

INDUSTRIALISED BUILDING SYSTEM: A DEFINITION AND CONCEPT

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ABSTRACT

Industrial Revolution is a process of social and economic change for human society to transformed from pre-industrial to a new industrial country. Industrialization in construction industry is part of a process in change and improvement management. The degree of industrialization and its characteristics carried out the different understanding in its terminology and definitions. Through a thorough literature review, this paper is highlighted the concept of Industrialized Building System (IBS). A comparison of terminology used for IBS from various countries is highlighted for discussion. This paper concluded the IBS as part of modern method of construction.

KEYWORDS : Industrialization, Industrialised Building System (IBS), Terminology, Definition

INTRODUCTION

To date there has been no one commonly accepted or agreed definition of Industrialised Building System (IBS). Whilst IBS is not new and many have published on the subject, the fundamental issues on definition and classification have not been adequately covered. One can view IBS as a systems, process, approach or industrial philosophy. IBS was commonly assumed by fellow researchers to be on the similar characteristics and definition with Off-site Construction (OSC), Modern Method of Construction (MMC), Off-site Manufacturing (OSM), Off-site Production (OSP), Industrialised Building, pre-assembly, prefabrication, modularization which in common use at various times in the literature. In principal, regardless of the terms, the idea is to move some effort away from the construction site to a more controlled environment of the manufacturing floor. But many terms can lead into confusion and mislead interpretation by the stakeholders (i.e. client, contractor, designer, manufacture). Even if the principality of IBS may be well understood by manufacturers, contractors and some designers, but unless the definition and classification of IBS is well documented and understood in common ground, then their misunderstandings and prejudices will continue to be a barrier to further

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development. Thus, the researcher should identify workable definition and classification to could bring IBS to the next level of understanding

WHAT IS IBS?

The definition of Industrialised Building System (IBS) is varies. It depends on the authors' position and philosophy in ontology and epistemology. Several authors may define IBS as process or as techniques. The following table 1 below is highlights the categories of definitions for IBS. On the other hand, there are ontology position either can be terms as a approaches, philosophies, products, innovation, improvements, modernisation and new methodology. The issue has been discussed in construction industry since the industrial revolution change the ways of human living and economic activities. Since the concept of improvement and quality take place in industry, the invention and innovation become significant to industry to deal with. Such progress and development of production and services become continuously in construction industry, the factors of newest and modern instruments comes in. Then each industry stakeholders will make their own definition on their practices and approaches. The following table 1 below only describe the list of authors that define IBS as process and techniques.

Bil	Authors	Process	Techniques
1	Dietz (1971)	X	
2	Dickerman (1973)	X	
3	Junid (1986)	X	
4	Pañd (1997)		X
5	Esa & Nurrudin (1998)		X
6	Badir & Razali (1998)		X
7	Trikha (1999)		X
8	Warszawski (1999)	X	
9	CIDB Malaysia (1999)		X
10	CIDB Malaysia (2003)	X	
11	Lessing (2005)	X	
12	Marsono. (2006)	X	
13	Rahman & Omar (2006)		X
14	MD Rahim. (2006)	X	
15	Chung L.P. (2006)	X	
16	Henry M.A. (2006)	X	
17	(CIB) TG57	X	
18	(CIB) W24)	X	

Table 1: The Ontology of Building System
 (Sources : Adopted from Abdullah M.R. , 2009)

Authors	Characteristics							
	Factory Base (Off Site) Production Techniques	Mass Production	Site Erection and Pre Assemblies	Modular Component Elements	Standardisation	Labour Reduction	Modern Method	Automation Manufacturing
Parid, W., 1997	X							
Trikha, D.N., 1999	X	X		X		X		
Gibb, A., 1999	X	X	X					
Warszawski, 1999	X		X	X	X			
Ingemar, L. and Gylltoft, K. 2000		X					X	X
Kadir, M.R.A., et al., 2005	X	X		X		X		
Marsono, A.K et al., 2006	X				X	X		

Table 2: The Characteristics of Building System
(Sources : Adopted from Abdullah M.R. , 2009)

DEFINITION OF IBS

IBS has many terms which are in common in definition and perspective and up to date there has been none commonly - accepted or agreed on the issue of definition for IBS.

