the risk of accidents either in probability or consequences. Risk factors in the high-rise building construction sources from many angles include the working environment, legal and monetary, tight project schedule, knowledge and competency of the construction stakeholders, poor management, and communication problem. Different worker culture causes communication problems that may contribute to the accident occurrence (Sousa et al., 2014). Large numbers of construction workers in Malaysia originated from foreign countries such as Bangladesh, Indonesia and Myanmar. Communication deficiencies between the labour and management personnel become one of the drawbacks for successful implementation of safety management at the site. Delays are very common in completing one construction project. Time-delays bring adverse impact on project success in terms of time, cost, quality and safety (Faridi & El-Sayegh, 2006; Koushki et al., 2005). In terms of monetary, little attention are always given to the safety budget resulting in cost and corner cutting (Biggs et al., 2005). Safety motivations are also determined as significant individual safety features. A study by Khosravi found strong correlation among the workplace safety condition with the psychological condition compared to physical condition (Khosravi et al., 2014).

Risk Management

The risk is present in all project components of any projects irrespective of their size or sector and no project is totally free from risk. The aim of RM is to identify the undesired event to estimate risk, and it aims to like hood the unfavourable event to occur (Al-Shibly et al., 2010). Management of risk is described as the processes concerned with conducting risk

management planning, identification, analysis, responses and monitoring and control on a project (Khodier & Mohamed, 2014). In order to apply RM effectively, it is important that RM culture is developed. Elkington and Smallman suggested that there is a strong relationship between the amount of RM efforts undertaken in a project and the level of the project success (Elkington & Smallman, 2002). The key success indicators of RM are achieving the project goals between estimated cost and time, desirable quality without jeopardizing environmental and safety. These goals are interrelated where each of them is affecting and affected by the others.

Despite substantial research on RM and related outcomes, there is still a paucity of research about how risk factors and challenges impacted the implementation of RM. Therefore, the primary objective of this paper is to identify the causal effect of risk factors and challenges towards the implementation of RM in the high-rise building construction. Researchers have proposed various RM model for representing the interdependencies between project risks, project objective, project quality and performance (Wibowo & Taufik, 2016; Algahtanya et al., 2016; Qazi et al., 2016; Gładysza et al., 2015; Priyadarshani et al., 2013). Table 1 summarizes recent RM model studies in the construction industry.

Table 1. Risk management model studies in the construction industry

References	Model Description
Wibowo and Taufik, 2016	1. A self-assessment model of risk management maturity for client organizations of public construction projects in the Indonesian context.
Algahtanya et al., 2016	1. The model that can minimize client decision making, and enable the client to utilize expertise, thereby improving project quality and performance. 2. Derived from the Information Measurement Theory (IMT) and Performance Information Procurement System (PIPS).
Qazi et al., 2016	1. A new process that aids in capturing interdependency between project complexity, complexity induced risks and project objectives. 2. A modelling approach is grounded in the theoretical framework of Expected Utility Theory and Bayesian Belief Networks.
Gładysza et al., 2015	1. A mathematical model supporting the management of project risk. 2. The model distinguishes between risks which have to be accepted and risks which can be eliminated at some cost, helping to decide which risks should be eliminated so that the customer requirements with respect to project completion time can be satisfied at the minimal cost
Priyadarshani et al., 2013	1. Development of a method for measuring safety management on construction sites by identifying factors that affect construction safety performance.

Challenges in the Implementation of Risk Management

Various factors influence the successful implementation of RM and certainly, the management of occupational safety and health in construction has unique challenges. Despite such challenges, firms that demonstrate a commitment to well-structured and well-funded safety programmes and techniques can effectively reduce incidents. Because most firms allocate limited resources for safety management, contractors are forced to carefully select from the available elements (Hallowell & Gambatese, 2010). To effectively manage construction safety, adherence to safety procedures is important when maximising safety performance. Uncertainty about how RM adds value to a firm or brings potential benefits also makes a construction company reluctant to implement it (Kleffner et al., 2003). Robust support for RM activities along with clearly defined and communicated expectations of the value the firm aims to derive from the RM process is a key factor in establishing a strong risk culture. Construction is well-acknowledged of its density and diversity which involves many

construction parties. Indeed, a strong commitment is needed from all parties to ensure the successful implementation of RM at a construction site.

RESEARCH METHOD

The research adopted in this study is similar to Ahmad Zaini et al. (2017) and included the following three (3) steps: literature review, questionnaire survey, and statistical analysis. However, this research employed a Confirmatory Factor Analysis (CFA) and Structural Equation Modelling (SEM) to increase the reliability and validity of the research (Easterbrook et al., 2008). This research includes 22 items of risk factors, 10 items of challenges in managing risks and 16 items of risk management. These items need to be reduced into a manageable item before CFA and SEM analysis can be executed. One of the methods normally employed for data reduction is factor analysis. In the factor analysis procedure, items which possess similar characteristic will be group together under one component. Thus, instead of having to deal with 48 items, it can be reduced to a few components (Zainuddin, 2014).

The theoretical framework in this research was developed based on the relationship of constructs in this study. The constructs of the research consist of risk factors, challenges and risk management. This research theorized that risk factors and challenges in managing risks have a significant influence on the risk management implementation.

Theoretical Framework
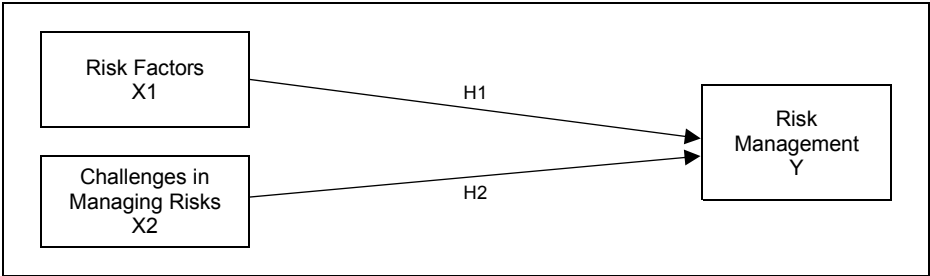
Figure 1. Theoretical framework illustrates several hypotheses to be tested in the study.

