# THE EXPERIENCES OF MALAYSIAN IN INDUSTRIALISED BUILDING SYSTEM (IBS) TO ENHANCE CONSTRUCTABILITY AND SUSTAINABILITY IN CONSTRUCTION PROJECT

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## ABSTRACT

*The reality of construction is that most of the problems encountered in the field such as reworks, delay and low in quality or productivity are often compounded by inherent design flaws that generated in the design phase. Implementing constructability concept is an alternative solution to overcome the problem. Constructability is often portrayed as integrating construction knowledge, resource, technology and experience into the engineering and design of a project. Since 1998, Malaysian government through Construction Industry Development Board seriously took an action to reform the current construction practice (currently use conventional method) towards industrialization concept. One of the main strategies been taken by the government which introduced a concept of design of prefabrication, pre-assembly and modularization especially in public projects. This paper will highlight the initiative be done by in the Malaysian construction industry to implement that system and indirectly the concept of constructability will be enhanced.*

**Keywords:** Constructability, Industrialised Building System (IBS), Sustainability, Malaysia construction industry.

## INTRODUCTION

As a developing country, Malaysia is rapidly developing in every domain, including construction. The construction process refers to a wide range of activities, such as civil and structural engineering construction projects such as building work, bridges, dams, hydraulics, airports, sewerage treatment facilities and demolition activities. Construction project usually has many stages and involves a lot of processes starting from the establishment of the client's brief or customer requirements to eventual construction, erection or installation, and life-cycle operation and maintenance. All the practice activities that contribute to the sustainable development are called sustainable construction. These may consist of processes which enhance the quality of life and customer satisfaction, offer flexibility and potential to cater for user changes in the future, provide and support desirable natural and social environments and maximise the efficiency of resources use (GRI, 2005 and Government, 2000). Generally, sustainable development is defined as the process of meeting basic needs of the public and promoting the balance of environmental protection, economic development and social development for better life without compromising abilities of future generations (World Commission of Environment, 1987).

In an attempt to develop a sustainable development, the Malaysian government has taken the initiative of implementing a new or modern construction method called Industrialised Building System (IBS). IBS is a construction technique in which components are manufactured in mass production under a controlled environment (on or off site), transported, positioned and assembled into a structure with minimal additional site works (CIDB, 2003b). As stated by Hassim et al, (2009), this industrialisation process is essentially an organisational process-continuity of production implying a steady flow of demand; standardisation; integration of the different stages of the whole production process; a high degree of organisation of work; mechanisation to place human labour wherever possible; research and organised experimentation integrated with production. The benefits which could be gained from the implementation of this system help to speed up the construction process, decreasing cost, labour and wastages on site, and minimising the effect of risk (Hassim 2009; Kamar et al 2009; Nawi, 2007; Thanoon et al, 2003). These are among the reasons why a lot of countries such as Sweden, Holland, Norway, Japan, including Malaysia have chosen to use the IBS in their construction industries (Thanoon et al, 2003).

The following section will describes the development of techniques and strategies to support the constructability during design phase through the adoption of industrialisation (offsite) building system – IBS as a new or modern construction method. It focuses on the investigations based on the literatures based on the series of resources and industrialisation methods that have been successfully done by the Malaysian government to improve their construction performance and image since 40 years ago.

## DEFINITION AND CONSTRUCTABILITY CONCEPTS

The idea or concept of constructability was come out in the late of 1970s, to integrating engineering, construction, and operation knowledge and experience to increase cost efficiency, quality and to better achieve project objectives in the construction industry. Nowadays, constructability concept has been extensively being developed and applied in the USA, UK and later in Australia, where their studies have demonstrated that improved constructability has lead to significant savings in both cost and time required for completing construction projects (Russel *et al*., 1992a; Jergeas and Van der Put, 2001). However, in Malaysia, there a few studies have be done related to process implementation, integration and assessment of constructability concept during design phase (Nima et al. 2001; Rosli et al, 2005).