However, there are a few definitions by authors who studied into this area previously were found through literature emphasizing on prefabrication, off-site production and mass production of building components (Rahman & Omar, 2006) (Warszawski, 1999) (Lessing *et al.* 2005) (Triksa, 1999) (Esa & Nurudin, 1998). IBS is often referred by the literatures as off-site construction (Pan *et al.* 2008), off-site production (Blismas *et al.* 2006), industrialized and automated construction (Warszawski, 1999), off-site manufacturing, prefabricated building, pre-assemblies building (Gibb & Isack, 2003), pre-cast building, pre-cast construction, non-traditional building and Modern Method of Construction (MMC).

Rahman & Omar (2006) defined IBS as a construction system that is built using pre-fabricated components. The manufacturing of the components are systematically done using machine, formworks and other forms of mechanical equipment. The components are manufactured offsite and once completed will be delivered to construction sites for assembly and erection. IBS is also defined as an integrated manufacturing and construction process with well planned organization for efficient management, preparation and control over resources used, activities and results supported by the used of highly developed components (Lessing, *et al.*, 2005).

Chung & Kadir (2007) defined IBS as a mass production of building components either in factory or at site according to the specification with standard shape and dimensions and transport to the construction site to be re-arranged with certain standard to form a building and the Construction Industry Development Board (2003) defined 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 works.

IBS CLASSIFICATION

MMC is a term adopted as a collective description for both offsite based construction technologies and innovative onsite technologies. The latter includes techniques such as thin-joint block work and tunnel-form construction (Goodier & Gibb, 2006). MMC also include modern methods of construction of floor or roof cassettes, pre-cast concrete foundation assemblies, pre-formed wiring looms, and mechanical engineering composites. They can also include innovative techniques (which is essential feature) such as tunnel form or thin-joint block work (NAO, 2005) (Gibb and Pendlebury, 2006). As the reference above, IBS is in which component are manufactured, positioned and assembled into a structure with minimal additional site works both off-site and on-site (CIDB, 2003 and Chung, 2006). While an off-site technique will be discussed below, an on-site IBS can be in the form of in-situ pre-cast system using steel formwork (CIDB, 2003).

Offsite construction is the description of the spectrum or part there of which are manufactured assembled remote from building site prior to installation in their final position. Whereas all Offsite may be regarded as falling within a generic IBS and MMC heading, not all IBS and MMC may be regarded as offsite (Gibb and Pendleton, 2006). Offsite Construction (OSC), Offsite Manufacturing (OSM) and Offsite Production (OSP) is largely interchangeable terms that refer to that part of the construction process that is carried out away from the building site, such as in a factory or sometimes in specially created temporary production facilities close to the construction site (or field factories) (Goodier and Gibb, 2006).

Pre-fabrication is a manufacturing process generally taking place at a specialised facility, in which various material are joined to form a components part of final installation (Tatum et al, 1986). While, the components maybe assemble on and offsite,

Pre-assembly carried on a definition as a process by which various material, pre-fabricated components and or equipment are joined together at a remote location for subsequent installation as a sub unit. It generally focused on system (ibid). Therefore,

a generic classification of IBS-MMC term is promoted in this paper based on the following assumption compiled by the previous researchers.

