Modular Construction System in Malaysia: Issues for Research in Sustaining an Affordable Home Project

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Abstract

A house that is manufactured in factory processes and produced in a module (as a unit) is defined as Modular Construction System (MCS). It was also known as Modern Method of Construction (MMC) or Offsite Fabrication (OSF) in the construction industry in other developed countries. In Malaysia, the MCS or Volumetric Modules building was categorised as an innovative method in Industrialised Building Systems (IBS) classification. It was considered to promote a solution to the construction industry in enhancing a better productivity and quality objectives. Hence, it seemed to achieve and satisfied the sustainable issues of the housing industry. From the previous research findings such as availability of reliable manufacturers, sustained and durable materials, accessibility to site, factory location, best transportation routes and management, user perception, authority approval, manufacturing and production cost are the outstanding issues that challenged the adoption of modular construction system in Malaysia. This paper is a division of current research on modular design for an affordable home. The adoption of a new method (MCS) was anticipated to promote a new paradigm and way forward for IBS industry to solve its current problems that it has to face in the construction industry. It was expected that the adoption of modular construction into IBS was the avant-garde to produce more affordable home in future. The data and information presented in this paper was gathered from the reviews of the available relevant literature related to MCS and IBS in Malaysia. This paper suggested an analysis of the initial findings for MCS issues to be searched and explored in depth in Malaysia context. This paper also recommended a conclusion that green and sustainability agenda in affordable housing construction are underpinned by design "combinatorial concept" of MCS.

Keywords: Affordable Home, Combinatorial, Design Sustainability, Modular Construction

1.0 Introduction

Continuous change in the present market, social structure and global warming resulted in a demand for more versatile and environmental friendly buildings. This aspect can be classified as needs for more acceptable building design especially for housing: it has become a major issue for the people. To build a sustainable building design, one has to consider the study of production of CO2 emissions of the building, energy and other environmental aspects of law require more assertive and integrated regulations in the building codes, new protocols and certification systems. Conventional buildings is one of the major current systems in building industry which has failed to meet the needs of sustainability in term of quality, waste reduction, shorter time of construction, mass customization for an affordable home for people. In this situation, this research proposes "Combinatorial Concept" as a counter for the demands of sustainability agenda. This paper narrows down on issues and trends related of MCS in Malaysia. This issue is important to be searched in Malaysia as to find out what is the current perceptions and acceptance of Malaysians towards of MCS and sustainability.

A government plan for 600,000 to 800,000 house units was expected to be built (8th Malaysia Plan, 2001-2005). This was affected by huge demand of housing in Malaysia and also the growth of IBS. The traditional method of construction could not cope with the demand (Kadir et al. 2005). Between 2005 and 2010, Al Aghbari (2004) stated that 709,400 units of the houses needed to be constructed. Increased total of 8,850,554 units (included 4,964,560 units of new housing) were the demand of Malaysian residential buildings between 1995 and 2020 (Yoke et al. 2003). The issues of an affordable home in Malaysia are crucial -since the price of the housing increases every year. In recent years, house prices in city centre are exorbitant for the people. The biggest effect of house price was the land itself. When restricted by the constraints of space, cost or materials, there was a great challenge but also a great opportunity to design homes that are not just functional but liveable. As cities continue to grow, affordability and availability of living spaces become increasingly problematic. Malaysia

housing department focused on various segments of society and on boosting socioeconomic status, built environment, safety and comfortable (10th Malaysian Plan). PR1MA housing was an example of affordable home that is supposed to use the modular construction in Malaysia as planned by the government. This paper recommends that the shape of green (design sustainability) have to be considered in designing a building. There are some critical issues on IBS construction in Malaysia which mostly IBS project use the traditional approach in construction (Nawi et al. 2013). The adoption of modular construction into IBS is a way forward to produce more houses in future in limited time.

This paper aims to identify the potential sustainable attributes in MCS through IBS in Malaysia, issues, current trend and challenges faced in the construction industry, and then continue to discuss the correlation between modularity and shape of sustainability. In addition, this paper proposes a combinatorial concept through modular design as future innovation IBS projects in Malaysia in an aspect of volumetric construction.

1.1 Affordable Home in Malaysia

Currently, the Malaysian residential property market continues to drive the growth in the property market in the past few years, developers and property players were fascinated and projects related to sustainable buildings upsurge. Construction stakeholders (architects, builders and developers) in the country have changed towards accomplishing sustainable building guideline as initiative to housing issues. The advantage of this change also impacts the growth of reasonably priced houses. In past few years, interest and practiced link to green building have increased. Construction industry players have changed toward accomplishing green building guideline and sub-guideline of energy and an extensive usage of reuse and recycled materials in developing houses. Affordable house is most important basic needs for the people and the fund was allocated from the government around RM 1.9 billion for construction of 123,000 units of affordable home in several strategic locations. These projects will be implemented by PRIMA, Syarikat Perumahan Nasional Berhad (SPNB) and Department of Statistic Malaysia (Malaysia Budget, 2013). According to National Budget 2014, the government emphasized the issue of housing in the five important things related to the budget. It is referred to as MyHome private affordable ownership housing scheme. Preliminary report on Household Income Survey 2014 conducted by the government showed the average household income was above the RM5, 900 a month, including non-salary income as well as returns from investments in various instruments such as unit trusts. What demand can be attributed to increasing low-cost housing? Through this statistic, for every new housing construction, developers need to take into account the construction of affordable housing. For the average level of household income RM5, 900, the houses must be made for those earning between RM2, 350 and RM2, 100 on average. Azriyati et al. (2011), stated that the affordable price for housing can be identified according to different states in Malaysia. In Kuala Lumpur, an acceptable price for affordability is between RM 180,000 and RM 200,000 for a unit of house.