Constructability is the optimum use of construction knowledge and experience in the conceptual planning, detail engineering, procurement, and field operations phases to achieve the overall project objectives (CII, 1986). It also identified as the integration of construction expertise into the planning and design of project (Mendelsohn, 2002). Constructability concepts have been applied in countries like the USA, the UK, and Australia (Grif. th and Sidwell, 1995) and the outcome documented. For Malaysia these concepts had yet to be examined (Nima el al, 2001). Based on the constructability concepts established by the Construction Industry Institute (CII) and other relevant literature (CIRIA, 1983; Tatum, 1987; Adams, 1989; CII, 1993; CIIA, 1993; Nima *et al.*, 1999), 23 constructability concepts were formulated by Nima (2001) to utilise a study in relation to the engineered construction phases (the engineered construction process refers to the process of construction that contains the planning and design, i.e. starting from conceptual planning to the end of construction and the start-up of the project. According to the same author, the phases of the engineered construction process are the conceptual design, the final design, procurement, construction and start-up), as follows:

*Project constructability enhancement during conceptual planning phase comprises of concepts C1 to C7:*

- Concept C1: The project constructability programme should be discussed and documented within the project execution plan, through the participation of all project team members.
- Concept C2: A project team that includes representatives of the owner, engineer and contractor should be formulated and maintained to take the constructability issue into consideration from the outset of the project and through all of its phases.
- Concept C3: Individuals with current construction knowledge and experience should achieve the early project planning so that interference between design and construction can be avoided.
- Concept C4: The construction methods should be taken into consideration when choosing the type and the number of contracts required for executing the project.
- Concept C5: The master project schedule and the construction completion date should be construction-sensitive and should be assigned as early as possible.
- Concept C6: In order to accomplish the field operations easily and efficiently, major construction methods should be discussed and analysed in-depth as early as possible to direct the design according to these methods.
- Concept C7: Site layout should be studied carefully so that construction, operation and maintenance can be performed efficiently, and to avoid interference between the activities performed during these phases.

*Project constructability enhancement during design and procurement phases comprises of concepts C8 to C15:*

- Concept C8: Design and procurement schedules should be dictated by construction sequence. Thus, the construction schedule must be discussed and developed prior to the design development and procurement schedule.
- Concept C9: Advanced information technologies are important to any field including the construction industry. Therefore, the use of those technologies will overcome the problem of fragmentation into specialized roles in this field, and enhance constructability.
- Concept C10: Designs, through design simplication by designers and design review by quali*fi*ed construction personnel, must be configured to enable efficient construction.
- Concept C11: Project elements should be standardized to an extent that will never affect the project cost negatively.

- Concept C12: The project technical specifications should be simplified and configured to achieve efficient construction without sacrificing the level or the efficiency of the project performance.
- *Concept C13:* The implementation of modularization and preassembly for project elements should be taken into consideration and studied carefully. Modularization and preassembly design should be prepared to facilitate fabrication, transportation and installation.
- Concept C14: Project design should take into consideration the accessibility of construction personnel, materials and equipment to the required position inside the site.
- Concept C15: Design should facilitate construction during adverse weather conditions. Efforts should be made to plan for the construction of the project under suitable weather conditions; otherwise, the designer must increase the project elements that could be prefabricated in workshops.

*Project constructability enhancement during field operations phases (concepts C16–C23):*

- Concept C16: Field tasks sequencing should be configured in order to minimize damages or rework of some project elements, minimize scaffolding needs, formwork used, or congestion of construction personnel, material and equipment.
- Concept C17: Innovation in temporary construction materials/systems, or implementing innovative ways of using available temporary construction materials/systems that have not been defined or limited by the design drawings and technical specifications will contribute positively to the enhancement of constructability.
- Concept C18: Incorporating innovation of new methods in using off-the-shelf hand tools, or modification of the available tools, or introduction of a new hand tools that reduce labour intensity, increase mobility, safety or accessibility will enhance constructability at the construction phase.
- Concept C19: Introduction of innovative methods for using the available equipment or modification of the available equipment to increase their productivity will lead to a better constructability.
- Concept C20: In order to increase the productivity, reduce the need for scaffolding, or improve the project constructability under adverse weather conditions, constructors should be encouraged to use any optional preassembly.
- Concept C21: Constructability will be enhanced by encouraging the constructor to carry out innovation of temporary facilities.
- Concept C22: Good contractors, based on quality and time, should be documented, so that contracts for future construction works would not be awarded based on low bids only, but by considering other project attributes, i.e. quality and time.
- Concept C23: Evaluation, documentation and feedback of the issues of the constructability concepts should be maintained throughout the project to be used in later projects as lessons learned.

