CHAPTER 3

CUSTOMER SATISFACTION FACTORS AND INDUSTRIALISED BUILDING SYSTEM (IBS) ADOPTION

3.1 INTRODUCTION

This particular chapter presents the literature review on customer satisfaction factors and industrialised building systems (IBS). The chapter begins with a discussion on criteria of project success, customers in the construction industry, and customer satisfaction factors concerning housing projects and the selection of customer satisfaction factors for housing projects. This chapter also presents the definition and concept of industrialised building systems, which provides a clear focus on Malaysia with a comparison with other countries experience of IBS. Previous studies in respect of IBS adoption factors concerning housing projects and the selection of IBS adoption factors are also presented in this chapter.

3.2 CRITERIA OF PROJECT SUCCESS

Based on previous research carried out by researchers it was found that the traditional factors that impact on project success could be categorized according to time, cost and quality. This has been extensively studied (Turner, 1999; Songer & Molennar, 1996; Chan & Chan, 2004). Similarly, Diallo & Thuillier (2005), in their study, confirmed that time, cost and quality are the management dimensions for project success in international projects. These studies expanded into many related universal factors, for example, the study by Nguyen *et al.* (2004) looked at factors including completion on time, within budget, according to specification and customers' satisfaction. The study by Ashley *et al.* (1987) looked at factors including cost, schedule, quality, safety and satisfaction to the customer. The criteria of success in construction means meeting with "budget performance, client satisfaction, functionality, contractor satisfaction and project manager/team satisfaction" (Ashley, 1987; de Wit, 1988 cited in Nguyen *et al.* 2004). Another set of dimensions of project success forwarded by Sadeh *et al.* (2000) included meeting the design goals, benefit to the development of the company and country, and benefit to end user.

Here, the customers play a pivotal role in the determination of the success of IBS house demand and the success of IBS adoption in Malaysia's construction project (Elias, 2006). Customer satisfaction can be linked to the application of QFD and can thus be established as the platform to voice the acceptable quality of IBS houses. The power of QFD is in its founding philosophy: "the voice of the customers will drive everything an organization does throughout the process of developing and delivering products and services" (Bossert, 1991).

3.3 CUSTOMERS IN THE CONSTRUCTION INDUSTRY

The first step in quality planning is to identify the customers that are considered to be impacted by a product (Juran, 1988). In general, customers are divided into the vital few external customers and internal customers (Juran, 1988; Abdul-Rahman *et al.*, 1999).

External customers are not part of the organization producing the product or services. For engineering, the products are plans, specifications and the customers are the construction organizations and the owner. For construction, the product is the completed facility and the customer is the final user of the facility (Juran, 1988; Abdul-Rahman *et al.,* 1999).

In contrast, internal customers are those from within the engineering and construction organizations. The customers receive products and information from other groups or individuals within the organization (Juran, 1988; Abdul-Rahman *et al.,* 1999). Satisfying the needs of these internal customers is an essential part of the process of supplying the ultimate external customer with a quality product (Burati, 1990).

Every participant in the construction process can be portrayed as a customer as well as a supplier depending on whether he/she is an end-user/consumer, owner/client, designer or constructor (Juran, 1988; Abdul-Rahman *et al.*, 1999). The owner is usually considered to be the customer and employs the designer to develop construction documents that the constructor will use to satisfy this owner. In one sense, the constructors are the designer's customers because these constructors receive the designer's product (plans and specifications) (Juran, 1988; Abdul-Rahman *et al.*, 1999). Similarly, so is the designer, as the owner will provide the designer with performance parameters for the project. If the information (product) is incomplete or inaccurate, the design that results will likely be flawed (Juran, 1988). The ultimate customer for the whole construction project will be the end-users or consumers who will provide feedback in terms of their needs or requirements expected from the product or complaints of any inadequacy in the design or defects through market survey and any after-sales services (Juran, 1988; Abdul-Rahman *et al.,* 1999). Whenever one construction entity receives a product from another entity to either use or add to or build upon, then that receiving entity is in fact a customer. This understanding of the concept of the customer is important to the application of QFD.

3.4 CUSTOMER SATISFACTION FACTORS IN HOUSING PROJECTS

The customer satisfaction or dissatisfaction is a core concept in marketing. It is determined based on the overall feelings or attitude of a person about a product or service after it is purchased or experienced. Consumers are engaged in a constant process of evaluating things they bought and these products are integrated with their daily consumption activities. It is a generally accepted notion that consumer satisfaction is the most efficient and least expensive source of market communication because satisfied consumers will disseminate their favourable experience to others (Dubrovski, 2001 cited by Mustafa & Ghazali, 2011). Conversely, if they are dissatisfied, they will spread unfavourable appraisal of the product or service they encountered. This danger is clearly derived from various researchers (Desatnick, 1989 cited by Mustafa & Ghazali, 2011; Dubrovski, 2001 cited by Mustafa & Ghazali, 2011).