Abdullah (2010) stated factors of using IBS in Malaysia housing construction are economic, social, politic and environmental factors. MCS is included in IBS as the new method of offsite construction. Modular construction is one of the innovative methods for a sustainable design solution for the building industry instead of traditional construction. Musa et al. (2015) stated that modular construction is a construction process to produce a building component or modules with the same design and standard in a manufacturing facility, then to be transported and installed to become a building. In Malaysia, it was reported that a MCS which has been used for public projects are handled by world-class Malaysian developers. It is agreed that affordable houses for the average Malaysians are desperately needed. The report stated that the majority of Malaysian's' household income is approximately in between RM 2,000 and RM 3,000 (Department of Statistic Malaysia, 2014). Therefore, to provide an affordable house within the range of target group income becomes the focus of new agenda for the government as stated in 2013 and 2014 Malaysian National Budget. The introduction of a new scheme of an affordable housing project was Perumahan Rakyat 1 Malaysia- PR1MA (Mampu Milik) which was acted and enacted by parliament in 2012 (Razak, 2011). Hence, it proves the highest commitment by the government in providing an affordable housing for a future. Construction of affordable housing for public becomes a crucial issue in Malaysia. The urgency of purchasing the first home for every Malaysian becomes critical. There is a huge demand for housing in Malaysia but as a house price becomes expensive because the requirement is not met. However, the government is committed to ensuring that public has the opportunity to own a house.

1.2 Definitions and Characteristics of Modular Construction

IBS is also justified as product or process, industrialised construction and prefabrication concept (Kamar et al. 2011). In addition Kamar et al. (2011) quoted, revolution of IBS classification into seven types started from frame system (pre-cast or steel), panelized system, on-site fabrication, sub-assembly and components, block

work system, hybrid system and volumetric (modular system). IBS implemented in Malaysia because of issues skilled craft worker, fast-track completion, cost and transportation (Azman et al. 2012). It has similarity with United Kingdom (UK). The major material used for IBS in Malaysia is precast concrete system just like in the UK. Automation is linked to the works repetition in a factory. Besides that, it's applied with massive product series, while architectural design carries implicitly the idea of exclusivity (Diez, Victor, A. Mohamed and Balaquer, 2012). There was different in term of a technique of site built construction and modular construction. Conventional construction using manual technique and modular construction used automation for its method of construction. Common practice construction method in Malaysia using conventional system; the system used reinforced concrete frame and brick, beam, column, wall and roof which are cast in situ using timber framework while steel reinforcement is fabricated off-site (Lou & Kamar, 2012). The adoption of MCS into IBS is way forward for future IBS industry in Malaysia. Modular construction defines as a method of constructing a building using three-dimensional or modular units, which are assembled and produced in a factory (Musa et al. 2015). Modular IBS define for construction method with better quality output which produce in factory, productivity and efficiency, speed up project period, flexible, economic design (mass customization), and reduce risk for occupational safety and health (Musa et al. 2015). In addition, modular IBS come up with green design and construction solutions to improved environmental impact (Lawson et al. 2012; LEED, 2009; MBI, 2010, 2013). Table 1.0 shows definitions of modular construction from successful countries applied MCS and Malaysia.

Table 1: Definitions of Modular Construction (Azman et al. 2012)

No	Countries	Definitions of Modular Construction	Author
1	Malaysia	Standalone units or combined (fully assembled 3D modules), by joining on-site, to form a modular building, consisting of several linked and stacked modules with appropriate cladding features. Volumetric modules perhaps stacked a few storeys high based on module construction and require extra structural components, etc.	Rohana Mahbub (2015)
2	US	Operation that constructs a building off-site (produce in modules), under supervise plant conditions apply the similar materials and designed to same codes and standards as conventionally built facilities but in about half the time. Building modules when put together on site look alike traditional built facility.	Modular Building Institute (2013)
3	UK	Fully fitted out in a manufacturing facility comprises of prefabricated room size volumetric units (load bearing; building block) and will be install on site.	Lawson (2010), Goodier and Gib (2004)
4	Japan	Modular units produced off the site; in the factory (offsite construction method). Then, the modular units are transported to the building site.	Japan Modular Construction (2013)

Modular buildings refer to permanent, temporary or relocatable building. These are offsite construction which it's affordable building solution and fast construction. Manufactured modular buildings are built to merge the suitable buildings codes. It based on occupancy and site context. After that, units transported to the site, located on a foundation, secured at the mate lines and linked to utilities. Entry doors can be access by installed decking or concrete flatwork. At last, its apply finishes to the construction modules such as brick façade, peaked roof or entrance canopy. This aspect of finishes applied to the buildings for the aesthetic value of the building include exterior appearance (Innovative Modular Solutions, 2011). Planned use and occupancy of the building codes are two criteria's to be considered when to construct prefabricated modular building. Moreover, Newman (2014) quoted prefabricated housing is a next generation housing construction industry, a game changer in a cost of housing, competitiveness, efficiency and productivity. According to Lawson (2012), the primary advantages of modular construction are;

- Speed of installation on site
- Manufactured economy (mass customization units)
- The manufacturing process improves the quality and accuracy of its building.

