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**Research Article**

# Green and Sustainability Policy, Practice and Management in Construction Sector, A Case Study of Malaysia

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**Abstract:** The aim of this study is examining construction industry's strategies, preparation and administration towards the agenda of the green and sustainability with respect to Malaysia. Today, sustainability is no longer considered a buzzword, but a reality that should be applied in policy, practice and management of all sectors of society. It's a cornerstone needed by humans to live decently within their own conception of welfare, with respect to others without compromising the ecosystem as well as social and cultural norms. The pursuit of sustainable development puts the construction industry at the forefront both globally and nationally due to its total energy, resource consumption and carbon emission. However, the industry is identified as one of driving forces of the nations' economy because of its contribution in generating wealth through constant growth in GDP. In addition, it influences the development of social and economic infrastructures and provides job opportunities. Based on the findings, most of the construction work in Malaysia and in the rest of the world is still applying conventional methods which are not often sustainable. However, IBS has capabilities to be considered as a vital pillar in helping the government to attain sustainable development when there is a need to balance economic growth, social expansion and environmental protection. For achieving these gaols it is necessary that more legislation, incentives and financial supports be considered and launched in the construction industry and governments exploit their foresight regarding this transition to maximize the potential benefits through policies supporting the development of the private demand for and supply of activities which meet this agenda. And, all initiatives need to be taken forward simultaneously by cooperation from all stakeholders.

**Keywords:** Green construction, IBS, Malaysia, sustainability

## INTRODUCTION

Sustainability is no longer a buzzword, but a reality that should be considered in all sectors of society. It is a concern that has grown out of wider recognition that rising population and economic development are threatening a progressive degradation of the earth's resources. Creating a sustainable world is actually a complex idea that involves much more than just saving trees and wildlife. Based on Brundtl and commission, it is a kind of development "that meets the needs of the present without compromising the ability of future generations to meet their own needs". It is a cornerstone needed by humans to live decently within their own concepts of welfare, with respect for others without compromising the ecosystem and social and cultural norms. The pursuit of sustainable development puts the construction industry in the forefront both globally and nationally as one of the most significant contributors to the depletion of natural resources (Luo *et al*., 2008). Construction, maintenance and building use has substantial impact on our environment and are significant contributors to irreversible changes in the world's climate, atmosphere and ecosystem. Buildings are by far the greatest producers of harmful gases such as CO2 and this eco-footprint can only increase with the large population growth predicted to occur by 2050. Therefore, the construction industry is constantly being challenged to reduce its large amount of energy consumption, raw material and water usage (Low *et al*., 2009).

The issues of sustainability have been duly highlighted in the Construction Industry Master Plan (2005-2015) as of significant importance for the Malaysian construction industry. In this regard, the Malaysian Green Building Index (GBI) has been recently developed in order to promote sustainability in built environment. On the other hand, the industry is

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under constant pressure to deliver and to tackle issues on performance, safety, shortage of labour, environment and sustainability, dependency on foreign labour and demand in affordable housing. And, to cope with these challenges, Malaysian construction industry has been urged to use innovative construction techniques and to shift from traditional practice to Industrialized Building System (IBS) construction. The main objective of this study is examining sustainability practice, policy and management in construction industry with respect to Malaysia. Accordingly, construction industry, green and sustainable construction, IBS and its capabilities have been investigated.

## MATERIALS AND METHODS

In achieving the objectives of this study, literature review considered as main strategy. The purpose of conducting the literature review is to enable the author to enhance her knowledge and understanding of the core subject matter involved. By doing literature reviews, the outline and overview of the research topic can be identified. Besides that, necessary information and additional references needed for a research can be gained by conducting literature reviews. The materials for literature reviews are such as books, articles, magazines, internet, journals, documents and etc. The literature review thus provides guidance towards the preparation of the survey questionnaire, which is discussed in the following sections.

Accordingly, an initial discussion and extensive preliminary literature review regardingconstruction industry, followed by highlighting IBS and prefabrication, its definition, classification, its products and components, importance and expansion in all over the world and locally in Malaysia were examined. In addition, sustainability, green construction and rating systems that applied in this area for evaluating the environmental design and performance of buildings according to green and sustainability criteria were reviewed from both primary and secondary resources including related books, papers, web pages and etc.

## RESULTS AND DISCUSSION

**Construction industry:** Construction's worldwide market volume accounts for 10% of the world's Gross Domestic Products (GDP). Also, based on an estimate from the International Council for Research and Innovation in Building and Construction (CIB), "a dollar spent on construction may generate up to three dollars of economic activity in other sectors"(UNEP Industry and Environment, 2003). In addition, construction is a major source of the jobs providing around 7% of world employment (28% of industrial employment) with a workforce of about 111 million.

On the other hand, the pursuit of sustainable development puts the construction industry in the forefront both globally and nationally as significant contributors to the depletion of natural resources (Luo *et al*., 2008). Increasing costs and lack of on-site skilled labour provided the stimulus the recent innovations toward sustainability and Green construction. In this regard, statistics indicate that building industry exploited about 30-40% of the total natural resources in industrialized countries and 50% of this energy flow is used for weather conditioning (heating and cooling) in buildings. According to the U.S. Department of Energy (DOE), buildings contribute roughly one-third of greenhouse gas emissions worldwide. In the United States, 76% of all electric power consumption can be attributed to buildings. In other words, buildings account for 76% of electricity consumption and 39% of greenhouse-gas emissions. Also, 40% of the world's consumption of materials is converted to the built environment and about 30% of energy use is due to housing (Pulselli *et al*., 2007). Subsequently, improving building energy performance and accepting the challenge to achieve carbon neutral buildings and a healthy environment form the basis for regulation and present an enormous opportunity for innovative architecture, engineering and construction practices.

