Sustainability of industrialised building system for housing in Malaysia

Article *in* Proceedings of the Institute of Civil Engineers: Engineering Sustainability · February 2017

DOI: 10.1680/jensu.16.00061

4 authors:

Maryam Qays
Universiti Kebangsaan Malaysia
22 PUBLICATIONS **68** CITATIONS
SEE PROFILE

Mohd Farid Mohamed
Universiti Kebangsaan Malaysia
44 PUBLICATIONS **523** CITATIONS
SEE PROFILE

A. I. Che-Ani
Universiti Kebangsaan Malaysia
212 PUBLICATIONS **2,008** CITATIONS
SEE PROFILE

Sudharshan N. Raman
Monash University (Malaysia)
116 PUBLICATIONS **2,361** CITATIONS
SEE PROFILE

Engineering Sustainability

Sustainability of industrialised building system for housing in Malaysia
Oleiwi, Mohamed, Che-Ani and Raman

ice | proceedings

Proceedings of the Institution of Civil Engineers

http://dx.doi.org/10.1680/jensu.16.00061
Paper 1600061
Received 12/07/2016 Accepted 28/11/2016
Keywords: sustainability

ice Institution of Civil Engineers publishing

Sustainability of industrialised building system for housing in Malaysia

Maryam Qays Oleiwi
PhD candidate, Department of Architecture, Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia, Bangi, Malaysia (corresponding author: maryam@archicivi.com)

Mohd Farid Mohamed
Senior Lecturer, Department of Architecture, Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia, Bangi, Malaysia

Adi Irfan Che-Ani
Associate Professor and Deputy Director (Academic), Pusat Citra Universiti, Universiti Kebangsaan Malaysia, Bangi, Malaysia; Department of Architecture, Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia, Bangi, Malaysia

Sudharshan N. Raman
Senior Lecturer, Department of Architecture, Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia, Bangi, Malaysia

The key issues in sustainable construction, such as environmental, economic and social issues, have become a global concern. The *Construction Industry Master Plan 2006–2015* intended to address sustainability in the Malaysian construction industry with the objective of globalising its market. The Malaysian government has also pledged to provide high-quality housing for all income groups. However, low quality remains the main obstacle for this type of construction. Therefore, this paper aims to describe and explore the potential of the industrialised building system (IBS) to achieve sustainability for housing projects in Malaysia. A review of the literature was completed. It was found that many studies have highlighted the significance of using the IBS for enhancing the quality of buildings. Nevertheless, the literature review also revealed that no study has looked into the potential of attaining sustainability through the IBS in the Malaysian housing sector and that housing projects in this country should be given due attention regarding construction sustainability through IBS application.

1. Introduction

The Malaysian government has pledged to adopt the industrialised building system (IBS) for its construction sector. In 2003, the Construction Industry Development Board (CIDB) Malaysia submitted the IBS Roadmap 2003–2010 to the Cabinet of Ministers to serve as a blueprint document for adopting industrialisation in the Malaysian construction industry (CIDB, 2003). The *Construction Industry Master Plan 2006–2015* has endeavoured to address the sustainability issues encountered in this sector (CIDB, 2007). All of these undertakings are realised because the Malaysian government plans to provide high-quality housing for all income groups as one of its fundamental aims. However, numerous obstacles need to be addressed in this type of housing (Bujang *et al*., 2010).

The advantages of the IBS can be extremely helpful in the implementation of sustainability (Kamar *et al*., 2010a). Said *et al.* (2009) mentioned that the application of sustainability in the housing sector is relatively new in Malaysia and such implementation is exceedingly poor due to deficiencies in knowledge among building parties – namely, clients, consultants and contractors. Thus, this research gap in Malaysia needs further investigation. In addition, existing housing projects in Malaysia are generally not optimised for sustainability. A possible solution to this issue is the introduction of sustainability by using the IBS, which can provide high-quality construction and improve the living environment for occupants. This paper provides a descriptive and exploratory study of the possibility of achieving sustainability in housing projects in Malaysia through IBS implementation.

2. Sustainability

'Sustainability' originates from the Latin word *sustinere*, which means 'maintain', 'support' or 'endure' (Onions, 1964). Sustainable development is considered the unique solution to protect the environment from further disintegration due to climate change. Sustainable development has been given various definitions, but the most widely used and internationally accepted is derived from the Brundtland report, which is 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs' (Brundtland *et al*., 1987: I.3.27).

3. Housing developments in Malaysia

Housing demands have been increasing worldwide due to population growth and improvement in household income (Bujang *et al*., 2010). Idrus and Ho (2008) asserted that population growth and age profile, urbanisation and migration and household income are the main factors that push the urgent need for housing. The National Housing Policy of Malaysia primarily intends to provide housing for all residents, in particular for low-income groups. However, some obstacles regarding the quality of these types of projects remain unaddressed. The substandard conditions of housing construction are the most common problem encountered by house purchasers in Malaysia (Sufian and Ab Rahman, 2008). Auchterlounie (2009) clarified that construction defects exist because of substandard techniques, flawed work inside and outside the house, use of low-quality materials, inaccurate analysis of soil, weakness of planning for construction process and faulty drainage systems.

4. The IBS in Malaysia

A number of studies have defined the IBS. However, the most official definition of this system in Malaysia is the one published by CIDB Malaysia – that is, 'the IBS is a construction system through which components are manufactured in a factory, on- or off-site, and positioned and assembled into structures with minimal additional site work' (CIDB, 2003: p. 7). This innovative and novel system has been considered by several studies as the solution for meeting urgent demands in construction. The encouragements and great efforts accomplished by CIDB Malaysia have improved the application of the IBS in the country (CIDB, 2003). In 2003, CIDB submitted the IBS Roadmap 2003–2010 to the Cabinet of Ministers to serve as a blueprint document for adopting the IBS in the Malaysian construction industry (CIDB, 2003). The first strong indication by the government after the Cabinet's endorsement of the IBS Roadmap was through the 2005 budget announcement that all new government building projects were required to have at least 50% IBS content, which was calculated through the IBS Score Manual developed by CIDB (2005a). Furthermore, full exemption from CIDB's levy was given to housing developers in the private sector who utilise IBS components exceeding 50% (Badawi, 2005). In 2008, the required percentage of IBS component use in government projects was increased from 50 to 70% (Qays, 2009). It was found that the reason for making the use of the IBS compulsory for government projects and giving exemption on CIDB's levy was to encourage use of the IBS in construction and to create sufficient momentum for the demand of IBS components. Later, in 2010, CIDB announced the *IBS Roadmap 2011–2015*, which aimed to pave the way for sustainable IBS adoption, in both the public and private sectors. This second roadmap focused on implementing a 50% compulsory usage of the IBS in the private sector and sustaining the percentage of 70% of IBS implementation for public building projects (CIDB, 2010).