Besides that, the benefits of modular construction use a shorter time to finish construction at the site, reduce the number of deliveries and quality of materials is better than conventional building because it is not affected by weather conditions. There was less noise and involvement to the daily operation of the site and its occupants in modular building construction. The benefits of offsite construction such fast delivery and affordable modular building solutions. The building can be permanent, temporary or re-locatable. MCS can minimise time on the site, reduce the number of deliveries and are virtually unaffected by weather conditions. That's differentiated between conventional systems. MCS may be combined with the traditional method of construction (hybrid

system) to give the best output of the building (end-product). Table 2 shows characteristics of modular construction from successful countries applied their modular construction industry.

Table 2: Characteristics of Modular Construction (Musa et al. 2015)

No	Countries	Characteristics of Modular Construction	Author
1	USA	Identical modules, Greener, Smarter, Faster	Lu (2009)
2	UK	Room size volumetric units, Economic, Faster, High quality, Sustainable	Goodier & Gibb (2004)
3	Japan	Modular units, Quality control, Green, Movable, Faster, Solid construction	Japan Modular Construction (2013)
4	Malaysia	Faster, High quality of modular units, Sustainable, Flexibility and reuse, Ease renovations, Logistic, Organized coordination, planning and communication	Faiz et. al (2014)

Structurally, modular buildings are stronger than conventional construction. The factors modular building stronger because of each modular unit is engineered independently. A quality engineered modular unit can withstand the rigors of transportation and to ensure that they can be lifted onto foundations. In an aspect of time finishing the project, modular construction speeds up project schedule about forty per cent earlier than conventional construction. In short, the term modular construction can be defines home or house buildings that are manufactured in a factory processes and produced in a modules (as a unit), recycle and re-use ability, flexible in term of geometrical design (rectangular is the appropriate design to suite sustainability), variation of materials, smarter technology, speed up project, cost effective, systemize project management, planning and design and sustainable.

2.0 Issues and Trend of Modular Construction in Malaysia

In the on-going research, the Author conducted a few case studies on Malaysia modular buildings in different urban place in order to search for issues and information of the research topic. In this paper, the Author stated the issues from current and past literature review by other authors. The needs of MCS in construction industry as to discover solutions and appropriate methods to the present construction system to overcome the various problems affecting the ownership of affordable housing and the problems that arise in Hybrid and Innovative system stage of IBS. There are needs for innovation in the MMC in Malaysia construction industry. Pan (2005) quoted lack of skills shortage, to attain agreed costs and time, accomplish high quality and reduce on-site period were the reasons to used MMC and offsite technologies in the country.

2.1 Issues for Implementation of Modular Construction in Malaysia

2.1.1 Lack of Modular Experts

Musa et al. (2014) suggested that sustainability requires innovation and adoption of MCS through IBS. Building players in Malaysia seem to be lacking in knowledge in MCS. Construction stakeholders are also less aware and experienced in MCS, in the construction industry. These factors affected construction project flow. IBS designers in Malaysia are not interested in manufacturing industry because of various problems they have to face and risk from the IBS project itself. Moreover, there is an obvious lack of MCS skills and knowledge among building players. Construction stakeholders must acquire knowledge on the latest construction technology to implement IBS, MMC and OSM in the country. Change of economic and global competition in this MCS field can be achieved among building players by all these factors (Azman et al. 2012). Abdullah (2010) quoted that there is a need of IBS knowledge evolution among building players to implement IBS in the country. The suitable strategy, policy and procedures are required to achieve MMC. There was a lack of knowledge in structural analysis and pre-fabricated components design among civil engineers (Abd Rahman & Omar, 2006). This discourages and demotivate the relevant authority to pursue the implementation of IBS in Malaysia. Construction industry players have to make the necessary changes in the aspect of attitude, innovation, creativity, research and be supportive towards sustainability mentality (Hamid et al. 2011). Besides that, Hamid et al. (2011) recommended learning and education syllabus on green construction in primary school to university level.

Azman et al. (2014) stated that to initiate IBS, MMC and OSM in Malaysia construction industry, the building player needs knowledge on the present construction technology. The adoption of IBS in Malaysia construction industry, requires building players to revitalize of new mindset of awareness, change management and business engineering (Musa et al. 2014). There was the lack of skill and expertise in MMC among building players. This statement was supported by Kamar and Hamid (2011), who mentioned that the lack of mastery and capability in

IBS knowledge existed in the country. On the other hand, architects were inattentive ideate embody of IBS building parts in the architectural design process. As the architects have less knowledge and data about IBS, unessential design failed during detailed construction documentation. This resulted in the delay of projects scheduled (Mohamad Kamar et al. 2009). He added that, lack of skills and knowledge resulted in unsuitable fabrication of the building components. Teow (2015) quoted the unskilled worker and improper IBS manufacturers or contractor leads to low quality of IBS projects in Malaysia. Current IBS projects failure in Malaysia leads to modular entrepreneur and Malaysians feeling doubtful of the future in MCS. Lack of expertise of the building materials and fitting methods and no ideal design or specifications on the systems has led to the low quality of final products (Hamid et al.2007; Rahman & Omar, 2006).