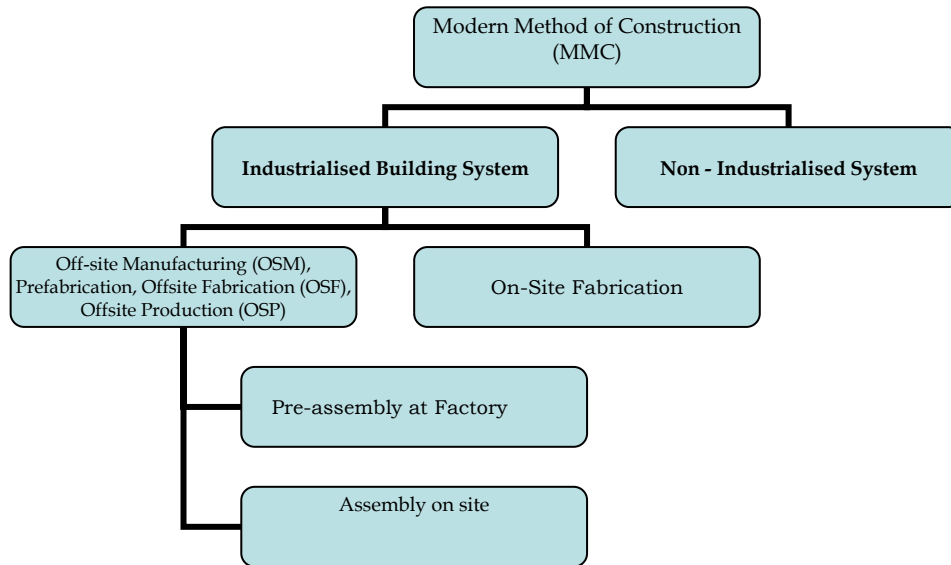


Table 2: A generic classification of IBS in MMC

Just as the definitions, IBS-MMC has a various different classification which based on material, process and system. Table 1, depicted the classification of IBS, building system, MMC and OSM. It compares different view and terminology of the classifications.

Industrialised system classification (Badir et. al (1998)	Majzub (1977) system classification	MMC classification (Gibb & Pendlebury, 2006), Ross and Richardson (2005) and (NOA, 2005)	Gibb & Issac (2003) pre-assembly and pre-fabrication classification	Abosad et al (2009) classification on OSM	IBS Classification (CIDB, 2003)
-Conventional building system -Cast in situ formwork system – table or tunnel formwork -Prefabricated system -Composite system	-Panel System -Box System -Frame System	-Volumetric -Panelized -Hybrid -Subassemblies and components -Non-off-site - Modern Methods of Construction	-Component manufacture and sub-assembly -Non-volumetric sub-assembly -Volumetric pre-assembly -Modular Housing	-Volumetric System -Panellised System -Hybrid System -Sub-assemblies and component system -Modular system	-Pre-cast concrete-framed building -Pre-cast concrete wall system -Reinforced concrete Building with Pre-cast concrete slab -Steel Formwork System -Steel-framed building and Roof Trusses

Table 3: Comparison of IBS-MMC Classification

The confusion of classification may lead to difficulties for the clients to make appropriate choice of construction method. For further exploration or and discussion between researchers in this field, a more general classification for IBS based on the above table is produced by the authors as follows:

- 1) Frame System
- 2) Panellised System
- 3) Cast in-situ formwork system
- 4) Hybrid System
- 5) Modular System

It is hoping that IBS classification can be standardised in order for IBS-MMC to be accepted by practitioners as a primer construction method

DEGREE OF INDUSTRIALISATION OF IBS

Industrialisation is a process of social and economic change whereby a human society is transformed from a pre-industrial to an industrial state (CIDB, 2003). It is a part of a wider modernisation process through the development of modern methods of production and technology system, mainly factory production where work is centrally organized, production operations are mechanized and are focused on mass production (Lessing, 2006). As stated by Richard (2005), this process is depended to the degree of industrialisation which is prefabrication, mechanisation, automation, robotics and reproduction. This degree or level of industrialisation is associated with the scope of works in construction process or life cycle. It can be summarized as following figure 3 and 4 below.

In the figure 2 below, the prefabricated scope of works is lesser than mechanisation approach in term of task involved. While the task covered by mechanisation which integrated the architectural works [painting, ducting, finishing] in factory earlier before mobilisation to site. It means that less workers or labour involve. Since pre fabricated only jointing the components of panels become an elemental of building, mechanisation level already done it in factory by machine. That distinguished the degree or level of industrialisation. The automation level utilised the programmable

machines i.e. robotics to performing task including the computerised tools for planning, design and operation.