## OFFSITE AND CONSTRUCTABILITY

The fundamental idea of offsite is to move some effort away from the construction site to more controlled environment of the manufacturing floor. Offsite is defined as the manufacture and pre-assembly of components, elements or modules before installation into their final location (Goodier & Gibb, 2007). Offsite construction, in addition, is refer to that part of the construction process that is carried out away from the building site, such as in factory or sometimes in specially created temporary production facilities close to the construction site (Gibb & Pendlebury, 2005). The offsite benefits extolled from the specific issues in construction sector such as improvement in quality, cost and time certainty (Pan et al, 2005) to more generic benefits like customer satisfaction and environment (Treadway, 2006).

Although, the improvement of constructability is rarely been mention as the benefit of offsite but in theory, offsite can improve constructability by providing designers with the fresh perspective and outlook on the concept of repetition, preassembly and standardization (as stated above in the contractibility's concept - Concept C13). For a long time, repetition, and standardisation is bemoan of dull and unattractive design but re-branding effort of offsite recently give a different view in the concept of sensible design where optimisation can go along with trend and awareness on sustainability issue. More important, standardisation allows easier assembly of components with the opportunity for exchange or addition modules thus make sense in term of cost reduction especially in mass-production process (Buildoffsite, 2008). The introduction of modular coordination concept to design offsite components, will improve overall constructability in construction project. Modular coordination is a concept of coordination of dimension and spaces where building and components are dimensioned and positioned in a basic unit or module known as 1 M which equivalent to 100 mm (Hamid et al, 2008). Although modular coordination can be used to design conventional system but it is most associated with offsite and manufactured production components where the element of repetitiveness exists.

However, in order to reap the maximum benefit of offsite, one has to synchronize three major function; construction, manufacturing and design. Perhaps, the plausible solution of adopting of offsite principal to improve construction constructability would face several shortcomings particularly on the design integration issues as depicted in the followings:

- Traditional contracts practice brings the constructors into the project only after the design has been substantially completed and the specification has been developed. No proper channel for constructability input or critiques to improve in design. Constructability input is needed due to high complexity of offsite project
- Offsite and late design change does not work together. Later design change cannot readily be implemented without influencing the production schedule and extending of time which are the pitfall for every project (NAO, 2005). It is vital to involve designer, supplier, manufacture, architect and client to ensure the development is designed for manufacture and the design suit to manufacture capability and site condition (ibid)
- The concept of design integration is still new in construction. The nature of construction industry is competitive and fragmented where the genuine collaboration is rare due to the issue of trust
- There is still lack of designers and professionals trained in offsite and prepared with an offsite skill set to understand the complex harmonisation between offsite design and constructability. The designer has to choose between the designs that could be build with widely available systems in the market or producing specialised design in offsite that will allows aesthetic attribute

There is consensus of opinion that to harmonising design and manufacturing capacity lies on the need for early involvement between the design team, manufacturer, contractors and clients (Pan et al, 2008; Sanderson, 2003; Blismas, 2007 and Gibb, 2001). It was commented that offsite need to be integrated from the start of the design process so that the whole design and construction process to be aligned (Goodier and Gibb, 2007). This will eventually lead to a call for better coordination and design integration between all parties involve in offsite construction project (NAO, 2005). The project team needs to be assembled at the beginning of each offsite project to discuss on manufacture capability and constructability in an open collaboration environment. Designers need to have valuable input and critique on the issues of constructability particularly in offsite where the late design change is not a viable option to the project team. There is imperative for the clients to play the role of coordinator to make this thing happen.