H1= Risk factors have a positive and significant effect on risk management
H2= Challenges in Managing Risks has a significant effect on risk management

X_1 and X_2 in Figure 1 are independent variables while Y is a dependent variable in a multiple regression model. Both variables are directly observed and can be converted into AMOS graphic. The multiple regression equation for this theoretical model is:

$$Y = B_0 + B_1 X_1 + B_2 X_2 + e_1$$

RESULTS AND DISCUSSION

Descriptive scores were obtained for each of 48 items based on the responses from 105 respondents. The measure of skewness for the 48 items are between -0.777 and 0.053. The general statistical measure of skewness ranges from -3.0 and 3.0. However, the measure

between -1.0 and 1.0 is considered normally distributed and acceptable to proceed with a parametric analysis procedure. Since the measure of skewness for all items in this research within the range, the required assumption for employing the parametric statistical procedures is satisfied (Zainuddin, 2014; 2012; 2015).

Risk Factors

In the factor analysis procedure, varimax rotation was performed for the 22 items of risk factors. The result indicates that Bartlett's Test of Sphericity was significant (Chi-square =1791.598, p-value <0.00). The measure of adequacy by Kaiser-Meyer Olkin (KMO) is 0.859 and has improved above 0.60. Since the KMO value is close to 1.0 and Bartlett's Test of Sphericity is close to 0.0, the data is adequate to proceed with factor analysis. The factor analysis has extracted four distinct components based on the eigenvalue greater than 1.0. According to Igbaria et al. (1995) the item which loads lower than 0.6 should be dropped from further analysis. Thus, research has dropped four items namely economic factors, knowledge and understanding, poor competency of labour and worker's attitude because the items have factor loading below than 0.6. The following Table 2 shows 18 items under four (4) components of risk factors with factor loading above 0.6. These components were renamed as safety performance factors, external factors, worksite factors and managerial factors to reflect the underlying items.

Table 2. Risk Factors

Item	Safety Performance factors	Factor Loading	Item	External factors	Factor Loading
SP1	Inadequate site information (Soil test and survey report)	0.635	EF1	Complexity of construction	0.832
SP2	Poor management ability	0.773	EF2	The complexity of construction method	0.777
SP3	Inadequate risk assessment	0.864	EF3	Excessive procedures of government approvals	0.699
SP4	Inadequate safety measures	0.883	EF4	Legal factors	0.682
SP5	Inadequate safety supervision	0.836	EF5	Tight project schedule	0.650
SP6	Communication barriers among workers	0.705			

Item	Worksite factors	Factors Loading	Item	Managerial factors	Factor Loading
W1	Equipment and machinery	0.858	MF1	Insufficient budget allocation	0.768
W2	Working environment	0.851	MF2	Allocation of responsibilities among stakeholders	0.768
W3	Working schedule	0.720	MF3	Insufficient professionals and managers	0.617
			MF4	Lack of coordination between project participants	0.633

The reliability measure for the measuring items was computed using Cronbach's alpha. The Cronbach's alpha of 0.6 or higher for the component reflects a reliable measure of internal consistency. Table 3 indicates that all reliability measures have exceeded the minimum value of 0.6 as recommended by Nunally (1978).

Table 3. Cronbach's Alpha and Cronbach's Alpha based on Standardized Items

Risk Factors	Number of items in a component	Cronbach's Alpha	Cronbach's Alpha based on standardized items
Safety Performance factors	6	0.920	0.920
External factors	5	0.863	0.865
Worksite factors	3	0.886	0.886
Managerial factors	4	0.837	0.837

Challenges in Managing Risks

There are ten (10) items of challenges in managing risks. From the factor analysis procedure, two components were rotated and renamed as organizational and project challenges with factor loading above 0.6. Table 4 shows the items rotated under these two components.

Table 4. Challenges in managing risks

Item	Organisational	Factor Loading	Item	Project	Factor Loading
OG1	The complexity of risk management	0.625	PR1	Lack of awareness and knowledge of safety	0.850
OG2	Unclear of potential benefits	0.692	PR2	Lack of safety expert	0.917
OG3	Budget allocation	0.867	PR3	Time constraint	0.627
OG4	Rigid contract terms	0.904	PR4	Not cost effective	0.671
OG5	Social-political factors	0.786			
OG6	Fear of liability	0.837			

Table 5 indicates the result of Cronbach's alpha for two components under challenges which were exceeded the minimum value of 0.6. Hence, these two components provide a reliable measure of internal consistency.

Table 5. Cronbach's Alpha and Cronbach's Alpha based on Standardized Items

Challenges in Managing Risks	Number of Items	Cronbach's Alpha	Cronbach's Alpha based on Standardized Items
Organisational	6	0.924	0.923
Project	4	0.864	0.863

Risk Management

Factor analysis was employed for 16 items of risk management. Based on the analysis, two components were rotated and renamed as Health and Safety Requirement and Managerial Concerns with factor loading above 0.6 as denoted in the following Table 6.

Table 6. Risk Management

Item	Safety and Health Requirements	Factor Loading	Item	Managerial Concerns	Factor Loading
SH1	Written and comprehensive safety plan	0.748	MC1	Sufficient Resources Allocation	0.793
SH2	Safety policy of a company	0.803	MC2	Available Technologies	0.834
SH3	Safety personnel at the site	0.872	MC3	Upper Management Commitment	0.798
SH4	Safety and health committee	0.841	MC4	Involvement of key stakeholders	0.829

Item	Safety and Health Requirements	Factor Loading	Item	Managerial Concerns	Factor Loading
SH5	Risk identification and assessment	0.836	MC5	Sub-contractor selection and management	0.693
SH6	Safety and health induction training	0.901			
SH7	Frequent workplace inspection	0.852			
SH8	Risk mitigation and emergency response plan	0.736			
SH9	Record keeping and accident analysis	0.766			
SH10	Employee involvement in safety management	0.812			
SH11	Incentive, punishment and recognition	0.746			

The reliability measure for the risk management items in Table 7 was computed using Cronbach's alpha. The Cronbach's alpha for these items was above 0.6 which reflects a reliable measure of internal consistency.