**Construction industry in Malaysia:** The construction industry in Malaysia as in many other countries is adriving force of the nations' economy. It has played a major role on generating wealth through a constant growth in GDP's contribution and has influence the development of social and economic infrastructure and buildings. Malaysian construction output is estimated to be approximately RM 50 billion. This represents 3-5% of Gross Domestic Product per annum (CIDB, 2007). Simultaneously, the industry also provides job opportunities for almost 1.03 million people which represented 8% of the total workforce (CIDB, 2006).

But, against these benefits the construction industry in Malaysia, compared to other sectors, suffers from low productivity and safety and quality control issues. In this regard, traditional labour intensive practices and

Table 1: Housing targets from the public and private sector, 2006-2010 (CIDB, 2007)

| | Number of houses | | | | | Total | |
|---|---|---|---|---|---|---|---|
| Program | Housing for the poor | Low cost | Medium low cost | Medium cost | High cost | Total units | (%) |
| Public sector | 20, 000 | 85, 000 | 37, 005 | 27, 100 | 28, 700 | 197, 805 | 27.9 |
| Private sector | | 80, 400 | 48, 500 | 183, 600 | 199, 095 | 511, 595 | 72.1 |
| Total | 20, 000 | 165, 400 | 85, 505 | 210, 700 | 227, 795 | 709, 400 | 100.0 |
| Percentage | 2.8% | 23.3% | 12.1% | 29.7% | 32.1% | 100.00 | |

3D Syndrome (Dirty, Difficult and Dangerous) are underlined as the main problems (IBS Survey, 2003). Accordingly, the local workforce and new graduates were reluctant to join the industry due to the 3-*D syndrome* which has long been associated with the construction industry. Subsequently, foreign labour dependency increase in this sector. According to Construction Industry Development Board (CIDB) Malaysia, 69% (552,000) out of a total of 800,000 registered workers as of June 2007 are foreign workers (Malaysian Construction Outlook, 2008). Moreover the social problems associated with foreign workers aggravate the situation. Most not skilled when they first arrive in Malaysia and this has had an impact on productivity and the quality of the construction industry as well.

On the other hand, rising population and the migration of rural masses to the cities and industrial centres has increased the demand for affordable and quality houses. In this regard, CIDB (2007) revealed an increasing demand in housing in the Ninth Malaysian Plan (200-2010) from the public to the private sector. According to the results (Table 1) around 709,407 houses were targeted for different user groups during the five year period. Therefore, in order to accommodate rising demand for housing and to deliver and tackle issues on performance, safety, shortage of labour and dependency on foreign labour, the industry is urged to use innovative construction techniques. In other words, the present traditional construction system is unable to meet the housing demand in the short term without sacrificing quality. Thus, meeting demand for higher performance, lower costs and faster projects require a transition from traditional building techniques to innovative construction methods.

To cope with these challenges, Construction Industry Development Board of Malaysia (CIDB) suggested a ten year master plan, from 2006-2015, which charts the strategic position and future direction of the Malaysian construction industry (CIDB, 2007). It is also aimed at supporting the nations' economic growth as well as increasing accessibility to adequate, quality and affordable houses for all income groups, especially lower ones. There are seven strategic trusts in the master plan which are interrelated in order to achieve the overall vision. The fifth strategic thrust in the master plan is innovation through research and development and the adoption of new construction methods. In this regard, Industrial Building System or IBS is underlined as an innovative solution provider in the development of new technology in the construction industry. Construction industrialization could be considered as a feasible tool to support the construction industry to achieve sustainable development in the current process of rapid urbanization. In other words the unique characteristics of Industrialized Building System have the potential to respond well to the sustainability challenge facing the construction industry.

**Green construction movement:** The vast majority of conventionally designed and constructed buildings that prevail today fortify their negative impact on the environment as well as on occupant health and productivity. Furthermore, these buildings are becoming increasingly expensive to operate and maintain in an acutely competitive market. Their contribution to excessive resource consumption, waste generation and pollution is unacceptable and needs to be addressed. Reducing the negative impact on our environment, establishing new environmentally-friendly goals and adopting guidelines that facilitate the development of green/sustainable buildings has become the priority of our generation. Green or sustainable architecture is becoming particularly relevant in today's world of rapidly dwindling fossil fuel, along with the increasing impact of greenhouse gases on our climate. For this and other reasons, there is a pressing need to find suitable ways to reduce a buildings energy load, increase building efficiency and employ renewable energy resources in our facilities. Green construction is considered environmentally friendly as it uses sustainable, location appropriate building materials and employs building techniques that reduce energy consumption. Indeed, the primary objective of sustainable design and construction is to avoid depletion of essential resources such as energy, water and raw materials and prevent environmental degradation. Sustainability also places a high priority on health, which is partly why green buildings are also comfortable and safe places to live and work.

The term "green building" however is relatively new to our language and a precise definition is elusive, but the concept of building "green" is no longer in the realm of the theoretical. It is deep in the mainstream heart of current construction practices and general acceptance by the industry as well as familiarity with green elements and procedures continue to drive down building costs. Building "green" now offers an opportunity to use our resources more efficiently, while creating healthier buildings and a better environment, in addition to realizing significant cost savings.