According to CIDB (2003), five types of IBS have been categorised, which are a precast concrete system, steel formwork system, steel framing system, prefabricated timber framing system and blockwork system.

4.1 The advantages and constraints of the IBS

The valuable advantages of the IBS cannot be neglected. These advantages have encouraged many of Malaysia's developers to use the IBS in their projects. However, numerous constraints still hinder the fruitful implementation of this system in the entire country. Table 1 lists the studies that include the general advantages of, and constraints to, IBS implementation.

4.1.1 The advantages of the IBS

4.1.1.1 HIGH QUALITY

Use of the IBS can provide high-quality production due to employing skilled workers with a specific scope of works in this type of construction (Badir *et al*., 2002; CIDB, 2005c, 2007; Haron *et al*., 2009; Hong, 2006; Kamar *et al*., 2009a, 2010b; Masod, 2005; Nawi *et al*., 2011; Qays, 2009; Rahman and Omar,

Table 1. The studies that included the advantages and constraints of the IBS

Study	Advantages						Constraints			
	1	2	3	4	5	6	1	2	3	4
Warszawski (2003)	X	X	X			X	X	X	X	X
CIDB (2005b)	X	X	X	X	X					
CIDB (2007)	X		X							
Masod (2005)	X	X	X	X	X	X				
Yee (2001)	X	X	X		X	X				
Qays and Bahri (2009)	X	X	X	X	X	X	X	X		
Kamar and Zuhairi (2007)					X					
Kamar *et al.* (2009a)	X		X		X					
Kamar *et al.* (2010b)	X	X	X	X	X	X	X	X	X	X
CIDB (2005c)	X				X		X	X		
Hassim *et al.* (2009)							X	X	X	
Thanoon *et al.* (2003a)							X	X	X	
Badir *et al.* (2002)	X	X	X				X	X		X
Rahman and Omar (2006)	X			X	X		X	X		
Hassim *et al.* (2008)								X		
Hong (2006)	X	X	X	X	X	X	X	X	X	X
Kamar *et al.* (2009b)							X	X	X	
Haron *et al.* (2009)	X	X	X		X	X	X	X	X	X
Hamid *et al.* (2008)							X	X	X	
Qays *et al.* (2010)							X	X	X	
Nawi *et al.* (2010)									X	X
Nawi *et al.* (2011)	X									
Lachimpadi *et al.* (2012)	X				X					
Tam *et al.* (2007)		X		X	X					

Advantages: 1 – high quality, 2 – time savings, 3 – cost savings, 4 – safety issues, 5 – environmental advantages, 6 – reductions in the number of foreign workers
Constraints: 1 – financial problems, 2 – shortages in IBS knowledge, 3 – technical limitations, 4 – transportation limitations

2006; Yee, 2001). The use of highly mechanised technology and material selection can also improve product quality (Warszawski, 2003).

4.1.1.2 TIME SAVINGS

It has been proved that application of the IBS can facilitate the rapid completion of projects due to advanced mechanised production and simplified installation processes (Badir *et al*., 2002; CIDB, 2005b; Haron *et al*., 2009; Hong, 2006; Kamar *et al*., 2010b; Masod, 2005; Qays, 2009; Tam *et al*., 2007; Warszawski, 2003; Yee, 2001). Additionally, more time can be saved because the production processes of components in factories can begin while the construction site is under preparation (CIDB, 2005b).

4.1.1.3 COST SAVINGS

It is well known in the industry that fast construction can improve cost benefit. A number of researchers have concluded that using the IBS can reduce overall construction costs due to faster completion of projects (Badir *et al*., 2002; Haron *et al*., 2009; Hong, 2006; Masod, 2005; Qays, 2009). If considering the whole-life cost, this method of building can be cheaper than other methods. Moreover, cost benefits in IBS projects can be significantly increased with the rise in the number of units manufactured (Chen *et al*., 2010). This specific point of interest is useful for building small shops and offices (Kamar *et al*., 2010b). The economic aspect of sustainability can obviously be achieved by implementing the IBS in projects, owing to the inevitable profit returns for stakeholders and clients (Kamar *et al*., 2009a). Yee (2001) explained another aspect of cost benefit. The researcher stated that the IBS projects can be more lucrative than conventional ones because the IBS can reduce the quantity of concrete materials that are used in construction. In the same context, Haron *et al*. (2009) mentioned that the total construction cost can also be reduced due to reductions in waste materials.

Moreover, waste materials can be recycled and reused to produce alternative aggregates (Kamar and Zuhairi, 2007). In an investigation by Begum *et al*. (2006), an IBS construction project site in Malaysia was researched and it was concluded that 73% of its building waste was reused and recycled, demonstrating the monetary benefit of waste reduction. The perspicuous advantage figured in this research was estimated at 2·5% of the total project budget. The procedure of reusing waste material can also reduce the cost of waste transportation (Qays, 2009).

Lachimpadi *et al*. (2012) examined construction wastes extracted from eight construction sites that used the conventional method, an IBS or a combination of the two. The results illustrated that the IBS was the most efficient building system, with a waste generation rate (WGR) of 0·016 t of construction waste/m^2 floor space. The mixed system was the second most efficient system, with a WGR of 0·030 t/m^2, followed by the conventional method, with a WGR of 0·048 t/m^2. Most of the extracted wastes from the conventional method were concrete and aggregate (60%). This high percentage reflected the inability of unskilled workers to deal with concrete and aggregates during construction works. In contrast, the percentage of concrete and aggregates that were used at construction sites was reduced in both the mixed system (30%) and the IBS (14%) as shown in Figure 1. The reason for the reduction of waste material is mechanisation and good quality control. This valuable reduction in concrete and aggregate is extremely beneficial in terms of cost saving.

Additionally, in a step to encourage implementation of the IBS in the private sector, CIDB provided full exemption from its construction levy for housing developers using over 70% of IBS components (Qays, 2009). This contribution can be considered as a good opportunity to reduce total construction costs.