Table 7. Cronbach's Alpha and Cronbach's Alpha based on Standardized Items

Risk Management	Number of Items	Cronbach's Alpha	Cronbach's Alpha based on Standardized Items
Safety and Health Requirements	11	0.974	0.974
Managerial Concerns	5	0.917	0.917

The following twelve (12) corresponding hypotheses were proposed from factor analysis and theoretical framework and further analysis need to be carried out using AMOS graphic.

H1 = Risk factors have a positive and significant effect on risk management
  H1a = Safety performance factors have a positive and significant effect on safety and health requirement
  H1b = Safety performance factors have a positive and significant effect on managerial concerns
  H1c = External factors have a positive and significant effect on safety and health requirement
  H1d = External factors have a positive and significant effect on managerial concerns
  H1e = Worksite factors have a positive and significant effect on safety and health requirement
  H1f = Worksite factors have a positive and significant effect on managerial concerns
  H1g = Managerial factors have a positive and significant effect on safety and health requirement
  H1h = Managerial factors have a positive and significant effect on managerial concerns

H2 = Challenges in Managing Risks has a significant effect on risk management
  H2a = Organisational challenges have a positive and significant effect on safety and health requirement
  H2b = Organisational challenges have a positive and significant effect on managerial concerns
  H2c = Project challenges have a positive and significant effect on safety and health requirement
  H2d = Project challenges have a positive and significant effect on managerial concerns

Testing the inter-relationship among variables

The research intends to execute analysis for twelve (12) hypotheses of the research using CFA and SEM in AMOS graphic. Figure 2 illustrates the theoretical model that has been converted into appropriate AMOS syntax. The following model has two dependent constructs and six independent constructs. All constructs are latent, and they are measured through a set of items in a questionnaire. The path analysis indicates how much the effects of every exogenous construct on the respective endogenous constructs. The standardised estimate showing the factor loading for every item and the correlation between exogenous constructs are presented in Figure 2. Fitness indexes for the model which reflect how fit the hypotheses are presented in the following Table 8.

Table 8. Fitness indexes

ChiSq	df	P-value	ChiSq/df	TLI	CFI	RMSEA
2003.180	875	.000	2.289	0.739	0.770	0.111

The CFA was performed for the measurement model of the latent construct to establish their unidimensionality, validity and reliability prior to modelling the structural model for analysis using SEM. The output of SEM is presented in Figure 2.
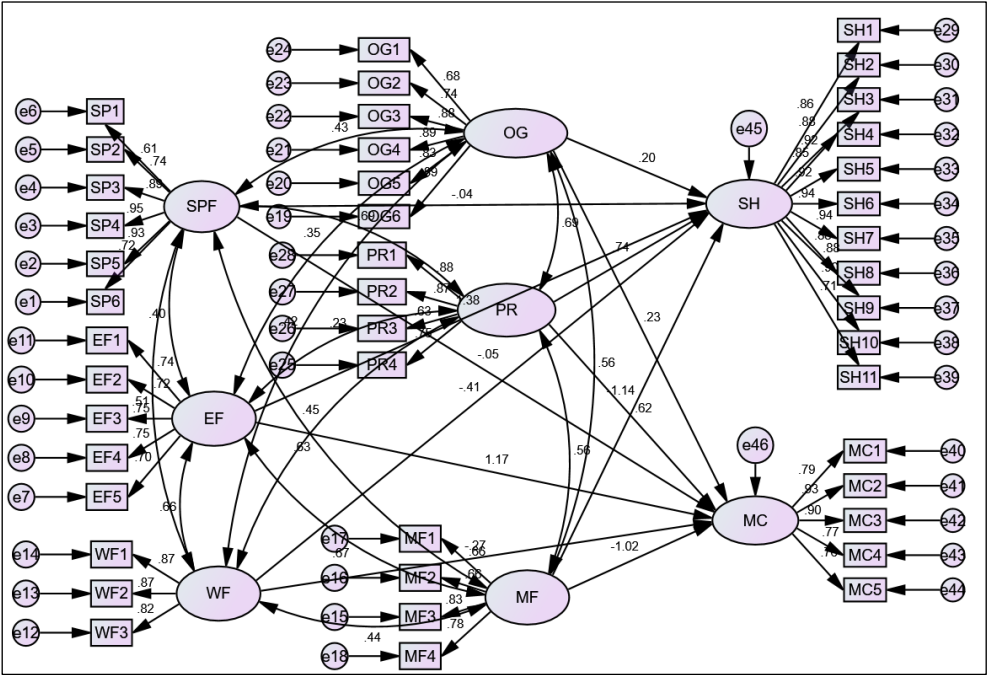

Figure 2. The AMOS graphic showing the output after the model is executed

The following Table 9 shows the regression weights and covariance for every path estimate. The regression weights indicate the estimate of the beta coefficient which measures the effect of every exogenous construct on the endogenous constructs based on twelve (12) hypotheses. The covariance estimate indicates the correlational relationship between two constructs.