**Green construction trends in Malaysia:** Driven by global environmental concerns and to sustain world resources for future generations, Malaysia has also embarked on initiatives for sustainable development. The Construction Industry Development Board Malaysia (CIDB), a body to assembled to develop and modernize the Malaysian construction industry, has always taken a proactive approach to the issue of sustainable construction and assists stakeholders in its

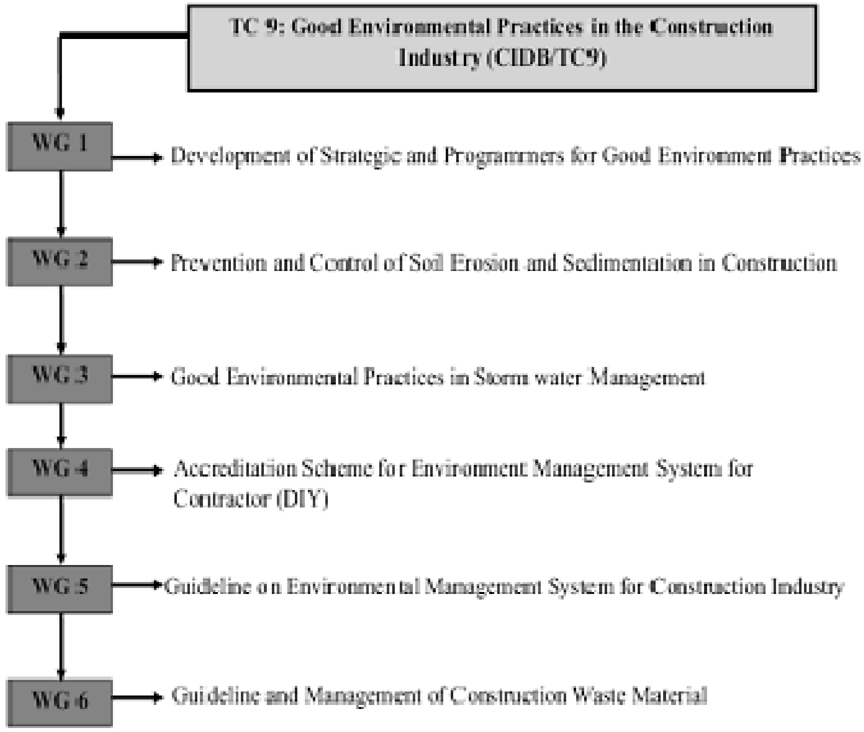


Fig. 1: Six groups that have been established under TC9 (CIDB)

adoption. In this regard, the following steps are established and conducted.

**Technical committee 9:** Back in June 1999, the CIDB established a technical committee to look into developing good environmental practices in the construction industry. Technical Committee 9 on Good Environmental Practices in the Construction Industry (TC9) was comprised of environmental experts from government agencies, professional bodies, academia and construction related associations. Six working groups have been established under the TC9 (Fig. 1).

Under the TC9, CIDB published Strategic Recommendations for Improving Environmental Practices in Construction Industry which highlighted the strategy required to move the Malaysian construction industry forward, a strategy which was adopted by all players. The recommendations are summarized as follows (CIDB, 2008):

- Strengthening the development approval process
- Enhancing law and enforcement
- Promoting self-regulation, reflecting the best regulatory practices which are necessary to achieve sustainable construction in the future
- Increasing capacity and public awareness and addressing the knowledge gap

**Construction industry master plan:** In June 2006, the Construction Industry Master Plan 2006-2015 (CIMP) was published to chart the way forward for Malaysian construction. The CIMP has identified that the demand for environmental sustainability is necessary to achieve and sustain economic growth and social development. The following milestones have been highlighted under the roadmap to be achieved in 2015 (CIDB, 2006):

- Foster a quality and environment-friendly culture and to increase customer demand in the global construction environment
- Encourage external accreditation in quality and environmental management i.e., ISO 14001 certifications
- Promote environment-friendly practices
- Green building material initiatives to ensure that impact activities can be provided in order to spur the economy and social benefits at large.

**National Green Technology Policy (NGTP):** NGTP was launched in 2009 to demonstrate the government's seriousness in implementing "green" initiatives for the country. These include among other things intensification of green technology research and innovation towards commercialization, promotion and public awareness of green technology. Specifically for buildings, the government promotes the application of Renewable Energy (RE) and Energy Efficiency (EE) in buildings such as solar Photovoltaic (PV), rainwater harvesting, phase out of incandescent lights and the application of a green building index. Energy, social,

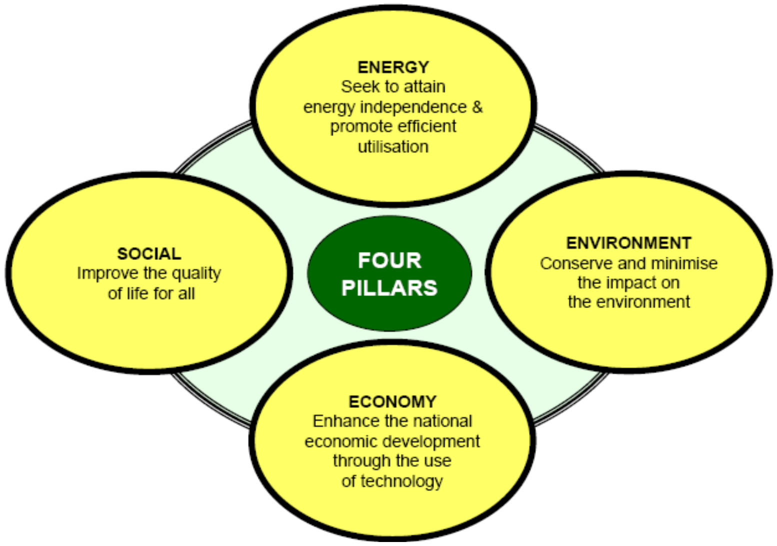


Fig. 2: The National green technology policy (Lockwood, 2007)