To achieve design integration during the project implementation, offsite construction team requires real time information between the factory and the project site (Malik, 2006). Information and Communication Technology (ICT) can be a vital and reliable tool to offsite implementation and to integrate design in offsite project. Extensive ICT will support tool effectively handles updates change (Lessing, 2005), support integration of design (Oostra & Johnson, 2007) and source for accurate information (Lessing, 2006). An example of ICT implementation in IBS project is a research carried out by Kaner et al. (2008) on projects which using Building Information Modelling (BIM) as a tool. The research was conducted on medium sized structural engineering firms which had different introductions to BIM. An important result of the research however shows that, in the context of constructability, there were no drawing errors that led to the construction problems on site, and all pieces built in accordance with the shop drawings, fit the complex curved geometry of the structure.

On the other hand, based on the research conducted by Ting et al. (2007), the result showed that BIM enables the users to visualize the constructability of the proposed construction approach by implementing 4D modelling. The system also assists the project team to design a precise construction schedule so as to remove any potential unproductive activities. The result of the study is similar to the result from a research by Koo and Fischer (2000). In the study, the 4D models able to identify and eliminate the construction related problems before going to site. It further investigated whether 4D could help project participants identify problems that would normally be overlooked in traditional bar chart techniques. The work concluded that 4D models communicate a schedule more clearly and enable even relatively inexperienced construction professionals to identify problems. The identification of problems before materialising could help companies save time and money in the long term. In developing 4D modelling, according to Kymmel (2008), the construction schedule can be developed if a preliminary schedule is available and a schematic construction sequence can be simulated. The 4D modelling could facilitate the visualization of the construction process and allow the consideration of alternative approaches to sequencing, site layout, crane placement, etc., during construction process. Eastman et al. (2008) then further explain that this graphic simulation provides considerable insight into how the building will be constructed day-by-day and reveals source of potential problems and opportunities for possible improvements which agreed with the case study conducted by Ting et al. (2007) and Koo and Fischer (2000). Hence, it is good tool for effective production which error of design and incapability of manufacture to produce certain design can be addressed efficiently (ibid).

## MALAYSIAN GOVERNMENT'S INITIATIVE FOR IBS ENHANCEMENT PROGRAMS

In Malaysia, the term Industrialised Building System (IBS) is widely used by the government and practitioners to represent offsite construction. IBS is 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 works (CIDB, 2003a). The term also covered the concept of Modular Coordination (MC) and Open Building System (OBS) (CIDB, 2003a).

IBS has been introduced in Malaysia since the 60's by the use of pre-cast concrete beam-column element and panelised system (CIDB, 2003a; Thanoon et al., 2003). The projects in Jalan Pekeliling, Kuala Lumpur and Rifle Range, Penang had used Danish System and French Estoit System respectively. However due to some criteria that were not suitable for local cultural habits, the technology did not take off as planned. The recent influx of foreign workers in the 90's, however, has reignited the interest on IBS. IBS research and promotion was pioneered by Housing Research Centre (HRC), Universiti Putra Malaysia. HRC had organised a series of national and international colloquiums and seminars on IBS. In 2001, their research on *'Interlocking load bearing hollow-block building'* namely the 'Putra Block' has won the prestigious 'Geneva Gold Medal' award for innovation. HRC were also engaged with the National Affordable Housing research program with the Ministry of Housing and Local Government in 2001. In 1999, Construction Industry Development Board (CIDB) Malaysia formed the IBS Steering Committee in the effort to bring to the fore all the IBS related issues in a framework and IBS Strategic Plan 1999 were published. In 2003, the government, through CIDB published 'parliament endorsed' roadmap to guide the practitioners and decision makers in adopting IBS in Malaysia. Known as the Industrialised Building Systems (IBS) Roadmap 2003-2010, the master plan is based on the 5-M Strategy (Manpower, Materials-Components- Machines, Management-Processes-Methods, Monetary and Marketing) with the target of having an industrialised construction industry and introduce open building concept by the year 2010 (CIDB, 2003a). The initiative of roadmap implementation is currently lead by two working groups; IBS Steering Committee and IBS Technical Committee. CIDB's IBS Center has taking a role of secretariat to monitor all the activities.