4.1.1.4 SAFETY ISSUES

Safety in construction is a prominent matter before, during and after construction which can be improved by an IBS (Mohd Khairolden *et al*., 2008). Many researchers mentioned that the IBS can promote a safe and systematic working environment due to mechanisation, thereby minimising the required number

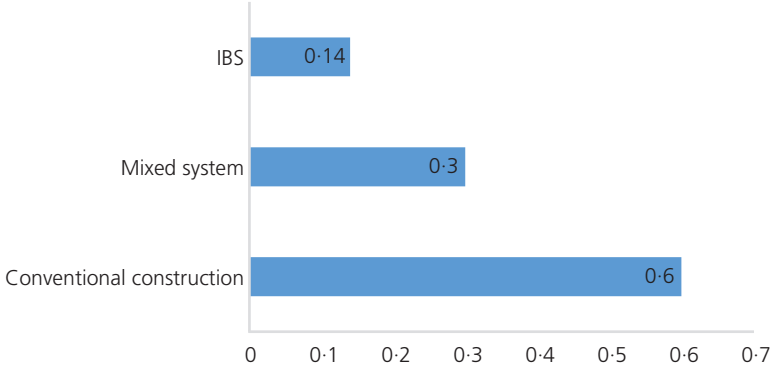

Figure 1. Distribution of concrete and aggregate in construction waste relative to total construction waste for each category (in weight percentage). Derived from Lachimpadi *et al.* (2012)

of workers and reducing materials and waste at construction sites (CIDB, 2005b; Hong, 2006; Kamar *et al*., 2010b; Masod, 2005; Qays, 2009; Rahman and Omar, 2006; Tam *et al*., 2007). However, Abas (2015) had another point of view regarding safety in construction, as there is a variety of risks which depend on the construction method and how the activities are performed. This is compatible with other researchers' claims that the IBS is safer and carries significantly less risk than traditional construction.

4.1.1.5 ENVIRONMENTAL ADVANTAGES

As mentioned previously, by using the IBS as a construction method, waste materials can be reduced (Lachimpadi *et al*., 2012), thus reducing environmental pollution due to these wastes. Recycling waste materials to produce alternative aggregates can also be a good environmental solution in IBS projects (Kamar and Zuhairi, 2007). This undertaking is an exceedingly valuable benefit compared with on-site wet constructions and can facilitate reductions in natural resource consumption. As a result, the environmental aspect of sustainability can be achieved. Yee (2001) stated that the precast concrete system (which is one type of IBS) has been shown to be a good solution to environmental pollution. Kamar *et al*. (2009a) mentioned that use of the IBS supports a sustainability agenda due to its ability to reduce waste materials and use of the same mould several times. In the USA, successful strategies for recycling the waste of construction/demolition operations have been presented by Peng *et al*. (1997).

In Malaysia, the increasing development of major infrastructure projects, housing and commercial buildings has created high volumes of construction waste materials. Therefore, the environment is significantly affected by the construction industry (Bujang *et al*., 2010). This state of affairs has raised the general population's awareness of negative natural effects in numerous local communities in Malaysia. In this way, the Malaysian government, through its executive hand CIDB, whose main goals include improving the construction industry by enhancing environmental protection through dedication to accomplishing sustainable development, proposed the *Construction Industry Master Plan 2006–2015* (CIDB, 2007; Papargyropoulou *et al*., 2011).

Yee (2001) mentioned that one of the customary aspects of wet conventional construction is dense activities on-site that cause constant irritation to local communities, including dirty and untidy environments, noise, dust and air pollution. In contrast, use of the IBS in construction can provide clean sites owing to the organised storage of components and on-time material delivery (CIDB, 2005b; Kamar and Zuhairi, 2007; Kamar *et al*., 2009a, 2010b; Masod, 2005; Mohd Khairolden *et al*., 2008; Qays, 2009; Yee, 2001). In fact, the relocation of construction processes in the IBS from construction site to factories, with improved controlled conditions, can improve environmental aspects and achieve clean construction sites. In addition, the use of timber formworks and props can be minimised, and the amount of dust and suspended particles on site can be decreased due to in-factory prefabrication, thereby reducing air pollution. Noise can also be minimised because scaffoldings and formworks no longer need to be erected and dismantled later (CIDB, 2005b).

4.1.1.6 REDUCTIONS IN THE NUMBER OF FOREIGN WORKERS

The IBS has also been suggested as a way to decrease the dependency on foreign workers in the construction sector and eliminate their impact on the construction industry (CIDB, 2007; Haron *et al*., 2009; Hong, 2006; Kamar *et al*., 2010b; Masod, 2005; Qays, 2009; Warszawski, 2003; Yee, 2001). Warszawski (2003) revealed that using industrialised construction results in 40–50% less manual labour than the traditional method, particularly when a high degree of mechanisation is involved. By adopting industrialisation in construction and decreasing the use of the traditional wet method, the dependency on foreign workers can be decreased and, as a result, the billions of ringgit currently being transferred to their home countries will be decreased and the social problems involving those foreign workers will be eliminated as well (CIDB, 2003). The CIDB took a pivotal role in reducing the dependency on foreign workers in the construction sector. One objective of the IBS Roadmap 2003–2010 was to decrease the percentage of foreign workers from 75% of total workers who were working in the construction sector in 2003 to 55% in 2005 and 15% in 2009, in particular those involved in wet trades such as carpenters, plasterers and bar benders (CIDB, 2003). Unfortunately, it has been reported that the number of foreign workers has increased dramatically in Malaysia. *Migration News* (2004) stated that, in 2004, there were 1·3 million foreign workers in Malaysia while, in 2006, Bernama (Lim, 2006) announced that the total number of foreign workers was 1·8 million. Five years later, the reported number of foreign workers was about 2 million, as declared officially in *Migration News* (2011).

In the same context, Gibberd (2008) found that use of the IBS has the possibility of enhancing local communities by providing variety to the economy and increasing local employment opportunities – specifically in working in IBS factories producing building materials and components. Normally, local workers are not excited about enrolling in the construction industry because of the low wages and low attention to working conditions (CIDB, 2007). Using the IBS will give a better image of the industry, which is strongly linked with the three D syndrome – 'dirty, dangerous and difficult' – and attract local workers to join (Kamar *et al*., 2009a).