Table 2: Well-known green rating tools, their origins and categories

| Name of rating tools | Development | Origin | Year of introduce | Categories |
|---|---|---|---|---|
| BREEAM | Building research establishment | UK | 1990 | • Energy use<br>• Transport<br>• Water<br>• Ecology<br>• Land use<br>• Material<br>• Pollution<br>• Health and Well-being |
| LEED | United States Green Building Council (USGBC) | USA | 2003 | • Energy and atmosphere<br>• Water efficiency<br>• Sustainable sites<br>• Materials and resources<br>• Indoor environment quality (IEQ)<br>• Innovation |
| Green star | Green Building Council of Australia (GBCAUS) | Australia | 2003 | • Energy<br>• Transport<br>• Water<br>• Ecology and use<br>• Emission<br>• Materials<br>• IEQ<br>• Management<br>• Innovation |
| Green mark | Building and Construction Authority (BCA) | Singapore | 2005 | • Energy efficiency<br>• Water efficiency<br>• Environmental protection<br>• IEQ<br>• Other green futures<br>• Innovation |
| Green building index | Green building index Sdn Bhd | Malaysia | 2009 | • Energy efficiency<br>• IEQ<br>• Sustainable site and management<br>• Materials and resources<br>• Water efficiency |

environment and the economy constitute the four pillars of a national green technology policy (Fig. 2).

**Green Building Index (GBI) and Green Assessment System in Construction (GASSIC):** In 2009, the Malaysian Green Building Index (GBI) was developed by the Association of Consulting Engineers Malaysia (ACEM) together with the Malaysian Institute of Architects (Pertubuhan Arkitek Malaysia or PAM) to promote sustainability in built environment. GBI is

Table 3: GIB points which allocated in rating residential buildings and green building index classification

| Assessment criteria | | Overall points score |
|---|---|---|
| Part | Item | Maximum point |
| 1 | Energy efficiency | 23 |
| 2 | Indoor environmental quality | 12 |
| 3 | Sustainable site planning and management | 37 |
| 4 | Material and resources | 10 |
| 5 | Water efficiency | 12 |
| 6 | Innovation | 6 |
| Total score | | 100 |
| Green building index classification | | |
| Points | | GBI rating |
| 68+points | | Platinum |
| 76-85 | | Gold |
| 66-75 | | Silver |
| 50-65 | | Certified |

fundamentally derived from rating tools, including the Singapore Green Mark and the Australian Green Star System, but was extensively modified for relevance to the Malaysian tropical weather, environmental context, cultural and social needs (Table 2). Accordingly, a building will be awarded a GBI rating score based on six key criteria; energy efficiency, indoor environment quality, sustainable site planning, material and resources, water efficiency and innovation. Table 3 demonstrates the GBI points which are allocated to the buildings.

The Construction Research Institute of Malaysia (CREAM), a subsidiary of CIDB, has set-up product testing facilities in its laboratory to ensure construction materials are certified as eco-label. CIDB is also developing Green Assessment System in Construction (GASSIC). GASSIC is a system or method to measure and evaluate the green attributes of a construction work from design to construction stage based on developed standards. This assessment system will be used together with GBI as a measure to certify green buildings in Malaysia. GASSIC will be made mandatory for all public projects in the future to ensure the total adoption of green technologies and sustainable development.

**Green technology and sustainable agenda:** In February 2010, the CIDB together with industry stakeholders met to strategize about green technology and a sustainable agenda. The aim is to formalise the strategic direction in green construction and sustainability. The focus areas which have been identified as priorities requiring urgent action are:

- Formulation of a green technology roadmap for the construction industry
- Establishing an eco-labelling task force
- Standardisation of provisions and legislation on green technology
- Education and awareness

Based on the output of the meeting, the CIDB is establishing a technical committee for green technology best practices in construction. The technical committee is looking into four area of interest; eco-labelling, training, contractor development and the development of a roadmap for green construction. As one of the most important aspects of sustainable construction and green buildings which need urgent attention, an eco-labelling task force was established comprised of captains from industries to look into the development of an eco-labelling scheme for construction materials.

**Off-site Construction or Industrial Building System (IBS) as one solution:** In embracing globalisation, it is necessary for all construction players to be equipped with the relevant technology and experience to successfully market their products and services both locally and globally. Industrial Building System or IBS is considered one of the innovations and solutions in the development of new technology in the construction industry. After World War II, building prefabrication was the best method to meet the housing demand. The phenomenal transition of the construction industry to prefabricate manufacturing has occurred in Australia, Hong Kong, Singapore, United Kingdom and United States (Blismas and Wakefield, 2009; Jeong *et al*., 2009). In addition, the adoption of IBS was successful in other countries such as: Germany, Japan, Finland and Sweden to cope with construction challenges. It created a value add to the industry with greater emphasis on building quality and end customer satisfaction. Table 4 summarises other countries' experience with IBS.