2.1.2 Current IBS (Hybrid and Innovative System) Project Risk Faced by Construction Industry Players

There were so many issues related on project risk faced by construction industry player in managing IBS project in Malaysia. Failure to deal with IBS projects risk was the reason behind the construction companies in Malaysia do not prepare for Offsite construction (Musa et al. 2014). In the Malaysia's construction process related to IBS project management, 28 problems had occurred and these were divided into three classes such as, pre-construction, construction and post-construction phase as reported in literature research (Jabar et al. 2013). Jabar et al. (2013) stated that construction phase was the biggest issues in IBS. The incorporation of many parties in construction stage caused crucial issues and generally construction stage has a longer schedule of time compared to the other two stages. It resulted in multiple problems of the construction arises (Jabar et al.2013). CIDB (2003) stated in 2003, about 15 % usage of IBS of the construction projects in Malaysia. In addition, low utilization and accomplishment of IBS projects in Malaysia conventionally have been recognized (Haron et al. 2009). The issues of IBS in Hybrid System are listed below;

a) Lack of project pre-planning, project coordination, preliminary design and transportation

Most IBS projects in Malaysia used the traditional approach in construction. Most building projects based IBS system in Malaysia still use traditional techniques (traditional approach) to use to run the project (Nasrun et al. 2014). The problems of IBS were imperfect coordination between architect and manufacturer, interaction conflict between manufacturers and limited application of building materials (Thanoon et al. 2003). Shukor et al. (2011) mentioned that no incorporation of the contractor at an early stage of the project (design phase). This resulted in the contractors have no voice or suggestion on the early phase of design, system and construction as well. The situation can be concluded as a result of the lack of cooperation among project team of the IBS construction in the country.

b) Prefabricated modular IBS was higher cost of production, manufacturing and construction

The higher cost of construction in using the IBS method was the major barrier to adoption. The current higher cost of construction using the IBS method is a major barrier to adoption. Due to the lack of commonly accepted sizes of products, IBS manufacturers are not producing at a cost for an optimal level. Hence, standardisation is the first step towards affordable IBS products (IBS Road Map 2011-2015). Besides that, in IBS Road Map 2011-2015 it was stated that IBS was not just for concrete based. Kamar (2013) indicated that many contractors were unwilling to engage in any IBS project due to the higher cost in term of material and cost of labour even when there is presently cost saving innitiative in the IBS itself. In addition, Shamsuddin et al. (2013) quoted, one of the benefits of IBS was the overall cost saving for the project prefer than individual cost view undeniably it offers secure returns of investment (profit). IBS implementation in Malaysia construction industry needs higher cost capital (CIDB, 2010; Pan et al. 2004; Pan et al. 2007; Blismas & Wakefield, 2009). This became the major issue for the promotion of IBS in the country. Moreover, in IBS construction there were needs of higher cost investments in aspect of situate the plant, allocate the machinery and mould, engineering attention in conducted with difficulty of interfaces and expense of the transportation procedure (Qays et al. 2010; Haas & Fagerlund, 2002). The stakeholders involved in IBS demand high cost of investment; a mega volume of tasks to break and a gigantic scale of manufacturing and fabrication in order to attain commercial viability (Pan et al., 2007; Hamid et al., 2008; Alinaitwe et al., 2011). Besides higher investment to set up a plant, maintenance of equipment and machinery also require some budget. Unsustainable of IBS faced by stakeholders occurred because of lack of consistency of size demand causing the adopters to deal with problem in business flow. Barriers to green building existed because of the ability of construction cost to suit acceptable project cost constraints (Robichaud and Anantatmula, 2010).

c) Technical Failures

There are many problems in the previous IBS projects such as technical issue and water leakage. Some designs of IBS components were not in the scale as it affects the safety of the structure and building envelope of the building. Structural defeat and water leakages happened in IBS projects because of construction defects which were difficult to rehabilitate. Monotonous design and lack of aesthetic value of the buildings were the outcome of the difficulty to rehabilitate obstacles of IBS construction defects. Consequently, this gives an impact to the architects and building designer creativity of architectural design of the IBS projects (Jaganathan et al. 2013). Low end quality occurred because of improper assembly of the IBS components (Mohamad Kamar et al. 2009). Not enough technical knowledge of IBS leads to poor workmanship for end quality of the IBS projects. The building finished with the problems of defects, less aesthetic value and functional faults (Onyeizu et al. 2011). Poor thermal insulation and improper joining leads to building defects such ask water leakage, moisture penetration blemishes and cracks (Onyeizu et al. 2011). Future maintenance of the buildings needs when there where defects of IBS buildings during handover (Wong et al.2003). Jabar et al. (2013) stated that if the issues of a technical problem are not properly overcome, the quality of building cannot be gained and it would be difficult to even reduce construction defects of the IBS buildings itself. Sustainable construction can be achieved by practices and application of Offsite Manufacturing (Hamid et al. 2011). Product selection and parameters joint design and need to be studied in order to understand the relationship between manufacturing and construction (Foley, 2002; and Tan, 2006).