4.1.2 Constraints to IBS implementation

4.1.2.1 FINANCIAL PROBLEMS

Despite the effective accomplishments in changing the managerial structure from the wet conventional method to the industrialised method, the market is yet to become ready and the construction industry is still a long way from accomplishing industrialisation. CIDB's 2005 architects survey indicated that the IBS is more expensive than conventional wet construction (CIDB, 2005c). The results of a survey carried out by Yong and Mustaffa (2012) showed that the financial capability of customers is the central

point basic to the achievement of a construction venture. The fundamental finding of Alaghbari *et al*.'s (2007) study showed that the financial factor is the most influential element of delays in construction projects in Malaysia. Qays *et al*. (2010) concluded that a large number of contractors (75%) claimed that use of the IBS in construction is more expensive than the traditional wet method. This reflects the apprehension of contractors to move to this new technology because the fluctuation in construction markets makes utilisation of this novel method perilous. Accordingly, numerous developers in advanced countries prefer to utilise the conventional wet method (Warszawski, 2003).

In addition, the availability and low wages of unskilled foreign workers motivate contractors to keep depending the traditional method (Kamar *et al*., 2010b; Thanoon *et al*., 2003b). However, low productivity and poor workmanship are the expected results of low wages and unskilled employees (Sambasivan and Soon, 2007). Moreover, local workers are not keen on working in the construction industry because of low wages (Kamar *et al*., 2009b).

In addition, capital expense remains the primary issue frustrating utilisation of the IBS in Malaysia (Badir *et al*., 2002; Hong, 2006). This expense ordinarily includes the setting up of plants, the employment of skilled and semi-skilled labourers, the provision of machinery and moulds and transportation procedures (Qays, 2009). Thanoon *et al*. (2003b) and Rahman and Omar (2006) specified that this new construction technique needs additional investment and time to train employees who will work in the new jobs, such as system integrators and assemblers. Hassim *et al*. (2009) found that financial failure is the most significant risk that may be experienced by IBS contractors in Malaysia. The same study also found that delays in payment on contracts and resolving contractual issues in IBS projects are highly ranked among the risks from which contractors may suffer. Moreover, the expense of transportation adds up to 3–5% of the total cost for distances from 50 to 100 km (Warszawski, 2003). Therefore, revenue can be achieved only in large projects when duplications in design are used.

Haron *et al*. (2009) mentioned that, unlike with traditional construction, the construction costs of the IBS are higher due to less competition in the tendering process and higher interest rates because of the higher initial costs to start manufacturing. Moreover, the adoption of such a system fails to attract adequate incentives from the government. Kamar *et al*. (2009a) explained that the IBS in Malaysia may need 'serious marketing and re-branding efforts'.

4.1.2.2 SHORTAGE IN KNOWLEDGE AND AWARENESS

The 2005 survey of CIDB showed that more than half of architects have poor knowledge of the IBS and that only 34% of these architects are willing to learn more (CIDB, 2005c). Furthermore, the scarcity of skilled workers in the market is notable (Abdul-Rahman *et al*., 2012). The key factor behind this is the lack of the new generation's interest in construction work. The academic curricula in universities do not provide satisfactory instructive courses about the IBS. In many universities, subjects related to the IBS design process are not provided to undergraduate students comprehensively (Haron *et al*., 2009; Rahman and Omar, 2006). Thus, designers and builders have propensities to utilise the familiar conventional method. Moreover, contractors in Malaysia also have a shortage of experience in IBS projects (Hamid *et al*., 2008; Warszawski, 2003). This deficiency in satisfactory awareness about industrialisation among building experts is the greatest impediment to its successful performance in practical application (Warszawski, 2003). In fact, insufficiency in the number of expert workers at construction sites has been identified as one of the critical problems encountered in IBS projects in Malaysia (Badir *et al*., 2002; Hong, 2006). Moreover, inadequate research and development (R&D) activities are being undertaken to substantiate the benefits of the IBS, and only a limited number of R&D activities in the field of novel building systems (IBS) using local materials are available (Haron *et al*., 2009).

The government spends millions of ringgit annually to provide training courses at the Akademi Binaan Malaysia (Malaysian Construction Academy). However, these short training courses are inadequate if the graduates are not inclined to seek employment in the construction sector due to the extremely low wages (Shaari, 2006). The training courses are also of little value if the academic curricula in universities do not provide sufficient and comprehensive study on the IBS. Hassim *et al*. (2009) mentioned that incompetence is one of the risks contractors suffer from in IBS projects. Hassim *et al*. (2008) concluded that the top three sources of risk in successful implementation of IBS projects in Malaysia are involvement of inexperienced contractors, complexity in design and poor performance of contractors and designers owing to their unfamiliarity with the IBS. The risk of attempting a new innovative technology is extremely high compared with the current profit margin in construction. Most stakeholders are already familiar with the traditional building method. They believe that this method suits their projects well and therefore do not want to transfer to a mechanisation-based system that requires extra capital to train workers and to provide new machinery.

Another obstacle is the non-respected reputation of the IBS among clients. Kamar *et al*. (2009b), Qays *et al*. (2010) and Rahman and Omar (2006) concluded that the IBS is negatively perceived by some because of historical failures at the early stage of using this construction method in Malaysia in the Pekeliling flats in Kuala Lumpur and the Taman Tun Sardon flats in Penang.

Therefore, to resolve the shortage of experience in IBS technology, more attention should be paid by the government regarding educational programmes and R&D; intensive training courses need to be conducted to develop the level of experience

among construction stakeholders. Furthermore, the negative perception of IBS should be changed by extensive awareness programmes through the media and publications.

4.1.2.3 TECHNICAL LIMITATIONS

Poor quality due to technical limitations is another constraint affecting the Malaysian housing sector (Hamid *et al*., 2008; Hassim *et al*., 2009; Thanoon *et al*., 2003b). Nawi *et al*. (2010) explained that broad use of the IBS is impeded by the absence of specialised technical experiences in this field; therefore, recognisable defects occurred in IBS projects – for example, cracks, moisture leakage and low degrees of thermal insulation. Shortcomings in the connection and adjoining methods in this type of construction have been reported also (Hamid *et al*., 2008; Hassim *et al*., 2009; Thanoon *et al*., 2003b), and can affect the quality of buildings.

It has also been reported that communication can be an impediment to integration among designers and construction workers. Thanoon *et al*. (2003b) and Qays *et al*. (2010) explained that fragmentation and diversity in the construction industry have prompted difficulties in arranging IBS stages, which requires congruence among parties. To reduce this fragmentation, IBS components or modules in design and construction should be integrated (Kamar *et al*., 2009a).

Poor planning and regulations is another barrier, as discussed by Kamar *et al*. (2009b), who emphasised that the authorities and responsible government bodies are not highly motivated by laws and regulations to guide the achievement of the IBS. Another technical constraint is the inflexibility and limitation of IBS components, which may be required to change over time, in particular for small rooms (Qays *et al*., 2010).