Even though IBS has been introduced for over 40 years, the government of Malaysia still feels that the pace of implementation and usage of IBS is still slow. However, in the last couple of years, the momentum has steadily increased and has gradually become part of the industry. Many private companies in Malaysia have teamed up with foreign experts from Australia, Netherlands, United State and Japan to offer pre-cast solution to their project (CIDB, 2003b). There have a number of IBS key projects such as:

- 17 storeys flats along Jalan Pekeliling, Kuala Lumpur project that was awarded to Gammon/ Larsen Nielsen using a Danish System of large panel of pre-fabricated system (CIDB, 2003b)
- Housing project comprising 6 blocks of 17 storeys flat and 3 blocks of 18 storeys flat was constructed at Jalan Rifle Range, Penang. The project was awarded to Hochtief/ Chee Seng using the French Estoit System (Din, 1984)
- Taman Tun Sardon Housing project in Penang. An IBS pre-cast component and system was used in the project and was designed by the British Research Establishment (BRE) in 1978 for low cost housing in tropical countries.

- Perbadanan Kemajuan Negeri Selangor (PKNS), low cost houses and high cost bungalows project in Selangor (CIDB, 2003b). The project is under a state government development agency which acquired pre-cast concrete technology from Praton Haus International based in Germany
- The 36-storeys Dayabumi complex which the first project used steel structure (part of IBS) as a method of construction was completed in 1984 by Takenaka Corporation of Japan (CIDB, 2003b)
- Hybrid construction (mixed used of IBS and conventional method) for national scale infrastructure projects and national landmark such as Bukit Jalil National Sport Complex (1998), Kuala Lumpur City Centre (KLCC) (1998), Light Rapid Transit (LRT) (1997), Kuala Lumpur International Airport (KLIA) (1997) and School Teacher's Quarters (2001)

The following is the key events of IBS promotion and initiatives taken by the government: in Malaysia:

- Through the *National Yearly Budget* announcement back in September 2004, the government had pledged to construct 100,000 units of affordable houses using IBS. In addition, all new government building projects were required to have at least 50% IBS content which had been calculated through the IBS Score Manual developed by CIDB.
- The Construction Industry Master Plan 2006-2015 (CIMP 2006-2015) had been published in December 2006 as means to chart the future direction of the Malaysian construction industry. The effort to promote IBS is highlighted under Strategic Thrust 5: Innovate through R&D to adopt a new construction method.
- Beginning from 2007 onwards, new incentives for IBS adopter has been introduced. The exemption of the levy (CIDB levy - 0.125 % of total cost of the project according to Article 520) on contractors that used some kind of IBS in 50% of the building components has been commenced since 1st January 2007 (Hamid et al, 2008).
- In early 2007, IBS Centre had been established in Cheras to promote IBS in Malaysia and also to play the role of consultant. The centre is equipped with IBS showhouse and Research and Development (R&D) capacity. Construction Research Institute of Malaysia (CREAM) was initiated to manage IBS research.
- The new circular of by the Ministry of Finance dated on October 2008 had emphasized on the full utilization of IBS for government's projects in Malaysia. Among the pressing matters raised in the circular were the use of IBS component in government projects must not be less than 70% and the inclusion of IBS component as part of contract documents for all building works. As in February 2009, 320 government projects worth RM 9.43 billion had been carried out using the IBS technology

## CONCLUSION

Although, the introduction of IBS (or offsite) construction faced the same problem to adopt constructability as for conventional method, the systems can provide practitioner with the fresh outlook on this issues. As stated by previous researchers, IBS (or offsite) adoption can be a great platform to improve constructability in the sense of design for standardization, preassembly and repetitiveness. More government incentive, research and promotion to generate greater use of IBS (or offsite), may solve the issue of constructability's implementation which indirectly could become good drivers or strategies for the process of enhancement of constructability. Initiatives have be taken by the Malaysian government to implement IBS (or offsite) seriously, was looked as a good step in order to improve the level of constructability in the construction business industry. In the end, constructability concept is believed could be an effective approach in order to enhance the level of product/project design by allows the early involvement of professionals or construction expertise such as contractors and facility managers to share their knowledge and expertise in the initial stage of design in order to produce the design for ease of construction and maintenance towards green or sustainable construction in the future.

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