Table 9. The regression weight and covariance for every path estimate in Figure 2

Construct	Path	Construct	Estimate	S.E	C.R.	P-value	Result
Regression Weight							
OG	⟶	SH	0.194	0.146	1.212	0.226	Not significant
PR	⟶	SH	0.736	0.239	3.251	0.001	Significant***
MF	⟶	SH	-1.134	0.212	-4.831	0.000	Significant***
SPF	⟶	SH	-0.043	0.201	-0.250	0.803	Not significant
EF	⟶	SH	1.384	0.345	5.153	0.000	Significant***
WF	⟶	SH	-0.409	0.210	-2.251	0.024	Not significant
MF	⟶	MC	-1.017	0.174	-4.565	0.000	Significant***
PR	⟶	MC	0.618	0.202	2.805	0.005	Not Significant
OG	⟶	MC	0.234	0.129	1.430	0.153	Not Significant
EF	⟶	MC	1.168	0.273	4.779	0.000	Significant***
WF	⟶	MC	-0.265	0.172	-1.546	0.122	Not significant
SPF	⟶	MC	-0.050	0.176	-0.291	0.771	Not significant
Covariance							
SPF	⟷	EF	0.861	0.273	3.151	0.002	Not significant
SPF	⟷	WF	1.202	0.312	3.857	0.000	Significant***
SPF	⟷	MF	1.920	0.437	4.393	0.000	Significant***
SPF	⟷	OG	1.298	0.365	3.553	0.000	Significant***
PR	⟷	SPF	1.794	0.399	4.494	0.000	Significant***
EF	⟷	WF	1.448	0.331	4.371	0.000	Significant***
EF	⟷	MF	1.880	0.428	4.392	0.000	Significant***
EF	⟷	OG	0.980	0.337	2.909	0.004	Not significant
PR	⟷	EF	0.546	0.282	1.935	0.53	Not significant
WF	⟷	MF	1.379	0.396	3.483	0.000	Significant***
WF	⟷	OG	1.298	0.371	3.501	0.000	Significant***
PR	⟷	WF	1.204	0.341	3.536	0.000	Significant***
MF	⟷	OG	2.240	0.516	4.342	0.000	Significant***
PR	⟷	MF	1.903	0.469	4.055	0.000	Significant***
PR	⟷	OG	2.346	0.486	4.832	0.000	Significant***

Risk Factors:
SPF = Safety performance factors
EF = External Factors
WF = Worksite Factors
MC = Managerial Factors

Challenges:
OG = Organizational Challenges
PR = Project Challenges

Risk Management:
SH = Safety & Health requirement
MC = Managerial Concerns

Table 10. Hypothesis testing

Hypothesis statement of path analysis	Results on Hypothesis
H1 = Risk factors have a positive and significant effect on risk management	
H1a = Safety performance factors have a positive and significant effect on safety and health requirement	Not supported
H1b = Safety performance factors have a positive and significant effect on managerial concerns	Not supported
H1c = External factors have a positive and significant effect on safety and health requirement	Supported
H1d = External factors have a positive and significant effect on managerial concerns	Supported
H1e = Worksite factors have a positive and significant effect on safety and health requirement	Not supported
H1f = Worksite factors have a positive and significant effect on managerial concerns	Not supported
H1g = Managerial factors have a positive and significant effect on safety and health requirement	Supported
H1h = Managerial factors have a positive and significant effect on managerial concerns	Supported

Hypothesis statement of path analysis	Results on Hypothesis
H2 = Challenges in Managing Risks has a significant effect on risk management	
H2a = Organisational challenges have a positive and significant effect on safety and health requirement	Not supported
H2b = Organisational challenges have a positive and significant effect on managerial concerns	Not supported
H2c = Project challenges have a positive and significant effect on safety and health requirement	Supported
H2d = Project challenges have a positive and significant effect on managerial concerns	Not supported

DISCUSSION

This research had tested twelve hypotheses related to high-rise building construction. From twelve (12) hypotheses tested, only five (5) were significant and supported. External factors and worksite factors are two constructs under risk factors that have a positive relationship towards risk management which is represented by safety and health requirement and managerial concerns. Meanwhile, only one construct under challenges that have a positive relationship to safety and health requirement. This research identified the complexity of construction as the highest factors with factor loading (Sig.= 0.832) and equipment and machinery (Sig.= 0.858) which leads to the implementation of risk management. This is in line with research done by Tan and Nicholas (2014) where a systematic approach in managing construction risks need to be done to minimize the construction project failure. High-rise building construction also needs to be assessed prior to manage and mitigate it (Md Sofwan et al., 2016). Lack of safety expert (Sig.= 0.917) in addition signifies the highest challenges in managing high-rise building construction risks and required a systematic approach of managing risks. According to Santoso and Ogunlana (2003), the development process of high-rise building construction requires experts with good coordination, communication and teamwork to provide smooth flows of construction activities. It can be observed that seven (7) hypotheses were not supported. One of the reasons is a small number of sample (105 samples) where SEM-AMOS require a larger sample size to get a better result. According to Hair (2010), if the model has more than seven latent constructs, it requires at least 500 sample. In view of validation, this research employed validation using statistical analysis (pooled-confirmatory factor analysis). Therefore, no validation is required because it was statistically proven using SEM-AMOS (Ahmad-Zaini, 2016; Guo et al., 2016).

CONCLUSION AND RECOMMENDATION

This research concludes that only five (5) out of twelve (12) hypotheses were supported after the theoretical framework were computed and modelled in AMOS syntax. This model will promote the safety climate in a construction site and at the same time can facilitate construction stakeholders in minimizing high-rise building construction risks. The research suggests future research to have a sufficient amount of data in order to employ SEM. Future research also may look into the inter-relationship of risk management towards the performance of the construction projects.

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NUMERICAL STUDY FOR INCOMPRESSIBLE BOUNDARY-LAYER FLOW PAST A SELECTED SARAWAK TERRAIN

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Abstract
This paper presents the study of a three-dimensional incompressible boundary-layer fluid flow passing a complex terrain. The main aim is to understand the airflow structures involved as the complexity of the terrain is increased. The motivation for the study originates from the frequent occurrence of helicopter accidents at mountainous areas. The problem is modelled by incorporating a selected topographical data into the incompressible boundary layer using reduced Navier Stokes equations where the derivation was earlier published. The governing equations are solved numerically by adopting the Newton-Raphson method. The distributions of the total skin-friction and the pressure over the terrain are presented and it was observed that there exist regions of flow separation, recirculation, and reattachment at certain critical height of the terrain. Due to the irregular shape of the terrain, the inconsistencies of the appearance and disappearance of flow separation are observed as the height of the terrain becomes relatively large.