4.1.2.4 TRANSPORTATION LIMITATIONS

Transportation has a number of restrictions, including the challenges in transferring enormous parts and components from factories to construction sites and difficulties entering construction sites (Hong, 2006). In addition, Badir *et al*. (2002) noted that deficiencies in raw materials, supply delays and inclement weather interrupting the transportation procedure are the main reasons for delays in IBS project fulfilment. Nawi *et al*. (2010) explained that one of the critical constraints is the long distances between construction sites and the locations of the manufacturers or suppliers. Most IBS producers are located in industrial areas such as Klang Valley, Seremban or Butterworth. This situation indirectly increases the cost of transportation when the producer is situated far from the site, in particular in cities in the north and east of Malaysia.

5. The IBS and sustainability in housing projects

Lessing *et al*. (2005) noted that use of the IBS for housing in Sweden is appropriate for the construction of apartment houses and homes. However, the scenario is different in Malaysia. With the current low-quality construction in housing projects in Malaysia, sustainability cannot be achieved for this type of building. The low-quality factors in housing development can be solved through application of the IBS by using highly mechanised technology, material selection, controlled environments and the use of skilled and semi-skilled workers with a specific scope of works. This system is one of the main methods to eliminate most defects in construction, and it can enhance the sustainability of buildings through three main features – namely, economic, environmental and social aspects – as Kamar *et al*. (2010b) explained that the potential characteristics of the IBS can meet the three aspects of sustainability. Yunus and Yang (2016) recommended that the sustainability framework for IBS construction be readjusted to accelerate the adoption of this innovative technology for Malaysia and other developing countries.

This paper is part of a comprehensive study on the possibility of achieving sustainability in housing projects in Malaysia by using the IBS.

During the collection of related literature, the authors noticed that most previous studies combined just two areas of research out of IBS, sustainability and housing, as listed in Table 2.

Table 2 shows that only the study conducted by Junior *et al*. (2015) in Brazil considered all three areas of research. The study compared three Brazilian engineering companies that used wood frames, steel frames and concrete in their construction projects to achieve the economic, environmental and social aspects of sustainability. The research determined that the economic performance of the companies had been improved. In addition, the study revealed that companies can further improve their performance by reusing some materials and by decreasing the amount of wastes produced on-site. The company that used concrete had the worst social performance of the three companies studied.

In contrast to the study of Junior *et al*. (2015), the studies of Richard (2006), Kamar *et al*. (2010b), Yunus and Yang (2011), Musa *et al*. (2014), Laili Jabar *et al*. (2015) and Yunus and Yang (2016) discussed only the IBS and sustainability. Richard (2006) posited that, through IBS implementation, investment in construction can be divided into small portions to simplify production, thereby achieving cost reductions and higher quality. The study discussed the experience of Japanese construction in using the IBS and verified the achievement of the economic and social aspects of sustainability for this type of construction. However, the study did not explain the achievement of environmental aspects. The research of Yunus and Yang (2011) was part of ongoing work targeted at eliciting guidelines for achieving sustainability from the designers' point of view. The study concluded that improvements in the frameworks of a sustainable IBS can disseminate sustainability elements among stakeholders. This study discussed the ability of the IBS to be sustainable in general, but no specific type of project was discussed.

Table 2. Studies in research areas of the IBS, sustainability and housing

Study	Research area			Country
	IBS	Sustainability	Housing	
Richard (2006)	X	X		Japan, Netherlands
Said *et al.* (2009)		X	X	Malaysia
Kamar *et al.* (2010b)	X	X		Malaysia
Yunus and Yang (2011)	X	X		Malaysia
Hashim *et al.* (2012)		X	X	Malaysia
Musa *et al.* (2014)	X	X		Malaysia
Zainul Abidin *et al.* (2013)		X	X	Malaysia
Ubale *et al.* (2015)		X	X	Malaysia
Hashim *et al.* (2015)		X	X	Malaysia
Laili Jabar *et al.* (2015)	X	X		Malaysia
McCutcheon (1989)	X		X	UK
Junior *et al.* (2015)	X	X	X	Brazil
Rahim *et al.* (2012)	X		X	Malaysia
Abdullah and Egbu (2010)	X		X	UK, Malaysia
Lessing *et al.* (2005)	X		X	Sweden
Armacost *et al.* (1994)	X		X	USA
Glass (2000)	X		X	UK
Yunus and Yang (2016)	X	X		Malaysia

Similarly, the work of Musa *et al*. (2014) was also a part of a continuing study on the adoption of sustainable construction through the IBS in Malaysia. The researchers specified that the commitment to sustainability in construction using modular IBS or modular construction is in line with government aspirations. The authors concluded that using a sustainable modular IBS will provide users with high-quality and durable buildings. Modular construction can be defined as a process that constructs a building off-site under controlled plant conditions by using the same materials and designing using the same codes and standards as those used in conventionally built facilities but in about half the time. Buildings produced in 'modules' and put together on-site reflect the identical design intent and specifications of the most sophisticated traditionally built facility without compromise (Lu, 2009). However, the study of Musa *et al*. (2014) indicated there is still a need for more practical experience.

Laili Jabar *et al*. (2015) discussed the perception of implementing IBS construction projects from the stakeholders' point of view. The stakeholders were divided into four groups – contractors, buyers, clients and designers. The contractors held the most negative perception towards the IBS due to their main role on construction sites and the fact that the actual use of the IBS can be seen only during the construction process on-site. The study verified that good comprehension of the IBS can contribute towards achieving sustainability.

Yunus and Yang (2016) studied the legislative part of the sustainable application of the IBS in Malaysia. The authors identified legislation as a crucial factor that participates fundamentally in enhancing sustainable deliverables for IBS construction and it has to be included in any strategy utilised to ensure the prospective application of sustainability in the IBS. In this study, Swot (strengths, weaknesses, opportunities and threats) analysis was used to analyse the data that were collected. The researchers identified each part of Swot that would considerably enhance the accomplishment of sustainability in IBS construction. For strengths, four elements were distinguished: early integration, mandatory orders, obligations and government support. For weaknesses, three components have been identified: lack of incentives and regulatory procedures in IBS implementation, a fragmentation of authority and little concern for sustainability issues. Opportunities included legal document integration, certification programmes, long-term benefits, global markets and improved image. Threats comprised client-driven projects, higher initial costs and limited understanding of IBS benefits. The study suggested four main action points to enhance sustainability in IBS construction from a legislation standpoint: strong legal machinery, organisation reviews, sustainability officers and authority consensus.