Japan is the world's largest practitioner of manufactured construction, with companies such as Sekisui Homes producing 70,000 manufactured homes a year (Gann, 1996). Other exemplars include the establishment of the Manufactured Home Construction and Safety Standards Act in the United States of America (USA) in 1976 (42U.S.C. Sections 5401-5426), also referred to as the Housing and Urban Development (HUD) Code, which was designed to regulate the construction of manufactured homes. The US government also in the early 1970s explored several prefabrication building systems (Jaillon and Poon, 2009). Among the largest prefabrication building system in the US is the Manufactured House (MH) which is the second largest provider of housing units, owning about 20% of the total share of the housing market (Jeong *et al*., 2006). The houses are constructed in a controlled factory environment based on the national building code specified by the US Government and the entire structure is transported to the site and installed onsite (Jeong *et al*., 2009; MHI, 2011). But the U.S., which accounts for 74% of the total capital spent in world construction, the highest of any nation, (CMAA, 2010) still face problems in the off-site construction industry as reported in CMAA (2006)

Table 4: Other countries experience of IBS

| IBS Experience in | Year of introduce | Due to | Applications | IBS Market % |
|---|---|---|---|---|
| United Kingdom | mid 1900's | • Widespread destruction of housing stock during the Second World War | precast concrete dwellings: ranging from small single story bungalow to large high rise buildings | 60% 1994-99<br>25% in 1999<br>40% in 2001<br>10% Now |
| United States | early of 1930s | • Price competitiveness, high capital and inconsistent local codes<br>• Resolve critical shortage of houses after second World War | prefabricated steel house | 30% in 1999 |
| Canada | 1970 | • The need to be competitive in the construction industry | Residential Complex (such as Habitat 67) | 3% in 1992 |
| Australia | Early 1950s | • To help overcome the acute shortage of accommodation in Canberra | civil, commercial and residential construction | 12% in 2008 |
| Japan | 1960 | • Application of Competitive Benefits | The steel framing system with a 73% share<br>The wood framing system with 18%<br>The reinforced concrete framing with a 9%. | 20% in 1999 |
| Singapore | Early 1960 | • Labour shortage problem<br>Shorter construction time<br>Better quality | Building of Public Housing, High rise buildings | 8% in 1992 |
| Denmark | Mid 1960s | | 80% of the detached houses produced since the mid-1960 | |
| Sweden | Mid 1960s | | 90% of all single-family houses by 1983 | |
| Germany | 1931 | • To solve post WWI Germany's housing shortage | 10% of the 250,000 dwellings in 1998 used precast concrete elements for 1-2 storey homes. | 24% in 1997 |

where more than 40% of the members of the Construction Management Association of America experienced construction schedule overruns due to the shortage of skilled craft workers, resulting in escalation of project costs.

Other initiatives include those of the United Kingdom (UK), where the government identified manufactured construction as a key tenet for improving construction in the 21st century and these initiatives were included in Egan (1998) entitled Rethinking Construction. But, Industrialised Building System (IBS) in the UK is currently around 2% (£2-3bn pa) of the country's total construction market and is mainly run by fairly small companies (Taylor, 2010). The great challenge faced by the construction industry in the UK is to integrate 'traditional' technology with appropriate off-site technology. In the UK, the strong 'traditional' technology is comprised of brick/concrete block cavity wall methods, timber/precast floors and timber truss roofs (Pan *et al*., 2007). Thus, home buyers are strongly influenced by the negative perceptions of the Modern Method of Construction (MMC) innovation in home construction, feeling that it will spoil the authentic 'traditional' house image (Edge *et al*., 2002). This has affected the construction industry and innovative building technologies where the industry players faces difficulty in implementing new concepts to the building system (Pan *et al*., 2007; Ball, 1999; Barlow, 1999; Roskrow, 2004). Nevertheless, the MMC is also known as Off Site Manufacturing (OSM) (Taylor *et al*., 2004). UK and Australia have similar OSM applications in their countries. Goodier and Gibb (2004) found it difficult to access the historic value of OSM in Australia. Thus a vague boundary exists between traditional and OSM approaches, as well as data reports on the performance of the construction and manufacturing industries.

**Industrial Building System (IBS) in Malaysia:** Industrial Building System or IBS is a term used in Malaysia to denote a construction technique whereby components are manufactured in a controlled environment (*on-site* or *off-site*) and then placed and assembled into construction works (CIDB Website, 2013). IBS is known worldwide by other terms such as: Off-site Construction Techniques (OSCT) in the US construction industry, Modern Methods of Construction (MMC) in the UK, Off-site Manufacturing (OSM) in Australia as well as the UK construction industry.

The importance of IBS is highlighted under Strategic Thrust 5: Innovate through R and D to adopt a new construction method in the Construction Industry Master Plan 2006-2015 (CIMP 2006-2015, 2006) which has been published as a means to chart the future direction of the Malaysian construction industry (CIMP 2006-2015, 2006). CIDB also published, in 2003, a roadmap to guide the practitioners and decision makers in IBS implementation in Malaysia.