In relation to the above, numerous studies have been conducted. For example, Chee & Peng (1996) examined the marketing of houses in Malaysia by focusing on the relationship between customer orientation and important components of the marketing concept, by analysing the satisfaction of house buyers. The work of Torbica (1997) includes an analysis of Total Quality Management (TQM) and customer satisfaction in home building. Torbica (1999), as cited by Mustafa & Ghazali (2011), assessed a model for quality performance control in residential construction, while Torbica & Stroh (2001) studied customer satisfaction in home building. Pheng & Nguan (2004) determined their satisfaction level from using smart features provided in their intelligent condominiums. San (2006) examined the implementation of corporate social responsibility (CSR) in product perspective by the developers, while Aziz & Yi (2006) determined the resources required to compete in the speculative housing development sector in Malaysia. Hai (2007) focused on the importance of the developer playing their role, while a conceptual framework for studying customer satisfaction in Australian residential construction was developed using marketing theory merged with construction concepts (Forsythe, 2007). Whilst, Forsythe (2008), cited by Mustafa & Ghazali (2011), developed a theoretical model concerning the way service quality could impact on the perceptions of customers in housing construction.

In Malaysia, the housing industry seems to move along with the requirement made by the potential house buyers. Although the housing industry has recognized customer satisfaction as a decisive business factor, it does not indicate how well the industry is meeting customer expectations. Furthermore, Zeithaml *et al.,* (1990) also suggested that one of the prime causes of poor performance by service firms, for example, the housing developers, is that the developers do not know the expectations of the house buyers. Most organizations are keen to provide and offer product and service quality but fall short simply because they do not have an accurate and precise understanding of what customers expect from them (Zeithaml *et al.,*1990). Hence, understanding customer expectations is important to the performance of private developers. The Ministry of Housing and Local Government in Malaysia (MHLG) emphasized that housing should provide residents with safety, security, comfort, health, privacy and other services (NorAini, 2007; Jose & Simoes, 2003).

Mustafa & Ghazali (2011) developed a conceptual framework on house buyers' satisfaction of housing projects. In their study they stated that the house buyers' satisfaction of housing project should consider the price, project location, delivery system, product quality, service quality and house buyers' characteristics.

Research conducted by Stehn & Bergstrom (2002) indicated that the most important customer demands concerning the design of multi-storey timber frame houses are: good economy (investment and operation and maintenance), attractive layout of flats (inner design and exterior design), low environmental impact (indoor environment and resources), high quality (product quality), and flexible design (movable and variable).

According to Abdul-Rahman *et al.* (1999), the factors influencing the quality of a low-cost flat are: structural elements (foundation, beam, column, roof, wall, flooring), building materials used for building (roof, floor, wall, door, window), safety and stability of building from natural elements (wind, rain, earthquake), workmanship in installing components, (ceiling, door, window, tiling, painting, plastering, plumbing work, electric wiring), environmental conditions (air quality, noise, traffic congestion), home security and safety during emergency, size of flat, basic amenities (water supply, electricity, shops, school, market, parking lots, playground), maintenance work (repairworks, repainting building, garbage collection system, overall cleanliness and maintenance of building), layout of flat (living area, kitchen, bathroom, bedrooms, balcony), internal condition (ventilation, temperature, lighting), location of flat (urban, suburban, rural area), and the appearance or design of the flat.

The important criteria that would satisfy the customers of high-rise building projects include location (social differentiation), size (large apartment unit), comfort (functionality and quality of materials/fixed furniture used in the kitchen, functionality and quality of accessories/materials used in the bathrooms), convenience (availability of independent/in house storage unit, architectural layout of the apartment unit) security (security from external threats), car safety (parking area/garage) social facilities (swimming pool, tennis court, fitness centre, playrooms and playing field for children), strength (earthquake resistance), HVAC (air conditioning, efficient central heating), energy (continuous water and electricity supply, low energy costs and high thermal quality), fire safety (availability of smoke/fire detectors, efficient fire extinguishing system), elevators (sufficient number of elevators with high speed), scenery (good and fascinating sight), management (efficient building management) and aesthetics (exterior appearance of the facility) (Dikmen *et al.*,2005).

Gargione (1999), in his study, stated that time, cost, product quality, design, and building specification, are the important points that could offer a potential for improvement according to the clients' requirements and needs for middle-class apartment unit projects.

The research study by Kam & Tang (1997) determined three (3) major components to implement quality assurance – structural works, architectural works and external works. The items assessed regarding structural works are formwork, reinforcement, finished concrete, concrete quality and reinforcement quality. The items assessed regarding architectural works are floors, internal walls, ceiling, doors and windows, rainwater down-pipes, plumbing, sanitary fittings, installation of mechanical and electrical services, permanent components, roof, external walls and material and functional tests. The items assessed regarding facilities of external works are aprons and drains, roadworks and car parks, footpaths and turfing, fencing and gates, and other areas specific to the project. Table 3.1 shows a summary of previous research studies on customer satisfaction factors for housing projects.