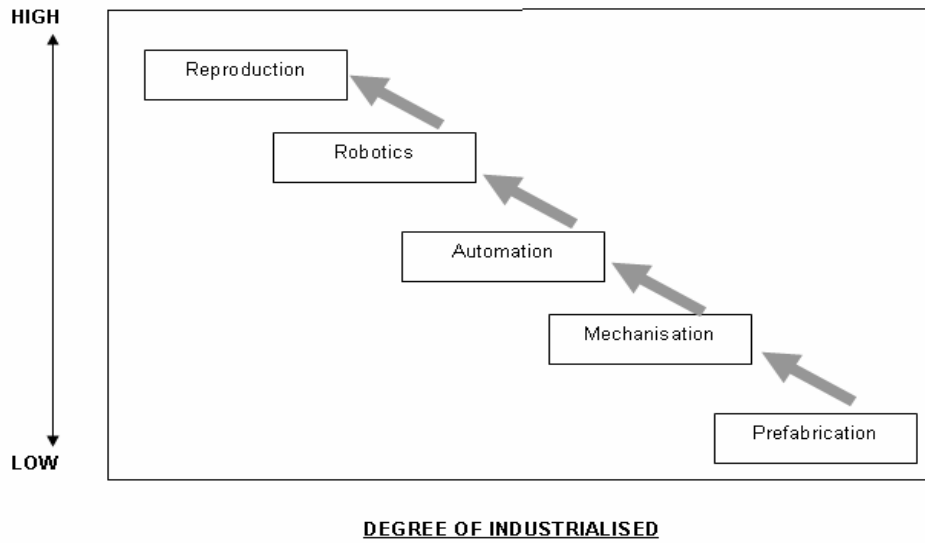


Figure 3: Degree of Industrialisation
(Sources : Adopted from Richard (2005))

The decision to adopt and implementing IBS must start from the conceptual stage. It because the earliest decision been made, the better for production planning to schedule the works if the project been successful awarded. The prefabrication level of IBS may be impart or alternatively done after design had been approved. With that the prefabrication can be later start or during planning and execution stage of project life cycle. But for mechanisation and robotics the design of that such building shall be determined earlier as soon as conceptual stage for factory production team to design the mould or other related tasks. The figure 3 below show the scope of IBS according to its industrialisation degree or level.

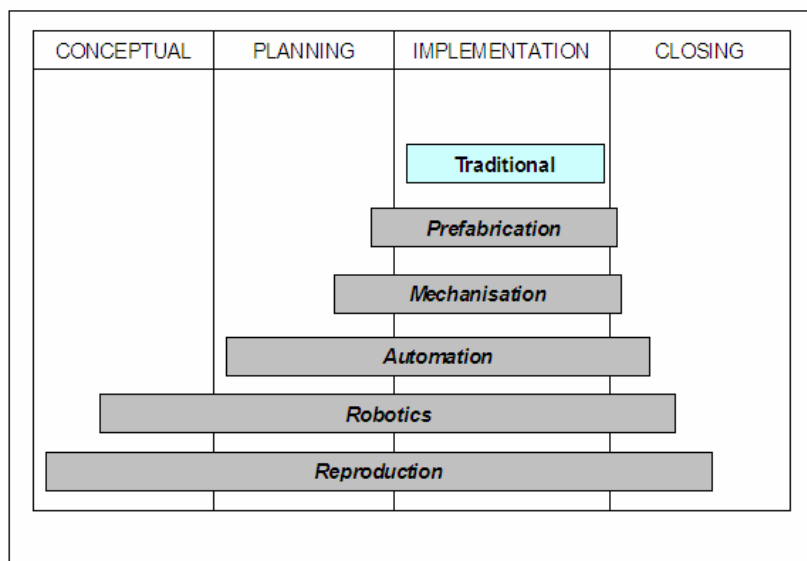


Figure 4: Scope of Works for IBS in Project Life Cycle

CONCLUSION

This paper proposed IBS definition, classification and its terminology relation with MMC and off-site although in principal, regardless of the terms, the idea is to move some effort away from the construction site to a more controlled environment of the manufacturing floor. It is hoping that the term will be well understood by manufacturers, contractors and some designers in common ground and could bring IBS to the next level of understanding among the researchers. Thus, will correct the misunderstanding and prejudices will continue to be a barrier to further development. The generic definition and classification proposed by this paper are not aim to be definitive but rather a stepping stone to get more feedback from practitioner and researchers.