On the other hand, the studies of Said *et al*. (2009), Hashim *et al*. (2012), Zainul Abidin *et al*. (2013), Ubale *et al*. (2015) and Hashim *et al*. (2015) looked into the sustainability of housing construction projects. Said *et al*. (2009) explained that achieving sustainability in the Malaysian housing sector is still in its infancy owing to insufficient knowledge among clients, consultants and contractors. However, the results of this study were very concise and the method of collecting data (questionnaire) is known with its scientific weakness to provide information about the context of the situation, inability to control the environment and predetermined outcomes. The study of Hashim *et al*. (2012) involved interviews and on-site observations of four public housing projects in Selangor State (Malaysia). The study indicated that the four projects were not sustainable and residents were unsatisfied with natural lighting, clothes line facilities, air circulation, space in the kitchen, inadequate parking spaces, safety and noise.

Zainul Abidin *et al*. (2013) showed that the absence of motivational programmes and limited advancement in related regulations from authorising bodies are the most critical obstacles for institutional empowerment. Ubale *et al*. (2015) analysed Malaysian housing policy towards sustainability, while Hashim *et al*. (2015) investigated the issues facing the management of low-cost housing to achieve sustainability in current facilities. As mentioned previously, these studies discussed the ability of achieving sustainability in housing projects; however, no specific construction method, whether the IBS or the traditional method, was discussed.

McCutcheon (1989), Rahim *et al*. (2012), Abdullah and Egbu (2010), Lessing *et al*. (2005), Armacost *et al*. (1994) and Glass (2000) discussed using the IBS in the housing sector. McCutcheon (1989) noted that the IBS was the main construction method adopted by the public sector in the UK since the 1950s. Glass (2000) indicated that no resistance exists against use of the IBS in the housing field in the UK. Glass expected that the industrialised system would monopolise construction markets and overwhelm the conventional method in the future. In the case of Malaysia, Rahim *et al*. (2012) concluded that application of the IBS can facilitate the renovation and extension of buildings to meet the needs of users, thereby allowing for flexibility in architecture.

Abdullah and Egbu (2010) highlighted the standardisation and requirements considered in selecting the IBS in the UK and Malaysia. The study clarified that an organised and comprehensive method for decision-making to select the appropriate type of IBS is imperative and is required partially in the housing sector and entirely in the construction sector in Malaysia. On the other hand, the research of Lessing *et al*. (2005) involved a case study of two different Swedish house manufacturing companies. The results showed that one of the companies had a high level of IBS implementation in housing construction due to its long experience (10 years) in the field. The researchers also mentioned that use of the IBS in housing construction in Sweden is convenient. In the USA, the study of Armacost *et al*. (1994) focused on defining the prioritisation and consideration of clients' needs to determine their priorities in the manufacture of exterior structural wall panels.

These previous studies indicate that the industrialised construction method is prosperous and sustainable in the housing sector in developed countries such as the USA, UK and Sweden. However, the scenario is different in Malaysia. The IBS in Malaysia is still in its infancy, and there is a need for great efforts to increase the use of this new building technology to achieve sustainability in the housing sector.

6. Conclusion

The Malaysian government aspires to attain sustainability in its construction sector, as highlighted in the *Construction Industry Master Plan 2006–2015*. The government has also pledged to provide housing for all income groups, in particular low-income groups. The literature review discussed in this paper reveals that housing projects in Malaysia should be given due attention regarding achieving sustainability through use of the IBS. However, extensive application of this system is hindered by numerous constraints, including financial problems, lack of knowledge, technical issues and transportation issues. These constraints need to be solved and the IBS should be implemented appropriately to provide high-quality economic projects to enhance the sustainability of housing construction in Malaysia. The survey of related literature showed that there is a deficiency in the combined study of three areas of research: the IBS, sustainability and housing. Therefore, the authors recommend concentration on these three areas in future work.

Acknowledgements

The authors would like to thank the Ministry of Education Malaysia and the Universiti Kebangsaan Malaysia for funding this research through the Exploratory Research Grant Scheme (ERGS/1/2013/TK07/UKM/02/6) and University/Industry Research Grant (Industri-2014-003), respectively.

REFERENCES

Abas NH (2015) *Development of a Knowledge-based Energy Damage Model for Evaluating Industrialised Building Systems (IBS) Occupational Health and Safety (OHS) Risk*. PhD thesis, Royal Melbourne Institute of Technology, Melbourne, Australia.

Abdul-Rahman H, Wang C, Wood LC and Khoo YM (2012) Defects in affordable housing projects in Klang Valley, Malaysia. *Journal of Performance of Constructed Facilities* **28(2)**: 272–285, http://dx.doi.org/10.1061/(ASCE)CF.1943-5509.0000413.

Abdullah MR and Egbu C (2010) Selection criteria framework for choosing industrialized building systems for housing projects. In *Proceedings 26th Annual ARCOM Conference* (Egbu C (ed.)). Association of Researchers in Construction Management, Leeds, UK, pp. 1131–1139.

Alaghbari W, Kadir MRA, Salim A and Ernawati (2007) The significant factors causing delay of building construction projects in Malaysia. *Engineering, Construction and Architectural Management* **14(2)**: 192–206, http://dx.doi.org/10.1108/09699980710731308.

Armacost RL, Componation PJ, Mullens MA and Swart WW (1994) An AHP framework for prioritizing customer requirements in QFD: an industrialized housing application. *IIE Transactions* **26(4)**: 72–79, http://dx.doi.org/10.1080/07408179408966620.

Auchterlounie T (2009) Recurring quality issues in the UK private house building industry. *Structural Survey* **27(3)**: 241–251, http://dx.doi.org/10.1108/02630800910971365.

Badawi AHA (2005) *The 2006 Budget Speech*. Dewan Rakyat, Kuala Lumpur, Malaysia.

Badir YF, Kadir MA and Hashim AH (2002) Industrialized building systems construction in Malaysia. *Journal of Architectural Engineering* **8(1)**: 19–23, http://dx.doi.org/10.1061/(ASCE)1076-0431(2002)8:1(19).

Begum RA, Siwar C, Pereira JJ and Jaafar AH (2006) A benefit–cost analysis on the economic feasibility of construction waste minimisation: the case of Malaysia. *Resources, Conservation and Recycling* **48(1)**: 86–98, http://dx.doi.org/10.1016/j.resconrec.2006.01.004.

Brundtland G, Khalid M, Agnelli S *et al.* (1987) *Our Common Future*. Oxford University Press, Oxford, UK.