Table 3.1: Summary of previous research on customer satisfaction factors of housing projects

Customer satisfaction Factors from previous studies	**Author**
The Ministry of Housing and Local Government in Malaysia (MHLG) emphasized that housing should provide residents with safety, security, comfort, health, privacy and other services.	NorAini (2007) Jose & Simoes (2003)
The house buyers' satisfaction of housing project should consider the price, project location, delivery system, product quality, service quality and house buyers' characteristics.	Mustafa & Ghazali (2011)
The most important customer demands to focus on in multi-storey timber frame house designs are: good economy, attractive flats layout, low environmental impact, high quality, and flexible design.	Stehn & Bergstrom (2002)
The factors influencing the quality of a low-cost flat are structural, building materials used, safety and stability of building from natural elements, workmanship in installing components, environmental conditions, home security and safety during emergency, size of flat, basic amenities, maintenance work, layout of flat, internal condition, location of flat, and appearance design of flat.	Abdul-Rahman *et al*.(1999)
The important criteria that would satisfy the customers of high-rise building projects are location, size, comfort, convenience, security, car safety, social facilities, strength, HVAC, energy, fire safety, elevators, scenery, management and aesthetics.	Dikmen *et al.* (2005).
Time,cost, product quality, design, and building specification, are the important points that could offer a potential improvement according to the clients' requirements and needs for middle-class apartment unit projects.	Gargione (1999)
Three (3) major components to implement quality assurance– structural works, architectural works and external works. The items assessed regarding structural works are formwork, reinforcement, finished concrete, concrete quality and reinforcement quality. The items assessed regarding architectural works are floors, internal walls, ceiling, doors and windows, rainwater down-pipes, plumbing, sanitary fittings, installation of mechanical and electrical services, permanent components, roof, external walls and material and functional tests. The items assessed regarding facilities for external works are aprons and drains, roadworks and carparks, footpaths and turfing, fencing and gates, and other areas specific to the project.	Kam & Tang (1997)

3.5 SELECTION OF CUSTOMER SATISFACTION FACTORS FOR HOUSING PROJECTS

The first step of this research study is the selection of customer satisfaction factors that focus on the context of IBS houses. The selection of customer satisfaction factors was drawn from the literature review of previous research. Table 3.2 shows the selection of customer satisfaction factors for housing projects.

Table 3.2: Selection of customer satisfaction factors for housing projects

Customer Satisfaction Factors	Source
Size of house	Abdul-Rahman *et al*. (1999) Stehn & Bergstrom (2002) Dikmen *et al*., (2005)
House price	Stehn & Bergstrom, (2002) Mustafa & Ghazali (2011) Gargione (1999)
Quality of workmanship	Abdul-Rahman *et al*. (1999) Dikmen *et al*., (2005) Kam & Tang (1997) Gargione (1999)
Quality of building materials	Abdul-Rahman *et al*. (1999) Stehn & Bergstrom (2002) Kam & Tang (1997) Mustafa & Ghazali (2011) Gargione (1999)
Design quality	Abdul-Rahman *et al*. (1999) Stehn & Bergstrom (2002) Dikmen *et al*.(2005) Kam & Tang (1997) Mustafa & Ghazali (2011) Gargione (1999)
Building strength	Abdul-Rahman *et al*. (1999) Dikmen *et al*., (2005) Kam & Tang (1997) Gargione (1999) NorAini (2007)
Comfort	Abdul-Rahman *et al*. (1999) Dikmen *et al*., (2005) NorAini (2007)
Environmental Conditions	Abdul-Rahman *et al*. (1999) Stehn & Bergstrom (2002) NorAini (2007)
Maintenance work	Abdul-Rahman *et al*. (1999) NorAini (2007) Mustafa & Ghazali (2011)

From Table 3.2, the researcher determines the list of customer satisfaction factors in housing projects. These are:

i. Size of house
ii. House price
iii. Quality of workmanship
iv. Quality of building materials
v. Design quality
vi. Building strength
vii. Comfort
viii. Environmental Conditions
ix. Maintenance work

Figure 3.1 shows the conceptual framework of factors affecting customer satisfaction in housing projects. The researcher will use this conceptual framework in order to conduct the quantitative study that will be further explained in the research methodology chapter.