2.1.3 Lack of Innovation in MCS

MCS still at an initial stage of adoption in Malaysian construction industry. New construction materials or new MMC is parallel with innovation in the IBS. Innovation of MCS can be as new as an improvement for IBS in Malaysia. Malaysian sustainable construction lacked innovation and research (Kamar and Hamid, 2011). They also stated the lack of knowledge of environmental undertone and its solution has to be that Malaysian strives for the sustainable construction. The lack of innovation in term of materials, design and system in MCS becoming the challenges to applying MCS in Malaysia construction industry. Materials, Information Technology (IT) and robotic were the field of innovation to improve building quality in the aspect of construction method and industrialization process (Sumadi, 2002). High-performance concrete and prefabricated composite elements were the innovation of materials in Malaysia. R&D for IBS in Malaysia lack in innovation for modern method innovation, scientific information, new materials, local design and manufacturer building system (Haron et al. 2009; Kamar et al. 2009; Hamid, 2008; Rahman & Omar, 2006; Thanoon et al. 2003; Razali et al. 2002; Badir et al. 2002). Musa et al. (2014) mentioned the needs R&D and innovation through IBS approach for material engineering, improvement in construction method and activities, and production and manufacturing. This aspect has to be considered for future development IBS in Malaysia. Design inflexibility and monotony were major issues on current modular design available in Malaysia. Jaganathan et al. (2013) stated architectural forms in IBS construction were inflexible. Rarely flexibility is found during the construction phase in IBS because of future modifications to manufacture building components were not possible. (Mawdesley and Long, 2002; Jaillon and Poon, 2009). Gibb (2001) stated the poor coordination at spatial design and dimensioning of components and its inappropriate incorporation into the spatial design and the practical space relations. Besides that, Howes (2002) mentioned there was no research in IBS in terms of form flexibility, in which manner the development of IBS construction could meet the balance of architectural design and contemporary design. Egbu (2000) mentioned that construction field in the past highly innovative rather than the present day as it innovation stay compare to other industry. Innovative culture must be introduced due its need for the stakeholders to understand in detail about manufacturing sector (Egan Report, 1996). Besides that, Abdullah (2010) mentioned the research in detailed for IBS industry in Malaysia and its adoption to the construction process benefits the clients and increases social benefits.

2.1.4 Lack of Government Support on Sustainability Agenda

There is an important issue to consider for the difference in the effective method to the construction system between the public and private sectors (Abdullah, 2010). Government Planning for future construction industries in Malaysia - conducting study on current and potential new IBS products (new technologies in the horizon etc) and the roadmap also suggested to conduct a study on current and potential new IBS products (new technologies in the horizon etc). Moreover, Egbu (2000) mentioned that there is no innovation of construction field rather than other industries. Historically, the facts construction industry been highly innovative. Groundwork or fact-finding and innovation was the appropriate method to boost and develop knowledge and technology in the country. Grant allocation on sustainability construction should be increased and encourage cluster on green issues should be look over by the government. The research should be implemented and include by observing

and study the example of successful practised of MMC in developing countries (Hamid et al. 2011). The effort of government to the IBS incentives and publicity were not adequate (Musa et al. 2014).

Besides that, Kamar and Hamid (2011) stated that government agencies in Malaysia were overlapping in term of roles and programs conducted by government: they received a slow respond from construction industry players. Moreover, they mentioned the lack of a policy-making framework of green growth and green technology caused Malaysia government fails to control and implement sustainability agenda in the country. Introducing grading guideline and certification mechanisms in green technology were the way forward of IBS in Malaysia (Kamar and Hamid, 2011). The authors mentioned primary education to university level should be included of green construction syllabus in their education. Argued by Shamsuddin et al. (2013) secured supply chain in the construction industry was established due to various activities organised locally to encourage implementation of IBS. Green construction in Malaysia needs investment through the private sector and for this context its needs enough support of the government to make it work (Hamid et al. 2011). Moreover, Abdullah (2010) suggested, to improve adoption of IBS in Malaysia construction, relevant parties need rules and regulations, building specifications and planning standards from the government.

2.1.5 Conventional System More Cost Saving

Malaysia construction industry players prefer to use conventional system in projects because it is more cost effective in many aspects such as cheap labour, variety of material selections, flexible design and lower investment of project start up. The implementation of green technology in Malaysia are still partially done because of the issues of benefits versus higher cost (Kamar and Hamid, 2011). The barriers to practise the IBS in the country were negative perception and readiness towards green technology, the cost issue, awareness and knowledge and planning and its implementation (Mohamad Kamar et al. 2009). Between 2003 and 2004, it was estimated that there were around 2.1 million foreign workers in Malaysia in between (CIDB and Department of Immigration). Foreign workers in the country are mostly illegal. The availability of illegal immigrant leads to a cheaper cost of labour for the construction (Abdullah, 2015). Perception of the current conventional construction industry, a nature of industry, economy development, research development and stakeholder's readiness were the barriers to adopting IBS in Malaysia construction industry (Abdullah and Egbu, 2010).