Table 5: IBS Classification in Malaysia

| Classification | Sub categories | Author/Year |
|---|---|---|
| Mazjub's classification (Based on relative weight) | • Panel system<br>• Box system<br>• Frame system | Majzub (1977) |
| Junid's classification (Based on structural system) | • Panel system<br>• Box system<br>• Frame system | Junid (1986) |
| CIDB Classification | • Pre-cast concrete framing<br>• Panel and box systems<br>• Steel formwork systems<br>• Steel framing systems<br>• Prefabricated timber framing system<br>• Block work system | CIDB (2003) |
| Warszawski's classification (Based on material) | • Timber<br>• Steel<br>• Cast in situ concrete<br>• Precast concrete | Warszawski (1999) |

The roadmap was endorsed by the parliament of Malaysia in October 2003 and involved greater government and inter-ministry action towards the adoption of IBS in Malaysia. In addition, in order to create a *spilt-out* effect on IBS usage in the private sector, the government pledged to construct 100,000 units of affordable houses using IBS, which was announced back in the 2005 and 2006 Budget. As an incentive to adopters from the private sector, construction projects that utilized IBS components in 50% of the building works received a construction levy exemption (CIDB levy -0.125% of total cost of the project according to Article 520) (Hamid *et al*., 2008). Also, the new circular by the Ministry of Finance (MOF) emphasized the full utilization of IBS for all government projects. The circular emphasized that the use of IBS components in government projects should not be less than 70%. As of 2009, 320 government projects worth RM 9.43 billion have been identified to be carried out using the IBS (BERNAMA). Moreover, the government will establish new policies to reduce by 50% the 320,000 foreign workers currently registered with the sectors and CIDB has been allocated RM 100 million to train skilled workers in IBS (Bernama, 2009).

**What is Industrial Building System (IBS):** A building system is usually defined as a set of interrelated elements that act together to enable the designated performance of a building. It may also include various procedures-technological and managerial-for the production and assembling of these elements for this purpose. Industrial Building Industrial Building System or (IBS) is a construction system with a combination of components that promote simplification and minimize on-site work (Riduan and Jay, 2011), a system that utilizes techniques, components or building systems which involve prefabricated and on-site installation. It is a system in which all building components are mass produced either in factory or on site under strict quality control and minimal on site activities (Rollet, 1986; Trikha, 1999), a method that transfers the onsite processes and practices to a controllable working environment (Luo *et al*., 2008). An Industrialised Building System (IBS) may also be defined as a system in which concrete components, prefabricated on site or in factory are assembled to form the structure with minimum in-situ construction (Trikha, 1999). It is a system that offers economy of design, site work and materials, provides shorter construction time, labour savings, better quality control, immunity to weather changes and most importantly, reduced costs.

IBS Roadmap 2003-2010 (2003) defined Industrial Building System (IBS) as a construction technique in which components are manufactured in a controlled environment (on or off site), transported, positioned and assembled into a structure with minimal additional site work. The importance of IBS is highlighted under Strategic Thrust 5: Innovate through R and D to adopt a new construction method in the Construction Industry Master Plan 2006-2015 (CIMP 2006-2015, 2006) which has been published as means to chart the future direction of the Malaysian construction industry (CIMP 2006-2015, 2006). In this regard, CIDB strongly supports the use of IBS in order to reduce the dependency on foreign labour and increase productivity, quality and safety in the local industry (IBS Survey, 2003). Construction Industry Development Board (CIDB) has classified the IBS system into 5 categories in order to make it a global player in the Malaysian construction system. However, to evaluate the systems, various parameters such as the industrialized process used, transportation and erection problems, architectural features and socio economic problems are considered. The following Table 5 shows IBS classification in Malaysia.

**IBS background in Malaysia:** The idea of using an industrialised building system in Malaysia was first mooted during the early sixties when the Minister of Housing and Local Government visited several European countries and evaluated their building system performance. Then, in 1964, the government took a brave decision to try two pilot projects using IBS concept. The first pilot project was constructed on 22.7 acres of land along Jalan Pekeliling which included the construction of 7 blocks of 17 storey flats and 4 blocks of 4-storey flats comprising about 3,000 units of low cost flats and 40 store shop lots. The project was awarded to Gammon/Larsen Nielsen using the Danish System of large panel industrialized prefabricated systems.

The second pilot project was built in Pulau Pinang with the construction of 6 blocks of 17 storey flats and 3 blocks of 18 storey flats comprising 3,699 units and 66 shop lots along Jalan Rifle Range. The project was awarded to Hochtief/Chee Seng using the French Estiot System (Din, 1984). With reference to the two pilot projects, a performance comparison between the IBS system and conventional system has been carried out in terms of cost, productivity and quality. It was discovered that the first pilot project incurred 8.1% higher cost than a similar building using conventional construction method, while the second project was 2.6% lower. In terms of construction speed, both projects required 27 months to complete, inclusive of time required to set up the recasting factories. The quality of IBS building finishes was also found to be better than conventional construction methods. In conclusion, the overall performance of an IBS is competitive with conventional construction methods.

Since then, the use of IBS has become more noticeable with the participation of the private and public sectors such as the Housing Research Centre in Universiti Putra Malaysia which aims to promote and develop novel building systems. In other words, early IBS promotion and research was initiated at that time by Universiti Putra Malaysia (UPM) and the Housing Research Centre (HRC). HRC had organized a series of national and international colloquiums and seminars on IBS. Not long after, the Construction Industry Development Board (CIDB) Malaysia formed the IBS Steering Committee in the effort to bring to the fore all IBS related issues in a systematic framework which led to the IBS Strategic Plan 1999. CIDB (2003) published a roadmap to guide practitioners and decision makers in IBS implementation in Malaysia. The roadmap has been endorsed by the Parliament of Malaysia in October 2003 and involved government and inter-ministry action toward greater IBS adoption in Malaysia.