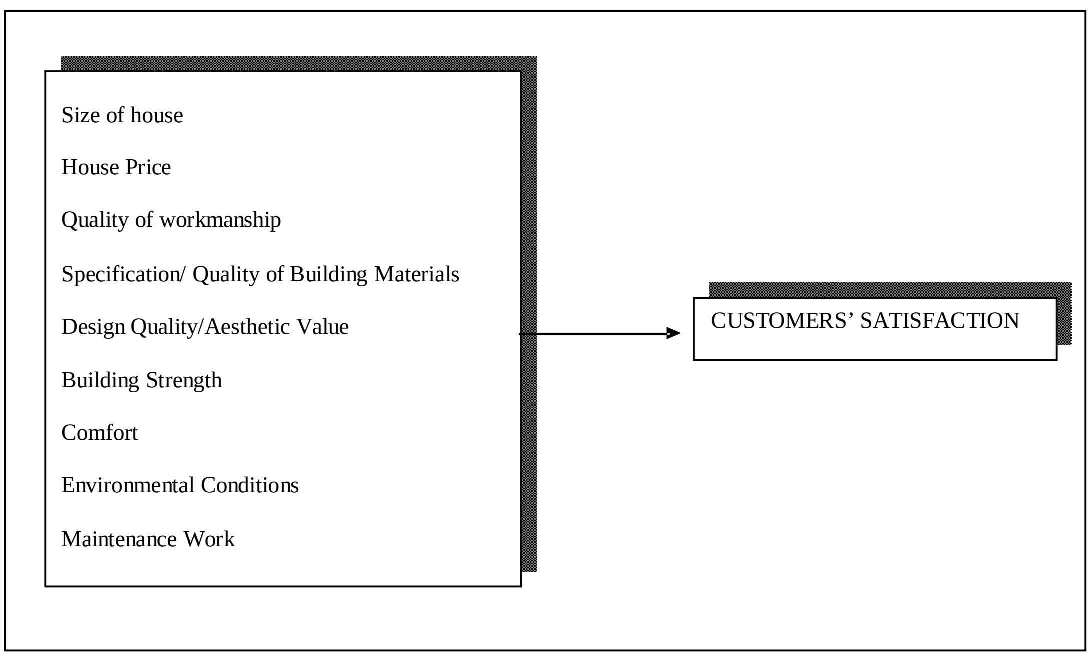


Figure 3.1: Conceptual Framework of Factors Affecting Customer Satisfaction in Housing Project

3.6 CONCEPT OF INDUSTRIALISED BUILDING SYSTEM (IBS)

Understanding the concept of Industrialised Building Systems (IBS) provides a greater opportunity for its adoption in the construction industry. IBS promises elevated levels of expertise throughout the industry, including manufacturers, installers, engineers, planners, designers, and developers. The benefits of IBS are numerous and far reaching -reduced construction time, better site management, reduced wastage and the production of better products for the population (CIDB, 2003).

IBS, which enables on-site prefabricated or pre-cast building components manufactured at factories, will enable cost savings and quality improvement through the reduction of labour intensity and construction standardization. In addition, it offers minimal wastage, less site materials, cleaner and neater environment, controlled quality, and lower total construction cost (CIDB, 2003).

The concept of mass production of quality building is termed as "Industrialized Building System" (CIDB, 2003). Among the advantages of using an industrialized building system are, speed, quality and economics, all of which are required so as to meet the large demand for housing (CIDB, 2003).

In order to develop techniques for mass produced houses, Malaysia needs to access the world's most modern building systems, building materials and housing products (Thanoon *et al.,* 1997). The different IBS definitions in the manufacturing and construction industries have a bearing on understanding the concept of IBS. These are all discussed in the next section.

3.7 DIFFERENT DEFINITIONS OF IBS

The different definitions of IBS bring about a closer understanding of its application in the construction projects. To date there has been no one commonly accepted or agreed definition of IBS. However, there are various definitions by researchers who have studied this area, including that of Rahman & Omar (2006) who defined IBS as a construction system built using pre-fabricated components.

The manufacturing of the components of IBS is systematically done using machines, formwork and other forms of mechanical equipment. The components are manufactured off-site and once completed will be delivered to construction sites for assembly and erection. In view of this, Parid (1997), cited by CIDB (1998) defined IBS as a system that uses industrialised production techniques either in the production of components or the assembly of the building or both. However, Lessing *et al*. (2005) defined IBS as an integrated manufacturing and construction process with well-planned organisation for efficient management, preparation and control over resources used, activities and results supported by the use of highly developed components.

Another definition of IBS by Trikha (1999) defined IBS as a system in which concrete components prefabricated at site or in a factory is assembled to form the structure with minimum in situ construction. IBS was also defined as a set of interrelated elements that act together to enable the designated performance of the building (Warszawski, 1999).

Still another definition of IBS, by Esa & Nurudin (1998), is that IBS acts as a continuum beginning from utilising craftsmen for every aspect of construction to a system that makes use of manufacturing production in order to minimise resource wastage and enhance value to the end users.

Junid (1986) and Abdullah *et al.* (2009), defined IBS as a process by which the components of a building are conceived, planned and fabricated, transported and erected at site. The system includes a balanced combination between software and hardware components. The software elements include system design, which is a complex process of studying the requirements of the end user, market analysis and the development of standardised components (Junid, 1986).

Chung & Kadir (2007) defined IBS as the mass production of building components either in the factory or on site according to the specification with a standard shape and dimension, then transporting those components to the construction site to be re-arranged according to a certain standard to form a building. IBS is often referred to by the literature as off-site construction (Pan *et al.*,2008), off-site production (Blismas *et al.*,2006; cited by Abdullah *et al.*, 2009), off-site manufacturing, prefabricated building, pre-assemblied building, pre-cast building, pre-cast construction, non-traditional building and modern method of construction (MMC) (Gibb & Isack, 2003; cited by Abdullah *et al.* 2009). A summary of IBS definitions is provided in Table 3.3.