2.1.6 Lack of Technology in Automation and Robotic Industry

In Malaysia, automation and robotic industry still have not gain so much popularity among construction building players. Lower labour cost (such illegal immigrant) rather than automation become one of the contributing factors to industry players who prefer to use immigrant labour in the construction industry (Abdullah, 2015). Besides that, Nasrun et al. (2015) stated the major obstacle that restricts works in prefab-system based projects are due to the deficiency insuperior and high technology equipment and machinery. The building players needs to invest a big amount of money to run MCS in the projects by utilizing high technology equipment and machinery. Minimal movement around the site due to the usage of equipment and machinery was the issue of using automation and robotic in the country (Blismass et al. 2005). Moreover, Kamar et al. (2007) mentioned the tasks which used high technology machinery and equipment was complicated. In addition, Nora (2015), stated the use of big and special transportation such as Self-Propelled Modular Transporter (SPMT) to move buildings module to site is still low in the country except for offshore and naval architecture.

2.1.7 Issues on readiness of Malaysian towards MCS

A few challenges to achieve sustainable modular IBS in Malaysia are issues on readiness, awareness and acceptance of construction stakeholders, players and end users (Musa, M. F. 2014). Lack of enthusiasm, opposition, and slow action of stakeholders and local authorities for the change of construction industry and building regulations the barriers to innovating and growth of prefab system in the country (Nasrun et al. 2015). Professionals were not alert of the fundamental of IBS such as MC besides the volumetric and non-volumetric construction methods (Badir et al. 2002). Furthermore, Jaganathan et al. (2013) indicated a standardized method usually restrains the freedom of designers to do any design, especially for the architects. The reason for non-readiness in stakeholders and customers of MCS and IBS was because they find it was difficult to manage many problems and critical issues that have to be faced such as jointing problems, inflexibility of form and production of monotonous building components. This fact will reduce the creativity of architectural design among architects and building designers. These negative perceptions among building designers and customers of current IBS issues affects the future development of MCS in the country.

2.2 Trend of MCS in Malaysia

2.2.1 Initial Stage of MCS Implementation in IBS Industry

Currently in Malaysia, IBS trend is on the method of hybrid and innovative systems of the construction. Faiz et al. (2014) quoted MCS in Malaysia is the beginning stage of its implementation. Currently, IBS in Malaysia in the stage of the hybrid and innovative system. The revolution of Offsite Manufacturing in Malaysia started from component, non-volumetric, volumetric, hybrid and the latest was modular building (Azman et al. 2012). A better and quality building can be achieved by adopting MCS in the current Malaysia's IBS projects. Najib (2013), mentioned on using Modular IBS in Malaysia construction projects through the PRIMA initiatives for Industrialised House Technologies (IHT) (Musa, M. F. 2014). Azman et al. (2012) stated technology advantages, systemize project planning and financing capability were the factors of construction industries to enter the international market. Published in December 2006, a strategy manifest the future direction of Malaysia construction industry included in Construction Industry Master Plan (CIMP) 2006-2015. The proposal of optimising the modular design of this research is included Under Strategic Thrust 5 (Innovate through R&D and adopt new construction method). It discusses thoroughly the consistent innovation of construction processes and methods in stimulating R&D activities through resource pooling initiative, amongst key players and provision of R&D infrastructure. Bruno Richard (2005) stated the degree of industrialization consist of prefabrication, mechanization, automation, robotics and reproduction. Industrialization refers to a large number of sub-assemblies, and the construction forever site-intense handicraft. In addition, MCS demand in Malaysia is increasingly rising. This is because there was already an awareness of green design and design that is practical, easy and fast to be applied to the society.

3.0 Design Sustainability through MCS in Aspect of Building Form and Arrangements

In order to overcome the on-going economic problems that the building industry is faced with, a significant increase in both the efficiency and the effectiveness of construction processes is necessary. However, a closer examination makes it clear that building industry worldwide has fallen well behind in comparison with other industries in terms of innovation and the use of future-oriented methods and technologies (Both. 2013). The adoption of modular construction in Malaysia is a new, economical and practical method to be considered to sustain building industry. The law of mass production expresses the relationship between the costs of a production method and the quantity of the product that is produced. The German economist Karl Bucher first formulated the effects associated with this principle in 1910. He established that unit costs fall with increasing production quantities, since the fixed costs are spread across a greater quantity of units (economies of scale). Therefore, in the case of more capital-intensives production methods, it is advantageous to produce greater quantities. The modular construction as part of mass customization production system like a furniture made.