Keywords: *Navier-Stokes equations; boundary-layer; high Reynolds number; skin-friction; nonlinear system.*

INTRODUCTION

The applications of modelling three-dimensional wind flow are not only focus on buildings, bridges, and vehicles but also on hills, escarpments, and complex terrains. In this study, a mathematical modelling of the wind flow motion that is produced when an oncoming incompressible boundary-layer flow passes a complex terrain is presented. The motivation for this study originates from the frequent occurrences of helicopter crashes at the mountainous area in Sarawak highlands. Wind flow can be defined as air in motion which is driven by pressure gradient; the greater the pressure gradient, the greater the wind speed. Typically, the wind flows over a single or multiple hills within the atmospheric boundary-layer can be modelled using the physical laws as described in the Navier-Stokes equations. The atmospheric boundary-layer is the bottommost layer of the atmosphere and the motion in this layer is known to be turbulent. Its motion can be affected by the changing of wind speed, wind direction, surface roughness and distance of the flow from the ground. Also, the thickness of the boundary-layer depends on the surface roughness, wind speed and level of the turbulence (Yiiong, 2015). Due to the dependence on the parameters mentioned, the field experiments for the flow modelling are difficult. Thus, the common approach has been to simulate the flow in wind tunnels with a scaled model that represents the hill or terrain. However, wind tunnel experiments are expensive and usually time consuming. In addition, the real operations and flow conditions are difficult to be fully replicated. At present, fortunately, broad ranges of accurate numerical simulations that are less expensive are available.

A substantial amount of numerical work has been carried out in investigating the behaviour of the flow over a single hill, ridge, gorge or all kinds, and also multiple hills or

mountains. The effect of the surface roughness on the behaviour of wind flow over hill had been done by Lun et al., 2003; Yassin et al., 2014; Cao etal., 2012. By adopting the standard and RNG k-ε turbulence models, the profile on the leeward side of the hill was found to be thicker due to the rough surface. The flow separation and recirculation in the wake region at leeward side of the rough hill were also noticed. Also, the reattachment point was found downstream of the hill (Yassin et al., 2014). The rougher the surface, the farther the reattachment point downstream of the hill had been observed by Cao et al., 2012 using a dynamic Smagorinsky subgrid-scale model. The effect of the slope on the flow was also studied, where they found a large-scale separation bubble was developed on the lee side of the steep hill whereas there was no separation bubble was noticed in the case of the shallow hill (Cao et al., 2012).

Besides that, Liu and Ishihara, 2014 had studied the effect of the canopy on the turbulent flow over the three-dimensional hill based on the standard Smagorinsky-Lily model. It was noticed that the velocity fluctuation at the top of the canopy was the greatest; and, high turbulence fluctuation was found in the wake region at leeward side of the hill, which was in line with the finding of Liu et al., 2016. In addition, Liu et al., 2016 reported that the flow in the wake of the three-dimensional hill was recovered much faster than that of two-dimensional ridge. This was due to the presence of the mean spanwise flow which was not considered in the two-dimensional configuration. Likewise, the separation bubble of the three-dimensional hill was found to be smaller than that of the two-dimensional ridge. This discrepancy was attributable to the limited two-dimensional flow features of the ridge, in which the change of flow pattern was not found in spanwise direction. Interestingly, an embedded of a smaller secondary separation bubble inside a large primary bubble at the leeward side of the axisymmetric hill was noticed without any turbulence model adopted Castagna and Yao, 2009. An investigation of the effect of a double hill on the flow pattern using k-ε turbulence model was done by Zhang and Liu, 2014. In comparison to a single hill, smaller mean, fluctuating quantities and speed-up ratio over the top of double hills were found; between and behind the double hills, intensive flow separations were also noticed. Moreover, the neighbouring higher hill was found to have significant influence on the flow over the lower hill; but the flow over higher hill was not much affected by the lower hill and thus caused the flow reversal behind the downwind lower hill nearly invisible.

In a recent work of Chaudhari et al., 2016, the effect of a complex terrain was investigated, and the smaller eddies were modelled using the one-equation eddy viscosity subgrid-scale model. It was found that the influence of the complex terrain on the local flow field was indeed significant, where the turbulent fluctuations were found to be more intense and the flow separations were found just after the cliff and on the leeward sides. Also, in the work of Hu et al., 2016 where a SST k-ω turbulence model was adopted, the terrain's height was found to have small effect on the mean wind speed and turbulence intensity at the centre of the gorge; a good agreement between the numerical results and wind tunnel test was obtained as well. Apparently, the flow characteristics mentioned above are undoubtedly caused by the complexity of the hill or terrain. Most of these studies (Liu et al., 2016; Castagna and Yao, 2009; Zhang and Liu, 2014; Chaudhari et al., 2016; Hu et al., 2016) uses turbulence model to formulate their governing equations. In this study the topographical data is incorporated into the mathematical model through a simplified mechanism and yet still producing similar results with those of the turbulence model.

MATHEMATICAL FORMULATION

In this study, the details of the mathematical formulation of the problem are not shown here and it could be found in the work of Yiiong, 2015. Hence, the nonlinear governing equations, which were derived from the steady three-dimensional incompressible Navier-Stokes equations in Cartesian coordinates system, are:

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + w = 0 , \tag{1a}$$

$$u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} = \frac{\partial \tau_x}{\partial y} , \tag{1b}$$

$$u\frac{\partial w}{\partial x} + v\frac{\partial w}{\partial y} + w^2 = -Q(x) + \frac{\partial \tau_z}{\partial y} , \tag{1c}$$

$$\tau_x = \frac{\partial u}{\partial y} , \tag{1d}$$

$$\tau_z = \frac{\partial w}{\partial y} , \tag{1e}$$

where $u(x, y)$, $v(x, y)$ and $w(x, y)$ are the streamwise, vertical and spanwise velocities respectively. The first-order equations (1a) – (1e) are subjected to the boundary condition

$$u \sim y + h\big(F(x) - F(-\infty)\big) as\ y \to \infty, \tag{1f}$$

the no-slip condition

$$u = v = w = 0\ at\ y = 0, \tag{1g}$$

and initial condition

$$u = y, v = w = 0\ at\ x = 0. \tag{1h}$$

It is noteworthy that the boundary condition must be satisfied in order to obtain the converged solution. τ_x and τ_z are the shear-stresses in streamwise and spanwise directions respectively, $Q(x)$ is the pressure and $F(x)$ is the equation of the shape of the oncoming obstacle where for this study is the terrain. Also, the spanwise velocity is required to be vanished when the flow gets far from the ground. This requirement indicates that

$$w \to 0\ as\ y \to \infty. \tag{1i}$$

In order to solve the system of the nonlinear governing equations (1a) – (1e), Newton-Raphson method was adopted and the work of Yiiong, 2015 could be referred for the description of solving the system of the nonlinear equations.