According to statistics, at least 21 suppliers and manufacturers are actively involved in the dissemination of IBS in Malaysia (Badir *et al*., 2002). The majority of the IBS originate from the United States, Germany and Australia with market shares of 25, 17 and 17%, respectively. Systems produced in Malaysia account for only 12%. This indicates that there is considerable room for improvement in the area of IBS research and development. However, despite well documented benefits and strong support from the government, the plan did not take-up as first anticipated. Recent reports (IBS Roadmap's mid-term review) have predicted that IBS will be involved in less than 35% of total construction projects (using at least one IBS products) in the year 2006 as compared to IBS Roadmap predictions of 50% in 2006 and 70% in 2008 (Hamid *et al*., 2008).

## IBS AND SUSTAINABILITY

The pursuit of sustainable development puts the construction industry at the forefront both globally and nationally. Construction maintenance and building use have a substantial impact on our environment and is currently a significant contributor to irreversible changes in the world's climate, atmosphere and ecosystem. Buildings are by far the greatest producers of harmful gases such as $CO2$ and this eco-footprint can only increase with the large population growth predicted to occur by 2050. Therefore, the construction industry is constantly being challenged to reduce its large contribution to energy consumption, raw material and water usage (Low *et al*., 2009).

Industrialized construction has the potential to be considered as one of solutions in steering the construction industry towards green and sustainability. Industrialized construction assist adopters in terms of cost and time certainty, attaining better construction quality and productivity and reducing risk related to occupational safety and health. From an environmental point of view, industrialized construction has great potential in terms of fabrication of more energy efficient buildings (Mullens and Arif, 2006) and minimizing waste, with the ability to reuse material from one module or product into another. From a socio-economic point of view, the construction industry currently employs more than half of its workforce from neighboring countries. This labor issue affects economical sustainability due to outflow of our currency and has also contributed to social illness. Industrialized construction delivers this goal through alleviating the issue of skilled workers and the dependency on manual foreign labour to achieve the ultimate goal of reducing overall construction cost.

**IBS potential towards sustainability:** IBS applications offer benefits to adopters in terms of cost and time certainty, attaining better construction quality and productivity and reducing risk related to occupational safety and health, Potential IBS advantages toward green and sustainability could be classified as follows:

**Environmental aspects:** The construction industry is seen as an industry that threatens the environment due to its total energy and resource consumption and carbon emissions. According to Klotz *et al*. (2007), buildings consume 36% of the total energy, 30% of the raw materials and 12% of potable water used or consumed in the USA. The American Institute of Architects (2007) estimated that nearly 50% of all the GHG emissions are generated by buildings and their construction in terms of the energy used in the production of materials, transportation of materials from production factories to construction sites, as well as energy consumed in the operational stage. In this regard IBS has some capabilities that could be categorized as follows:

- **IBS and CO2 emissions:** Some recent estimates suggest that the amount of environmental impact from material transportation activities accounts for one-third of the total environmental impact on the entire construction process. IBS offers another benefit and that is the ability to order in large quantities thus reducing the number of trips to be taken. Despite this potential benefit, it is important that a detailed material transportation and logistics plan be put in place.
- **IBS and energy efficiency:** Several pre-fabricated technologies such as Structural Insulated Panels (SIPS) offer great potential in terms of the fabrication of more energy efficient buildings (Mullens and Arif, 2006). However, if appropriate process control and planning are not implemented these potential benefits could be lost due to expensive on-site assembly processes. Therefore, it is important that the advent of new technologies should be accompanied by proper process design for onsite assembly.
- **IBS and waste:** IBS has traditionally been known to minimize waste, with the ability to reuse material from one module or product in another and the sustainability agenda is supported through its use. However, several planning aspects both in terms of material management and production management have to be monitored in order to achieve the waste minimization benefits promised by IBS.
- **IBS and controlled production environment:** IBS offers a controlled manufacturing environment with the ability to reach difficult nooks and corners, which are often inaccessible in regular in situ construction. With the availability of production tools and permanent jigs and fixtures, it is easier to control the workmanship, ensuring a tighter construction resulting in lot lesser energy loss due to leakage (thermal leakage).

**Social aspects:** Compared to other sectors, the construction industry in Malaysia, suffers from low productivity, safety and quality control. In this regard, traditional labour-intensive practices and 3D Syndrome (Dirty, Difficult and Dangerous) are underlined as the main problems (IBS Survey, 2003). Accordingly, the local workforce and new graduates were reluctant to join the industry due to the *3-D syndrome* which has long been associated with the construction industry. Subsequently, foreign labour dependency has increased in this sector. According to Construction Industry Development Board (CIDB) Malaysia, 69% (552,000) out of a total of 800,000 registered workers as of June 2007 were foreign workers (Malaysian Construction Outlook, 2008).