Bujang AA, Zarin HA and Jumadi N (2010) The relationship between demographic factors and housing affordability. *Malaysian Journal of Real Estate* **5(1)**: 49–58.

Chen Y, Okudan GE and Riley DR (2010) Sustainable performance criteria for construction method selection in concrete buildings. *Automation in Construction* **19(2)**: 235–244, http://dx.doi.org/10.1016/j.autcon.2009.10.004.

CIDB (Construction Industry Development Board) (2003) *IBS Survey 2003*. CIDB, Kuala Lumpur, Malaysia.

CIDB (2005a) *Manual for IBS Content Scoring System (IBS Score)*. CIDB, Kuala Lumpur, Malaysia.

CIDB (2005b) Precast concrete construction. *IBS Digest*, January–March: pp. 4–5.

CIDB (2005c) *Survey on the Malaysian Architects' Experience in IBS Construction*. CIDB, Kuala Lumpur, Malaysia.

CIDB (2007) *Construction Industry Master Plan 2006–2015 (CIMP 2006–2015)*. CIDB, Kuala Lumpur, Malaysia.

CIDB (2010) *IBS Roadmap 2011–2015*. CIDB, Kuala Lumpur, Malaysia. See http://www.cidb.gov.my/cidbv4/?option=com_content&view=article&id=594&Itemid=577&lang=en 2016 (accessed 16/02/2016).

Gibberd J (2008) Sustainable building assessment tool: integrating sustainability into current design and building processes. *World Sustainable Building Conference, Melbourne, Australia.*

Glass J (2000) *The Future for Precast Concrete in Low-rise Housing*. British Precast Concrete Federation, Leicester, UK.

Hamid Z, Kamar K, Zain M, Ghani K and Rahim A (2008) Industrialized Building System (IBS) in Malaysia: the current state and R&D initiatives. *Malaysia Construction Research Journal* **2(1)**: 1–13.

Haron NA, Rahman HA and Hanid M (2009) A literature review of the advantages and barriers to the implementation of Industrialised Building System (IBS) in construction industry. *Malaysia Construction Research Journal* **4(1)**: 10–14.

Hashim AE, Samikon SA, Nasir NM and Ismail N (2012) Assessing factors influencing performance of Malaysian low-cost public housing in sustainable environment. *Procedia – Social and Behavioral Sciences* **50**: 920–927, http://dx.doi.org/10.1016/j.sbspro.2012.08.093.

Hashim AE, Samikon SA, Ismail F and Ismail Z (2015) Managing facilities on Malaysian low-cost public residential for sustainable adaptation. *Procedia – Social and Behavioral Sciences* **168**: 52–60, http://dx.doi.org/10.1016/j.sbspro.2014.10.209.

Hassim S, Sazalli SAAH and Jaafar MS (2008) Identification of sources of risk in IBS project. *European Journal of Social Sciences* **6(3)**: 315–324.

Hassim S, Jaafar MS and Sazalli SA (2009) The contractor perception towers Industrialised Building System risk in construction projects in Malaysia. *American Journal of Applied Sciences* **6(5)**: 937–942, http://dx.doi.org/10.3844/ajassp.2009.937.942.

Hong OC (2006) *Analysis of IBS for School Complex*. BCE thesis, Universiti Teknologi Malaysia, Skudai, Malaysia.

Idrus N and Ho CS (2008) Affordable and quality housing through the low cost housing provision in Malaysia. *Proceedings of Seminar of Sustainable Development and Governance, Universiti Teknologi Malaysia, Skudai, Malaysia*, pp. 1–21.

Junior DJDB, de Oliveira Gomes J and de Lacerda JFSB (2015) Sustainability assessment in conventional and industrialized systems built in Brazil. *Procedia CIRP* **29**: 144–149, http://dx.doi.org/10.1016/j.procir.2015.02.190.

Kamar KAM and Zuhairi AH (2007) Utilisation of IBS waste material for the production of concrete pedestrian block (CPB). *Jurutera*, May: pp. 46–49.

Kamar K, Alshawi M and Hamid Z (2009a) Industrialised building system: the critical success factors. *Proceedings of the BuHu 9th International Postgraduate Research Conference (IPGRC), Salford, UK*.

Kamar K, Alshawi M and Hamid Z (2009b) Barriers to industrialized building system (IBS): the case of Malaysia. In *Proceedings of the BuHu 9th International Postgraduate Research Conference (IPGRC) 2009* (Alshawi M, Ahmed V, Egbu C and Sutrisna M (eds)). BuHu, University of Salford, Salford, UK, pp. 471–484.

Kamar KA, Abd Hamid Z, Ghani MK, Egbu C and Arif M (2010a) Collaboration initiative on green construction and sustainability through Industrialized Buildings Systems (IBS) in the Malaysian construction industry. *International Journal of Sustainable Construction Engineering and Technology* **1(1)**: 119–127.

Kamar KAM, Hamid ZA and Ismail Z (2010b) Modernising the Malaysian construction industry through the adoption of industrialised building system (IBS). *Proceedings of 6th International Conference on Multi National Joint Venture for Construction Works, Kyoto, Japan.*

Lachimpadi SK, Pereira JJ, Taha MR and Mokhtar M (2012) Construction waste minimisation comparing conventional and precast construction (mixed system and IBS) methods in high-rise buildings: a Malaysia case study. *Resources, Conservation and Recycling* **68**: 96–103, http://dx.doi.org/10.1016/j.resconrec.2012.08.011.

Laili Jabar I, Ismail F and Aziz ARA (2015) Public participation: enhancing public perception towards IBS implementation. *Procedia – Social and Behavioral Sciences* **168**: 61–69, http://dx.doi.org/10.1016/j.sbspro.2014.10.210.

Lessing J, Stehn L and Ekholm A (2005) Industrialised housing: definition and categorisation of the concept. In *13th International Group for Lean Construction Conference: Proceedings* (Kenley R (ed.)). International Group on Lean Construction, Sydney, Australia, pp. 471–480.

Lim J (2006) *More Than Five Million Foreign Workers in Malaysia by 2010?* Bernama, Kuala Lumpur, Malaysia.

Lu N (2009) The current use of offsite construction techniques in the United States construction industry. In *Building a Sustainable Future* (Ariaratnam ST and Rojas EM (eds)). American Society of Civil Engineers, Reston, VA, USA, pp. 946–955.

Masod WMS (2005) *Simulation of Allocation Activities of Logistic for Semi Precast Concrete Construction: Case Study*. MSc thesis, Universiti Teknologi Malaysia, Skudai, Malaysia.