As the focus of this study is to investigate the behaviour of the boundary-layer flow near the surface of the terrain, which means that the variable $F(x)$ must first be defined. A mountainous area located in Sarawak with its geographical coordinates from 3°45'18.73"N 115°28'20.20"E to 3°45'47.85"N 115°29'25.38"E, was selected as our case study. Figure 1 shows the elevation profile of the chosen terrain.
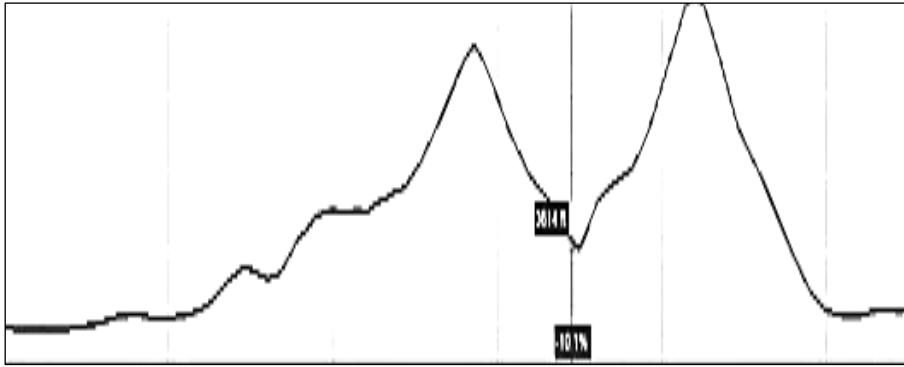
Figure 1. Elevation profile of the terrain

The obtained elevation profile is then rescaled, where the *x*-axis represents the distance of the chosen area which is set as 0 to 8 and the *y*-axis represents the elevation of the area is set as 0 to 2. Also, the rescaled elevation profile is digitized using a graph digitizer so that a new set of values that represent the *x* and *y* data can be extracted. By fitting a nonlinear function to the extracted *x* and *y* data, a function of *y* = *F*(*x*) that represents the shape of the terrain can be obtained as shown in equation (2).

$$F(x) = h\left(1.4979e^{\frac{(-\ln 2)(x-6.0798)^2}{(0.3112)^2}} + 0.8984e^{\frac{(-\ln 2)(x-4.1679)^2}{(0.2837)^2}} + 0.3477e^{\frac{(-\ln 2)(x-2.734)^2}{(0.3016)^2}} + 0.1822e^{\frac{(-\ln 2)(x-5.2027)^2}{(0.0856)^2}} + \right.$$
$$0.2271e^{\frac{(-\ln 2)(x-2.1171)^2}{(0.1675)^2}} + 0.4609e^{\frac{(-\ln 2)(x-6.654)^2}{(0.2454)^2}} + 0.9125e^{\frac{(-\ln 2)(x-3.745)^2}{(0.8219)^2}} + 0.0962e^{\frac{(-\ln 2)(x-7.7461)^2}{(0.1764)^2}} + $$
$$0.4094e^{\frac{(-\ln 2)(x-4.7413)^2}{(0.2778)^2}} + 0.3634e^{\frac{(-\ln 2)(x-5.6122)^2}{(0.2002)^2}} + 0.1124e^{\frac{(-\ln 2)(x-1.8633)^2}{(0.2656)^2}} + 0.0804e^{\frac{(-\ln 2)(x-1.1517)^2}{(0.2499)^2}} + $$
$$0.0665e^{\frac{(-\ln 2)(x-6.9526)^2}{(0.1261)^2}} + 0.375e^{\frac{(-\ln 2)(x-5.3479)^2}{(0.1402)^2}} + 0.0823e^{\frac{(-\ln 2)(x-8.0227)^2}{(0.1205)^2}} + 0.4971e^{\frac{(-\ln 2)(x-6.1144)^2}{(0.7772)^2}} + $$
$$\left.(-2.3033 \times 10^{77})e^{\frac{(-\ln 2)(x-(3.1825 \times 10^{74}))^2}{(-1.9505 \times 10^{73})^2}}\right) \tag{2}$$

where *h* is the parameter that controls the height of the terrain. Here, the terrain is reduced to two dimensions as its width is assumed to be very small since the behaviour of the flow near the surface is the focus. Once equation (2) is obtained, it can then be incorporated into the boundary condition (1f) and thus by solving the governing equations (1a) – (1e) with the corresponding conditions (1f) – (1i), the wind flow around this selected terrain can be obtained.