3.1 Design Sustainability in aspect of Building Form

There is a question among many, why are most of the buildings generally and largely rectangular and orthogonal. Another question is rectangularity related to green shape? As suggested by Steadman (2006), the author of "Why are most buildings rectangular?" Rectangularity was at minimal in part to do with the force of gravity in the vertical direction. In the horizontal flat, divergence from rectangularity tends to be found in buildings comprising of a single area, and around the boundary of plans made up of many areas. This recommended strongly that generation of the rectangularity in multi-room plans lie in the controls of packing those rooms closely together. A geometrical demonstration differentiates room forms and room arrangements on square, triangular and hexagonal grids preferable that it was the predominant flexibility of dimensioning enable by rectangular packings that guide to their superiority. At the same time of a development towards an adaptive, nonrepresentational from of production, 3D visualizations and photomontages of buildings take over many of the presentational functions of the plan. These, like any change in representational techniques, also influence architectural thinking (Stuckardt, 2013). A plan is in some sense a concentrate item like an analytical table of contents. It is in a form so concentrated that it seems like a crystal, like a geometric footprint, it contains an enormous quantity of ideas and driving intention (Le Corbusier, 1985). For simplicity, this depiction believes that all units can be a substitute as rectangles or combination of orthogonal rectangles (Michalek, 2002). One method to spatial allocation is to define the available space as a set of grid squares and use an algorithm to allocate each square to a particular room or activity and the second approach by to decompose the problem into two parts: topology and geometry (combinatorial concept) (Michalek, 2002).

By creating a house-like piece of furniture, many of the storage problems of living in a compact environment were solved (Ko, 2015). Living small or compact may not only be a lifestyle choice but rather a necessity.

However, with smart design and careful consideration of space, one can help reduce overcrowding while also reducing their ecological footprint. From floor plan to furniture, a small yet smart design can have a big impact on how people adapt and live in a costly and space-limited urban metropolis. According to Al – Atabi (2014) in his book *Think Like an Engineer*, he identified the good design products that are functional, safe, easy to use, and economical as well as appealing. He also stated that design for manufacturability must consist of standardization and fasteners for the system to be constructing itself. Besides that, he explained a good product is a design for affordability which consisted of the right material selection and functional. Other criteria to be considered while creating a design are design for safety, aesthetics, sustainability and ease of use of operability. Attractiveness isn't considered essential to sustainability (Hosey, 2012). Designers can promote sustainability by embracing what they have always cared about most—the basic shape of things. Their aim should be to create a home design which is sustainable in term of cost, shape and quality. All these call for a modular construction system as a new way to solve the problems faced in the industry. Major aspects expected in a design are homely and safe, high-tech, fit individual lifestyle, and empowered for public meetings, communication and community living were the elements a good home design that's designers must observed. That home design must be multifunctional (like for studio, home office, fitness room or workshop) and have the ability grows to the three generations. The house should be peaceful indoors and suited for elderly and young family (Zulkefli and Asiah, 2011). In that case, Malaysian designers need to establish a realistic design scheme for the IBS home project as listed below:

a) A flexible building that allows for the provision of diverse housing units and that responds to changes in the lifestyles of occupants within individual units.
b) Efficient for working with natural resources and conserves energy.
c) A building that minimizes harmful environmental impact.
d) Friendly innovation such as flexible for building technology.
e) Indoor spaces have relationship with the outdoor (friendly environment).

Zulkefli and Asiah (2011) suggested future case studies on Integrated Building Design, Concept of Recyclability, Adaptability and Green Effect. Furthermore, the people desire for secure, green and captivating buildings, not a semi-permanent setting (Gassel et al. 2006). There were four procedures to designing MCS such as Viz. market, R&D, product development, production and sales. The IBS housing designing basis includes dimensions with respect to transport, transport risk, freedom of choices for the client, costs, on-site construction period and labour. The top priority is to obtain cost efficiency and industrial production and satisfying the demands specified by clients possibly least of interest. The building system developed by modular builders, is present in their market and production exposure with the additional system or building products already added in their portfolio. So, the failure or risk can be reduced in future. They seldom start from the score. Building system perhaps developed something that will surpass with the other modular manufacturer's own system is one of the problems of this technique. This risk can be decreased by the practice of the design method and it strengthens of an unambiguity of a tremendous of options and by enhancing communication with others. Overall, it can be concluded that the definition of the shape of green designs with simplicity. It should be minimal, ease of system, economical, aesthetics appealing, long lasting and less waste.

3.2 Combinatorial Geometry

The relation between shapes and sustainability appeared in geometrical conceptual in Mathematics such as Combinatorial Geometry. In this research, the Author relates the combinatorial concept within a home design (in term of shapes and spatial planning). One hundred years ago, Hilbert and Sylvester questioned about combinatorial things:
"If given a big box with the total area of the same, what is the number of objects that have a certain shape and size can be put in the box? Can one plant and trees in an orchard, not all along the same line, so that every line determined by two trees will pass through a third?"