McCutcheon R (1989) Industrialised house building in the UK, 1965–1977. *Habitat International* **13(1)**: 33–63, http://dx.doi.org/10.1016/0197-3975(89)90007-6.

Migration News (2004) Southeast Asia. *Migration News* **11(4)**. See https://migration.ucdavis.edu/mn/more.php?id=3059 (accessed 13/12/2016).

Migration News (2011) Southeast Asia. *Migration News* **18(4)**. See https://migration.ucdavis.edu/mn/more.php?id=3719 (accessed 13/12/2016).

Mohd Khairolden G, Zuhairi AH, Zura M *et al.* (2008) Safety in Malaysian construction: the challenges and initiatives. *Jurutera*, May: pp. 18–19.

Musa MF, Mohammad MF, Mahbub R and Yusof MR (2014) Enhancing the quality of life by adopting sustainable modular industrialised building system (IBS) in the Malaysian construction industry. *Procedia – Social and Behavioral Sciences* **153**: 79–89, http://dx.doi.org/10.1016/j.sbspro.2014.10.043.

Nawi M, Lee A and Arif M (2010) The IBS barriers in the Malaysian construction industry: a study in construction supply chain perspective. In *Proceedings: TG57 – Special Track. 18th CIB World Building Congress, May 2010 Salford, United Kingdom* (Barrett P, Amaratunga D, Haigh R, Keraminiyage K and Pathirage C (eds)). TG57 – Industrialisation in Construction, CIB, Rotterdam, the Netherlands, CIB Publication 354, pp. 77–92.

Nawi M, Lee A and Nor K (2011) Barriers to implementation of the industrialised building system (IBS) in Malaysia. *Built and Human Environment Review* **4**: 34–37.

Onions C (1964) *The Shorter Oxford English Dictionary: on Historical Principles*, 3rd edn. Clarendon Press, Oxford, UK.

Papargyropoulou E, Preece C, Padfield R and Abdullah AA (2011) Sustainable construction waste management in Malaysia: a contractor's perspective. *Management and Innovation for a Sustainable Built Environment MISBE 2011, Amsterdam, Netherlands*, pp. 224–234.

Peng CL, Scorpio DE and Kibert CJ (1997) Strategies for successful construction and demolition waste recycling operations. *Construction Management and Economics* **15(1)**: 49–58, http://dx.doi.org/10.1080/014461997373105.

Qays M and Bahri N (2009) *Industrialised Building System in Malaysia*. Filspay Academy, Kuala Lumpur, Malaysia.

Qays M, Mustapha KN, Al-Mattarneh H and Mohamed BS (2010) The constraints of industrialized building system from stakeholders' point of view. *Proceedings of ICSE2010, Melaka, Malaysia*, p. 18.8.

Rahim AA, Hamid ZA, Zen IH, Ismail Z and Kamar KAM (2012) Adaptable housing of precast panel system in Malaysia. *Procedia – Social and Behavioral Sciences* **50**: 369–382, http://dx.doi.org/10.1016/j.sbspro.2012.08.042.

Rahman ABA and Omar W (2006) Issues and challenges in the implementation of IBS in Malaysia. *Proceedings of the 6th Asia-Pacific Structural Engineering and Construction Conference (Apsec 2006), Kuala Lumpur, Malaysia*, pp. 5–6.

Richard R (2006) Industrialised, flexible and demountable building systems: quality, economy and sustainability. *Proceedings of CRIOCM 2006: International Research Symposium on Advancement of Construction Management and Real Estate, Rotterdam, the Netherlands*, pp. 1–10.

Said I, Osman O, Shafiei MWM, Razak AA and Kooi TK (2009) Sustainability in the housing development among construction industry players in Malaysia. *Journal of Global Business Management* **5(2)**: 15.

Sambasivan M and Soon YW (2007) Causes and effects of delays in Malaysian construction industry. *International Journal of Project Management* **25(5)**: 517–526, http://dx.doi.org/10.1016/j.ijproman.2006.11.007.

Shaari SN (2006) IBS Roadmap 2003–2010: the progress and challenges. *Master Builders*, October–December: pp. 64–66.

Sufian A and Ab Rahman R (2008) Quality housing: regulatory and administrative framework in Malaysia. *International Journal of Economics and Management* **2(1)**: 141–156.

Tam VW, Tam CM, Zeng S and Ng WC (2007) Towards adoption of prefabrication in construction. *Building and Environment* **42(10)**: 3642–3654, http://dx.doi.org/10.1016/j.buildenv.2006.10.003.

Thanoon W, Peng LW, Kadir MRA, Jaafar MS and Salit MS (2003a) The essential characteristics of industrialised building system. *Proceedings of the International Conference on Industrialised Building Systems, Kuala Lumpur, Malaysia*, pp. 283–292.

Thanoon W, Peng LW, Kadir MRA, Jaafar MS and Salit MS (2003b) The experiences of Malaysia and other countries in industrialised building system. *Proceedings of the International Conference on Industrialised Building Systems, Kuala Lumpur, Malaysia*, pp. 10–11.

Ubale MY, Martin D and Ta Wee S (2015) Investigating housing affordability pursuant to sustainable development mechanisms and the new Malaysian housing policy. *Journal of Economics and Sustainable Development* **6(3)**: 49–66.

Warszawski A (2003) *Industrialized and Automated Building Systems: a Managerial Approach*. Routledge, London, UK.

Yee AA (2001) Social and environmental benefits of precast concrete technology. *PCI Journal* **46(3)**: 14–19, http://dx.doi.org/10.15554/pcij.05012001.14.19.

Yong YN and Mustaffa EN (2012) Analysis of factors critical to construction project success in Malaysia. *Engineering, Construction and Architectural Management* **19(5)**: 543–556, http://dx.doi.org/10.1108/09699981211259612.

Yunus R and Yang J (2011) Sustainability criteria for Industrialised Building Systems (IBS) in Malaysia. *Procedia Engineering* **14**: 1590–1598, http://dx.doi.org/10.1016/j.proeng.2011.07.200.

Yunus R and Yang J (2016) Legislative challenge to sustainable application of Industrialized Building System (IBS). *Jurnal Teknologi* **78(5)**: 45–55.

Zainul Abidin N, Yusof NA and Othman AA (2013) Enablers and challenges of a sustainable housing industry in Malaysia. *Construction Innovation* **13(1)**: 10–25, http://dx.doi.org/10.1108/14714171311296039.