NUMERICAL RESULTS

The focus of the study is to identify the region where flow separation occurrences, thus, the numerical results of the distribution of pressure and total skin-friction past through the selected terrain are presented in this section. The effect of increasing the height of the terrain to the total skin-friction and pressure will be studied. It is important to note that the equations (1d) and (1e) represent the perturbation of the skin-friction from the total value of skin-friction only, thus, the total value of skin-friction is $\tau_{total} = 1 + h\frac{\partial}{\partial y}\left[\frac{\partial \tilde{u}}{\partial x} + \tilde{w}\right]_{y=0}$. Generally, when the total skin-friction changes sign where it is approximately zero from positive value, the flow starts to separate at that particular point. The flow reversal is said to occur if the value of the total skin-friction is negative. Also, when the total skin-friction is approximately zero from negative value, the reattachment of the flow is said to be found at that point. Besides that, the speed of the flow increases with the increasing of the pressure gradient. In other words, the speed of the flow is proportional to the pressure gradient. As seen in Figure 2, the local

maximum values of total skin-friction are increased, and its local minimum values are decreased accordingly as h is increased. Besides that, the critical height h_c for the first separation point of the flow is found as $h_c = 0.385$ at the point of $x \approx 6.2$, where the total skin-friction decreased rapidly from positive value to zero and then increased again as the flow past through that point at rear-face of the terrain. As h is further increased to 0.4, it is found that the flow separated slightly earlier than the case of $h_c = 0.385$; the reversal of flow is found in the range of $6.15 < x < 6.25$, in which the values of the total skin-friction are negative. As depicted in Figure 3, similar behaviour of the distribution of the total skin-friction is also found in the distribution of pressure with the increment of h; the local maximum values of pressure are increased and the local minimum values are decreased accordingly as h is increased. However, different behaviour of the pressure is observed in the range of $6.8 < x < 7$ as shown in Figure 4. Within the range of $6.8 < x < 7$, the local minimum value of pressure is found to be increased with the increment of h to 0.2 but it is decreased as h is further increased; also, its local maximum value at $x \approx 6.95$ is found to be increased with the increment of h to 0.385 but it is decreased as h is further increased.
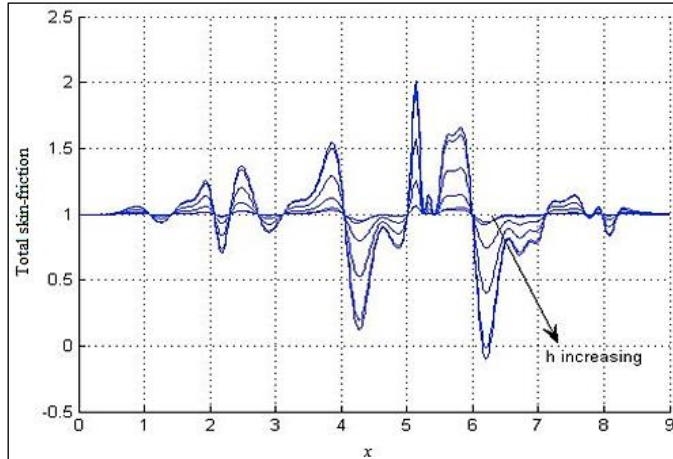
Figure 2. The distribution of the total skin-friction of nonlinear numerical case as h increases
$(h = 0.05, 0.1, 0.2, 0.3, 0.385, 0.4)$.
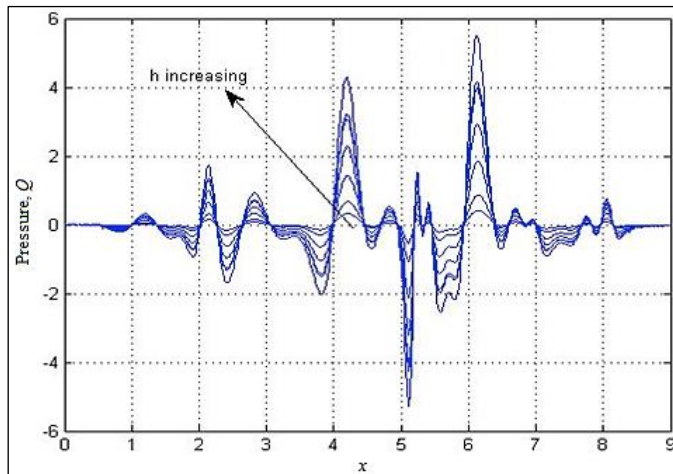
Figure 3. The distribution of the pressure Q of nonlinear numerical case as h increases
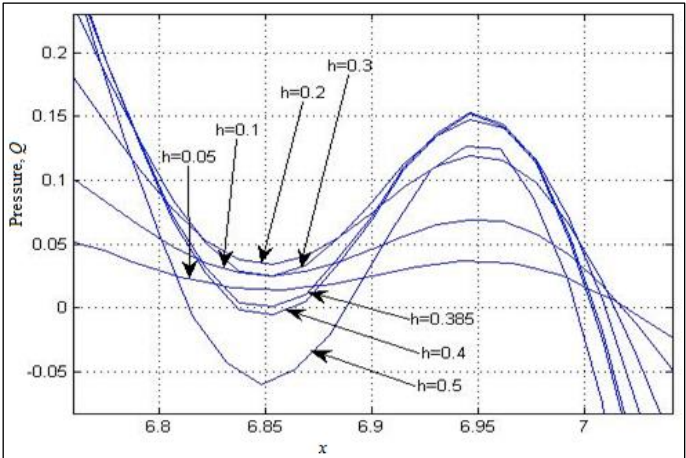$(h = 0.05, 0.1, 0.2, 0.3, 0.385, 0.4, 0.5)$.

Figure 4. The distribution of the pressure Q of nonlinear numerical case within the range of $6.8 < x < 7$ as h increases ($h = 0.05, 0.1, 0.2, 0.3, 0.385, 0.4, 0.5$).