Moreover, the social problems associated with foreign workers aggravate the situation. These workers are usually not skilled when they first arrive and this has had an impact on productivity and the quality of the construction industry as well. The Malaysian government has emphasized a reduction in the reliance on foreign labour and the ability of IBS to deliver to this goal is well documented. However, for this to succeed there is a need to develop a detailed training and dissemination strategy to promote IBS and to prepare the workforce. In this regard, identified IBS capabilities could be:

- **Less labour related problems:** IBS saves on manual labour onsite (up to 40-50% of the input in conventional construction), especially inskilled trades such as formwork, masonry, plastering, painting, carpentry, tiling and pipe laying (electrical and water supply) (Warszawski, 1999). Beside, large production output and standardisation of precast elements allow a high degree of labour specialization in the production process.
- **Increased site safety:** Less construction processes, especially wet work on site, ensures the increase in site safety. Thus, IBS provides safer construction sites as there are less workers, materials and construction waste (CIDB, 2003).

**Economic aspects:** In Malaysia, the construction industry has played a major role in generating wealth. Continual growth in GDP has had an influence in the development of social and economic infrastructure and buildings. Simultaneously, the industry also provides job opportunities for almost 1.03 million people which represented 8% of the total workforce (CIDB, 2006). IBS has some capabilities that could increase this contribution:

- **Cost saving:** IBS components allow for repetitive use which leads to considerable cost savings as well as labour cost savings as IBS depends more on machines to produce components.
- **Optimization of material used:** The utilization of machinery during the fabrication of IBS components leads to precise and accurate production, resulting in reduced material waste. In

addition, the reduction of construction waste utilizes standardized components and fewer in-site works, thus providing a cleaner site due to less construction waste (CIDB-(2), 2003).

- **High quality and better finishes:** Controlled and highly aesthetic end products through the processes of controlled pre-fabrication and simplified installation has maintained and ensured the quality of work in the construction industry (CIDB-(2), 2003). In other words, IBS components are of higher quality and better results as they provide an excellent selection of materials, advanced technology and strict quality assurance control.
- **Less construction time:** Less time is required to precast elements at the factory and the work foundation and erection of IBS components is done on site. This leads to earlier building occupancy which reduces interest payments.

**Obstacles in implementing IBS in Malaysia:** Despite the rapid advancement in the construction industry and emphasis on steering construction towards sustainability, most of the construction sites in Malaysia are still applying conventional methods which are not often sustainable. However, the unique characteristics of IBS have the potential to respond well to the sustainability challenge facing the construction industry. The construction industry in Malaysia has been slow to adopt IBS for several reasons including as:

- Wide swings in housing demand, high interest rates and cheap labour cost make it difficult to justify large capital investment. Contractors prefer to use a labour intensive conventional building system because it is far easier to lay off workers during slack periods.
- Fully prefabricated construction systems require precise construction. Our labour force still lacks skilled workers. Many foreign skilled workers left the country after the widespread crackdown on illegal foreign workers from July-September 2002. The new batch of foreign workers do not possess the required skills and have to be retrained.
- The construction industry is fragmented, diverse and involves many parties. Consensus is required in the use of IBS during the planning stage. However, owners, contractors and engineers still lack scientific information about the economic benefits of IBS.
- Lack of R and D in the area of novel building systems that use local materials. The majority of IBS in Malaysia are imported from developed countries, thus driving up the construction cost. Engineering courses in local universities seldom teach IBS design and construction.
- The economic benefits of IBS are not well documented in Malaysia. Past experience indicates that IBS is more expensive due to fierce competition from conventional building systems. Furthermore, cheap foreign workers are leaving Malaysia.
- The use of IBS in Japan and Sweden was so successful due to high quality and high productivity. But, in Malaysia, the scenario is different, as most projects constructed with IBS were of low quality and high construction cost.
- Lack of incentive and government promotion of the use of IBS, such that many architects and engineers are still unaware of the basic element of IBS such as modular co-ordination.

## CONCLUSION

This study reviewed the construction industry and the ability of the Malaysian construction industry to adopt the agenda of sustainability and going Green. The study underlined off-site construction or Industrial Building System (IBS) as a vital pillar in helping the government attain sustainable development when there is a need to balance economic growth, social expansion and environmental protection. Based on the review, unique characteristics of IBS have the potential to respond well to the sustainability challenge facing the construction industry. IBS applications offer benefits to adopters in terms of cost and time certainty, attaining better construction quality and productivity, reducing risk related to occupational safety and health, alleviating issues concerning skilled workers and dependency on manual foreign labour and achieving the ultimate goal of reducing overall construction cost.

However, despite the rapid advancement in the construction industry and emphasis on steering the construction towards sustainability, most of the construction work in Malaysia and in the rest of the world is still applying conventional methods which are not often sustainable. In this regard it is important for governments to exploit their foresight regarding this transition to maximize the potential benefits through policies supporting the development of the private demand for and supply of activities which meet this agenda. Accordingly, more legislation, incentives and financial supports should be considered and launched in the construction industry. As well, the strategic direction, implementation strategies and research and development have to be driven in harmony. It is envisioned that all initiatives need to be taken forward simultaneously. Also, cooperation from all stakeholders is necessary.

In addition, migration to a sustainable “mentality” requires a lot of change in attitude, innovation, creativity, research and support from many stakeholders. The construction industry must change its traditional approach to building, with little concern for environmental impact, to a new mode that makes environmental concerns a centre piece of its efforts.

However, “old habits die hard”, but to achieve these goals it is necessary to:

- Achieve an in depth understanding of green technology as a solution and economic driver
- Change mindsets, attitudes and habits of experts and the lay public.
- Encourage local inventors and innovators
- Increase R and D efforts

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