Geometry decomposition was one of the ideas on ways to relate modular construction and combinatorial things. The term modular is also used for the shortest line and the fact that it is compact. Combinatorial geometry is the study of combinations and arrangements of geometric objects and with discrete properties of these objects. Historically, modularity has played an important role in the study of combinatorial geometries (Brylawski, 1975). The questions might concern, for example, the complexity of arrangements of objects of the above type or the occurrence of certain substructures in such arrangements. The importance of the subject – apart from its apparent beauty and usefulness for educational purposes – lies in its close relationship to problems in such diverse fields as number theory, graph theory, combinatorial optimization or computational geometry. Besides that, the term combinatorial geometry related to the field of combinatorics. The divaricate of mathematic dealing

with combinations of objects belonging to a finite set in following certain limitations, like those graph theory called as combinatoric. Theory development of combinatorial design has brought incredible success; in the application is not expected, in connection with basic math, and the desire to produce order out of chaos, obviously (Colbourn, 2003). Besides that, he questioned about the future of application of combinatorial geometry. He explained that new mathematical truths will be found and that unanticipated application will arise. Our challenge is to seek both and to know that each profit from the other (Colbourn, 2003). Moreover, Christopher Alexander in his book, Pattern Language, defines patterns in a solution of space. In an aspect of design, combinatoric as mathematical approach can be found in the research by Alexander Christopher: he quoted that building blocks can be combined in an infinite number of ways (Alexander, 1977).

In this research, it was found out that, combinatorial concept was a revolution of layout plan design to maximize functional of space. This research explored on combinatorial simplistic way to design an economic and good layout plan. The rectangular shape was used to design logical layout plan in term of economic factor. Rectangularity in architecture was used in the history of architectural design such The Parthenon and various famous Islamic Architecture designs. Combinatorial was related to fractal geometry and Golden Mean (Golden Ratio). It was the law of natural design (universal design). With this law, nature design optimizes their design with an evolution of the same shape to larger shape but maintain their main character shape. Wolfram (2002), a computer scientist conducted experiments on this law, with a computational system to find out evolution figure of the shape being change to bigger scale. Rectangularity and Combinatorial forms a match to optimize the use of space of the land. Affordable home layout plan was in rectangular shape, a variation of this rectangular shape is arranged in few types to find an economic and practical shape suite with the square area of the land. The design arrangement types were a variety as long as the designs were in line with sustainable (minimalist design) and economical shape. Minimalist design or simple shape defined for direct, plain, easy, basic and no difficulty.

4.0 Research Methodology

A collection of data analyzed in this paper is obtained through literature review from other authors in the aspect of IBS and MCS development towards meeting green construction and innovation in Malaysia. Secondary data such as books, articles, journals, newspapers, web page, reports, thesis, and conference proceeding were also the sources of information of this paper. The analysis attempts to review the definitions, characteristics, issues, trends and sustainable design of modular construction and mathematical way of architectural design (in aspect modular architecture).

5.0 Recommendations and Conclusion

From the findings and analysis of literature review from others researchers, lack of expertise amongst construction industry players on MCS was the major reason in applying this method in Malaysian construction industry. The current problem faced in IBS projects becomes one of the major challenges to apply MCS for affordable home projects. There were serious technical issues including the aspect of engineering safety (structural and building envelope), connection and joinery in previous and current IBS projects. Besides that, lack of government support in terms of the fund, incentive and projects related MCS and IBS contributes to the issues for construction industry players to implement this innovative way in the construction industry. Moreover, lower cost of the conventional method of construction is also currently still being used causing MCS to be less accepted among Malaysian. In the aspect of innovation in MCS in Malaysia, R&D and innovation are poor. The researcher agrees that this requires change in people's attitude, innovation, R&D and cooperation from many stakeholders are the factors of success to sustainability mentality. Abdullah (2010) stated that critical factors to achieving green construction in Malaysia was the project stakeholder's commitment to verify the risk and innovate IBS itself. Besides that, he added, the sustainable development in Malaysia can be achieved by innovation, technology and human factors: those who are eager to learn and accept something new in construction. The study found that construction industry players were not ready with the technology in automation and robotics in the construction industry. Construction industry players are less interested in applying or highlighting this MCS in construction industry resulted in lack exposure on MCS among Malaysian. In short, the combinatorial design was an experimental design to find out the sustainable shape and economic way of design. Shaping product form was related to automation, mass customization and big series of production. Design sustainability in terms of shape has to be considered to design a modular building. Combinatorial geometry is a method which could be used in modular architecture as problem-solving to design in an economic way. With the rules of natural law of design, Combinatorial is included in this law. As the satisfaction from previous researches of Golden Mean, Fractal Geometry and Combinatorial (El Nashchie, Randy and Losoi, 2015), it was proven this method could be applied in any fields of design related to spatial

organisation itself such as furniture design, interior design, building design, and architectural computerised design.

6.0 Acknowledgement

The Author wishes thanks to En. Nazrol (CIDB) provided the Author of CIDB registered's MCS companies in Malaysia, lecturers in UiTM Perak (Department of Architecture, Building and Surveying) for helping the Author in pilot study (in developed and advised on questionnaires survey), Henry Losoi (Physicist, Finland), guided the Author detailed and narrow down the Combinatorial Concept to suite the context of architectural design, Dr. Randy (Mathematics Professor, Schoolcraft College, USA) as he help the Author for methods and recommended contacts of Combinatorial expert and Dr. Mohamad El Naschie (Physics Professor, Alexandria University, Egypt) for his answered on fractal geometry was related in combinatorial aspect. Besides that, thanks and full of appreciation to MCS and IBS companies in Malaysia for all their kind help towards this research. All of their kind cooperation in helped given information's for the research to the Author was valuable and highly appreciated.

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