Table 3.3 Summary of Different Definitions of IBS

Definition	Author
Construction system that is built using pre-fabricated components	Rahman & Omar (2006)
IBS as an integrated manufacturing and construction process with well-planned organisation for efficient management, preparation and control over resources used, activities and results supported by the used of highly developed components.	Lessing *et al.* (2005)
IBS is a system in which concrete components prefabricated at site or in the factory are assembled to form the structure with minimum in situ construction	Trikha (1999)
A set of interrelated elements that act together to enable the designated performance of the building	Warszawski (1999)

Table 3.3 Summary of Different Definitions of IBS (Cont'd)

Definition	**Author**
IBS acts as a continuum beginning from utilising craftsmen for every aspect of construction to a system that makes use of manufacturing production in order to minimise resource wastage and enhance value to end users.	Esa & Nurudin (1988)
Process by which components of building are conceived, planned and fabricated, transported and erected at site.	Junid (1986)
Mass production of building components at factory or site	Chung & Kadir (2007)
IBS is often referred to in the literature as off-site construction	Pan *et al.* (2008)
Off-site production	Blismas *et al.* (2006) cited by Abdullah *et al.* (2009)
Off-site manufacturing, prefabricated building, pre-assemblied building, pre-cast building, pre-cast construction, non-traditional building and modern method of construction (MMC) (Gibb and Isack, 2003).	Gibb & Isack (2003) cited by Abdullah *et al.*(2009)

All the above definitions emphasised prefabrication, off-site production and mass production of building components as the main characteristic of IBS. The focal point of discussion in this study synergises the key concept of IBS, which can be defined as follows: 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, 2003).

3.8 CLASSIFICATION OF INDUSTRIALISED BUILDING SYSTEM

The classification of IBS encourages the application of IBS in the construction projects. IBS are classified according to the type of construction, which ranges from conventional construction to fully prefabricated construction. Generally, the construction methods are classified here into four categories (Badir *et al.*, 1998). These are:

i. Conventional

ii. Cast-in-situ

iii. Composite

iv. Fully pre-fabricated

The first method is the conventional method. The second, third and fourth construction methods are non-conventional construction methods. The non-conventional construction methods are specifically aimed to increase productivity and the quality of work through the use of better construction machinery, equipment, technology and materials. The main point to consider here is the particular construction method most suitable for a particular project (Dulaimi, 1995). The following sub-section provides a description of the four construction methods according to the IBS category.

3.8.1 Conventional Construction Method

This construction method is where the components of the building are cast in-situ through the processes of timber or plywood formwork installation, steel reinforcement, and cast in-situ (Badir *et al.*, 1998). Conventional buildings are, mostly built of reinforced concrete frames (Andres & Smith, 1998).

The traditional construction method uses wooden formwork. It is much more costly for construction, which includes labour, raw material, transportation and low speed of construction time (Badir *et al.*, 1998), as can be seen in Figure 3.2.

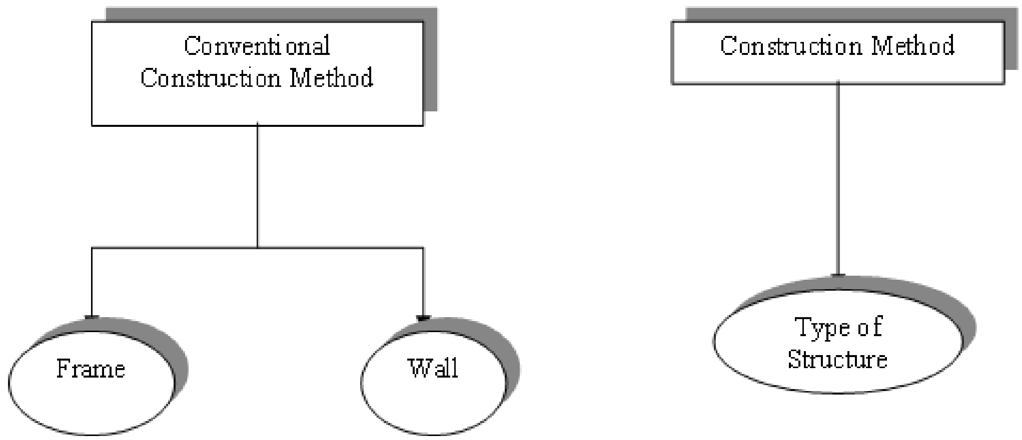


Figure 3.2 Classification of conventional construction method
(Source: Badir *et al.*, 1998)

3.8.2 Cast In-situ Construction Method

The cast in-situ method is the first construction in which IBS is classified. The cast in-situ system is suitable for a country where unskilled labour is limited. There is no heavy machinery or high technology involved. The system is technically applicable to almost all types of building. Formwork is used as a mould, where wet concrete is poured into a temporary system. The temporary system also acts as a temporary support for the structures (Badir *et al.*, 1998). The objective of the cast in-situ method is to eliminate and reduce the traditional site based trades like traditional timber formwork, brickwork, and plastering and to reduce labour content. A carefully planned cast in-situ work can maximize the productivity, speed and accuracy of prefabricated construction (Badir *et al.*, 1998). The cast in-situ method uses lightweight prefabricated formwork made of steel or fibreglass or aluminium, which is easily erected and dismantled. The steel reinforcement is placed within the formwork as it is erected and concrete is poured into the mould. When the concrete is set according to the required strength the moulds are dismantled. The workers can be easily trained to erect the moulds and set the steel reinforcement. Its advantages over the traditional construction method are, its low skill requirement, can be quickly constructed, maintenance is low, structure is durable and cost can be less, as shown in Figure 3.3. (Badir *et al.*, 1998).