Next, we seek for more critical height for the flow separation as well as the regions of flow recirculation as the flow past through the terrain. Figure 5 depicted the distribution of the total skin-friction with different values of critical height accordingly. Obviously, more flow separation points and flow recirculation regions are noticed as h is increased, where two, three, five and six separation points of the flow are respectively noticed at $h_c = 0.425$, $h_c = 0.7$, $h_c = 0.82$ and $h_c = 1$. When h is further increased, the behaviour of the flow becomes distinct. As shown in Figure 6 and Figure 7, for $h \geq 1.6$, new separation point is noticed in the range of $1 < x < 1.5$; but, the separation point at $x \approx 6.7$ is vanished as the local minimum value of total skin-friction is moved up to positive value. Apparently, when the complexity of terrain is increased by increasing its height, the behaviour of the flow over the terrain becomes complicated.
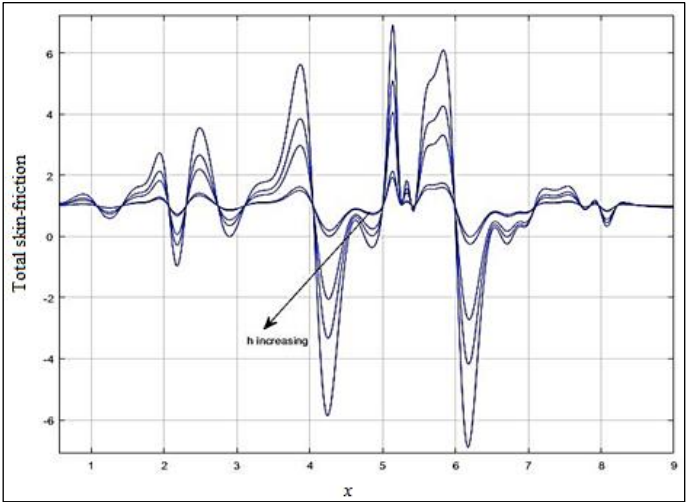
Figure 5. The distribution of the total skin-friction of nonlinear numerical case as h increases ($h = 0.385, 0.425, 0.7, 0.82, 1$).
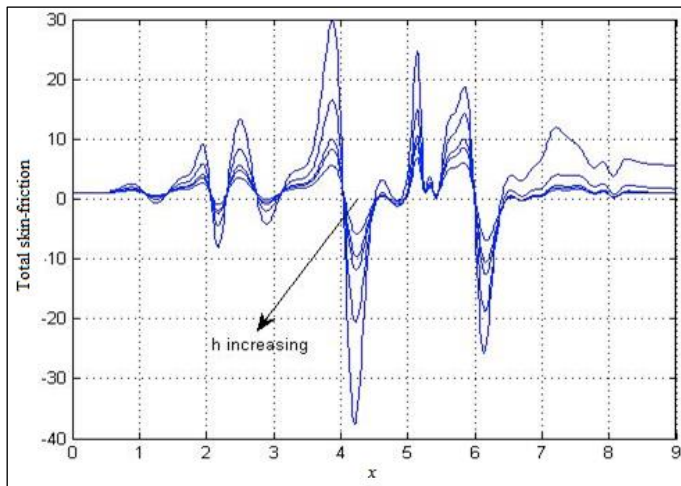
Figure 6. The distribution of the total skin-friction of nonlinear numerical case as h increases
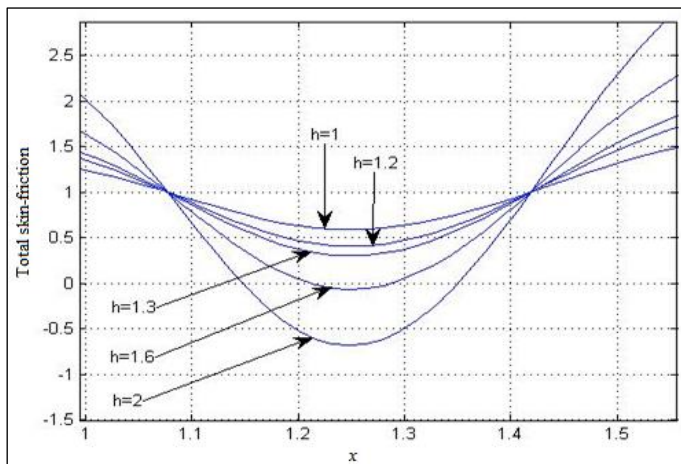($h = 1, 1.2, 1.3, 1.6, 2$).

Figure 7. The distribution of the total skin-friction of nonlinear numerical case within the range of
$1 < x < 1.5$ as h increases ($h = 1, 1.2, 1.3, 1.6, 2.0$).

CONCLUSION

In this study, the numerical results obtained for the boundary-layer flow past through a three-dimensional terrain have been presented. The topographical data obtained is successfully processed and incorporated into the three-dimensional mathematical model. The flow becomes nonlinear when the height of terrain is increased sufficiently. The behaviour of the total skin-friction and pressure are also found to be complicated as the height of terrain is increased. More flow separation points, flow recirculation regions and flow reattachment points are noticed with the increment of the height of terrain; however, some are vanished while some are newly appeared when the value of h is relatively large. Through the findings from this study, overall scientific understanding of the air flow patterns over the terrain can be improved and thus the best path of less eddies can be identified and provided to the pilot so that the helicopter accidents can be minimised. Therefore, the future work would be to take into account of other factors such as the temperature, wind direction and earth's rotation in order to have a more realistic mathematical model.

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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)*

HEADING 1 (Arial Bold + Upper Case, 11pt)

Heading 2 (Arial Bold + Lower Case, 11pt)

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Body Text: Times New Roman, 11 pt. All paragraph must be differentiated by 0.64 cm tab.

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.

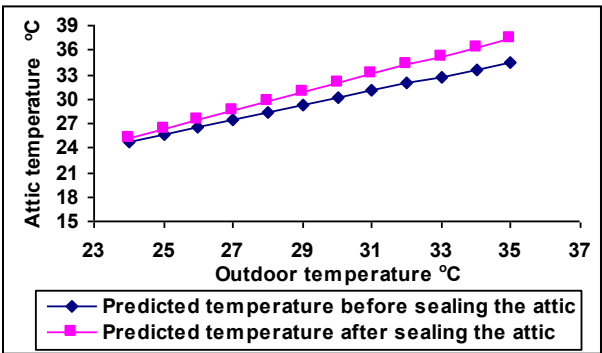**Figures caption:** Arial Bold + Arial, 9pt. should be written below the figures.

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)
Two authors	Walker and Allen (2004)	Walker and Allen (2004)	(Walker & Allen, 2004)	(Walker & Allen, 2004)
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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