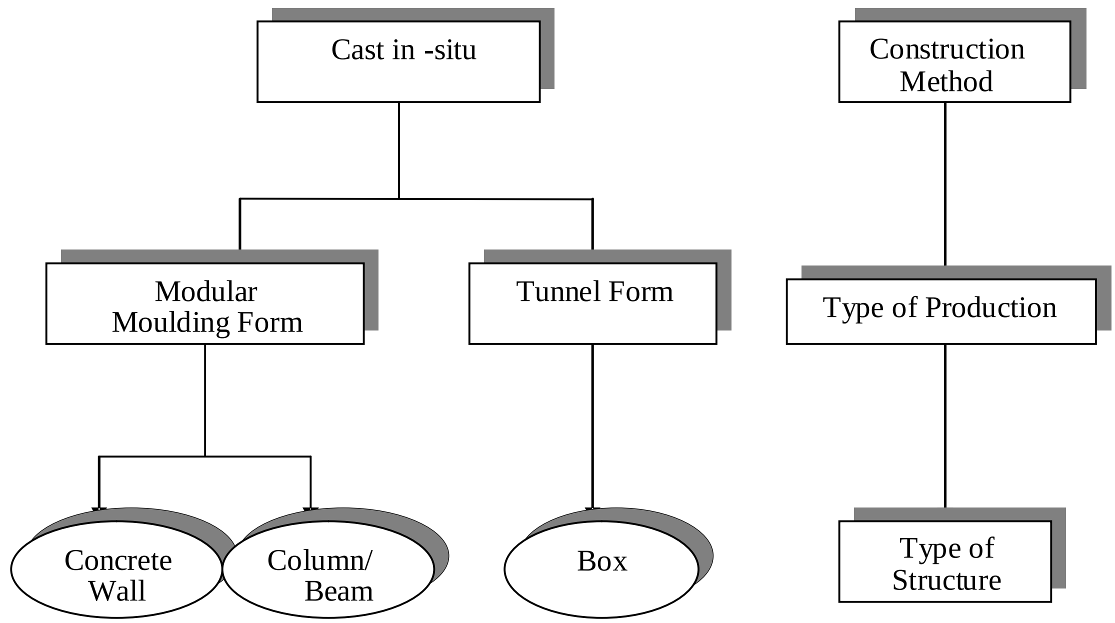


Figure 3.3: Classification of Cast in-situ construction method (Source: Badir *et al.*, 1998)

3.8.3 Composite Construction Method

The third classification of IBS construction is the composite construction method. The objectives of the composite construction method (partially prefabricated) are to improve quality, reduce cost, and shorten the construction time. The concept of partial industrialisation is derived from the composite nature of full industrialisation, and is used to describe a manufacturing or production strategy that selectively uses certain industrialising aspects, while avoiding or postponing the use of others. The prefabricated construction method is combined in such a manner that the features applied could be prominently demonstrated, especially in composing various works such as temporary facilities, building frames, building finishes, and equipment (Badir *et al.*, 1998).

In this method of construction, certain elements that can be standardized are prefabricated in the factory while others are cast in-situ. Normally, this method would involve the assembly of precast elements, such as floor slabs, unfilled walls, bathrooms, staircases, etc. in place for incorporation into the main unit, columns and beams,which are usually cast in-situ as it is relatively easier and less time consuming. The composite construction method has a wider range when compared with the conventional or fully prefabricated construction method (Ternear, 1972).

Furthermore, pre-cast units can be used to produce surfaces or finishes unattainable in the cast in-situ construction method without incurring extra cost. It can provide the floor slabs or beams, which can further reduce the formwork or construction time. It also provides the permanent floor or beams incorporating both main tensile reinforcement and shear links (Broadbent, 1996). Other combinations are also possible as the need dictates. This partially prefabricated construction method makes the building appear more compact, which is not found in other big panel or framing systems (Chew, 1986).

3.8.4 Fully Prefabricated Construction Method

The third method of classifying IBS is the fully prefabricated construction method. In the construction industry, the demand for fully prefabricated construction is made when a shortage of labour exists, especially that of skilled labour (Foster, 1973). This method of construction has reduced the amount of site labour involved in building operations and increased the productivity of the industry. Precast building systems can reduce the duration of a project if certain conditions are met such as enough amount of skilled labour (Al-Khaiat & Qaddumi, 1989).

The modern industrialised building system demands modern equipment, standardisation of building components and elements. Specialisation of labour means more skilled labour, concentration of production, purchasing, marketing, and, finally, the capital intensive requirement, which poses a problem in developing countries (Partadinata, 1988).

Both prefabrication and standardisation are two important processes that should be integrated directly with each other. Standardisation, according to Badir *et al.* (1998), is called “serial production”, which is the beginning of mass production as we know it. Standardisation also leads to prefabrication because prefabrication involves production in a factory instead of at a construction site. However, prefabrication is used here to refer to the factory production of components. Products are assembled into components, and when this is done off the site and in a factory, these components are called prefabricated (Collier, 1990), as shown in Figure 3.4.

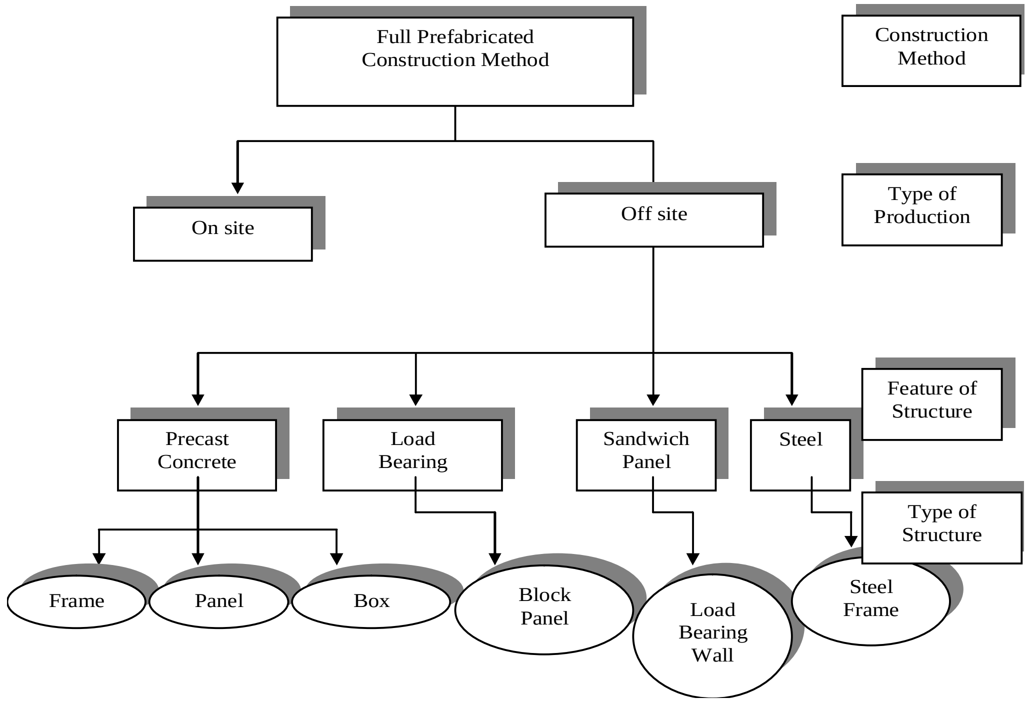


Figure 3.4: Classification of Full Prefabricated Construction Method (Badir *et al.*, 1998)

The implementation of the use of IBS in the Malaysian industry has brought about several advantages to the local construction industry.The Ministry of Housing and Local Government (MHLG) staff have made several visits to European countries to study and evaluate IBS, and assess the advantages and benefits. These potential advantages and benefits of IBS, which seem to be impressive, are (Thanoon *et al.*, 2003), time-saving (if there is proper planning and effective management in its implementation), cost-saving (given a sufficient number of units to minimize the amortisation cost of capital equipment and faster turnover in funds), potentially there will be a transfer of management and technical skills, there will be good quality control and higher level in finishing that might not be achieved by conventional construction.

3.9 DEVELOPMENT OF IBS IN MALAYSIA

In this respect, the advantages and benefits of IBS are closely related to its development and how it was adopted in the housing and construction industry in Malaysia. The history of IBS in Malaysia began back in the early 1960s when MLHG visited several European countries and evaluated their housing development programmes (Thanoon *et al.,* 2003).

After this successful visit in 1964, the government started its first project on IBS, which aimed to speed up the delivery time and build affordable and quality houses. About 22.7 acres of land along Jalan Pekeliling, Kuala Lumpur, was dedicated to the project comprising seven, 17-storey blocks of flats with 3,000 units of low-cost flats and 40 shop lots. This project was awarded to Gammon/Larsen Nielsen using a Danish System of large pre-fabricated panels (CIDB, 2003). In 1965, the second housing project initiated by the government of Malaysia was a project comprising six, 17-storey blocks of flats and three, 18-storey blocks of flats at Jalan Rifle Range, Penang. The project was awarded to Hochtief/Chee Seng using the French Estoit System (Din, 1984; Din, 1994). Among the earliest housing development projects using IBS was Taman Tun Sardon, Penang. The IBS pre-cast components and system in the project were designed by the British Research Establishment for low cost housing in tropical countries. Nonetheless, the building design was very basic and did not take into account the aspect of service ability, such as the need for wet toilets and bathrooms (Rahman and Omar, 2006). Between 1981 and 1993, Perbadanan Kemajuan Negeri Selangor (PKNS), a state government development agency, also acquired pre-cast concrete technology from Praton Haus International, Germany, to build low cost housing and high cost bungalows in Selangor (CIDB, 2003). However, the usage of steel structure, as part of IBS, first gained wide attention with the construction of the 36-storey Dayabumi Complex, which was completed in 1984 by the Takenaka Corporation of Japan (CIDB, 2003).

Today, the use of IBS as a method of construction in Malaysia is evolving. Many private companies in Malaysia have teamed up with foreign experts from Australia, the Netherlands, the United States and Japan to offer pre-cast solutions to their projects (CIDB, 2003). In addition, more local manufacturers have established themselves in the market. Pre-cast, steel frame and other IBS were used as hybrid construction to build national landmarks, such as the Bukit Jalil Sports Complex, Lightweight Railway Train (LRT) and Petronas Twin Towers. It has been reported that at least 21 suppliers and manufacturers are involved in the dissemination of IBS in Malaysia (Badir *et al.*, 2002). The majority of the IBS originated from the United States, Germany and Australia with a market share of 25%, 17% and 17%, respectively. Systems produced in Malaysia only account for 12%. This indicates that there is considerable room for improvement in the area of research and development of IBS. Figure 3.5 shows the source of IBS in Malaysia according to the country of origin.

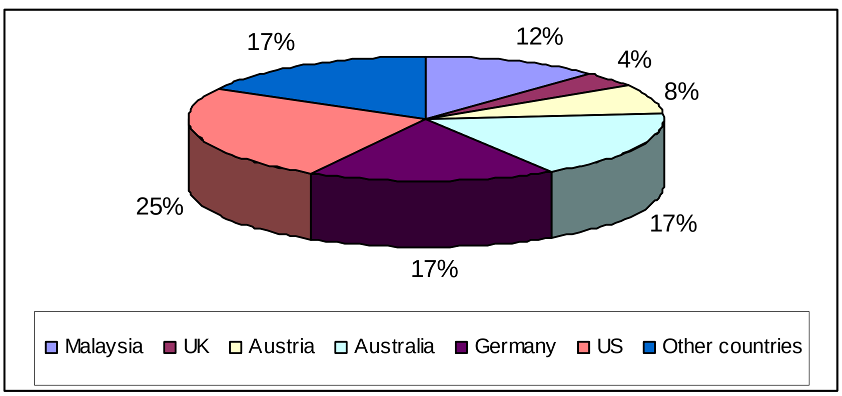


Figure 3.5: Origin of IBS according to country (Badir *et al.*, 2002)

Nevertheless, the government of Malaysia still feels that the usage of IBS is still low despite the vast potential it has. From the survey conducted by the CIDB of Malaysia in 2003, the level of usage of IBS in the local construction industry stands at 15% (IBS Survey, 2003). The total number of IBS contractors in 2007 that were registered was

1,993, and registered IBS manufactures in Malaysia, as at 2007,was 138, which, altogether produced a total of 347 IBS products available in the market.

Evidently, most of Malaysia's locally developed products are based on traditional materials, such as reinforced concrete and the use of innovative materials are totally based on imported technology (Thanoon *et al.*, 2003). There is no mandatory requirement on any certification or accreditation of components, companies or installers in place. Whilst, there is no empirical data, there is some anecdotal evidence suggesting that there has been sporadic dumping of sub-standard foreign products in Malaysia (Kamar *et al.*, 2010). A mechanism to ensure IBS products are bench marked to an acceptable standard must be introduced in the future, especially during the manufacturing process. The testing of components, verifying and certifying them will ensure safe and acceptable standards for IBS panels are achieved. The CIDB will take a lead role in this endeavour (Kamar *et al*., 2010).

With respect to the adoption of IBS in housing projects in Malaysia, it would be of interest to compare the IBS experience with other countries. The experience of other countries in IBS adoption has brought about a fundamental need to share the new challenges to contractors and developers alike. The following section compares the various experiences with IBS of other countries.

3.10 COMPARING THE VARIOUS EXPERIENCES OF OTHER COUNTRIES CONCERNING IBS APPLICATION

Table 3.4 shows the experiences of other countries concerning the application of IBS. In Japan, for example, the industrialisation of the housing industry started in the 1960s, and, since then, the market share has changed dramatically in the use of IBS. The construction of prefabricated components in Japan represented about 20% of all houses in the Japanese fiscal year 1999 (April 1999 – March 2000). Out of that, the steel framing system dominated the prefabricated market with a share of 73%; the wood framing system with 18% whiles the reinforced concrete framing comprised 9%. The wood-framed housing grew 2%, and steel-framed housing grew 3%, while concrete framed housing experienced a major setback of 12%, as shown in Table 3.4 (Nagahama, 2000).

Table 3.4: Prefabricated Housing Market Share in Japan 1999 (April 1999-March 2000) (Nagahama, 2000)

No	Framing Structure	Prefabricated Market Share, %	Growth Rate, %
1	Steel framing	73	+3
2	Wood framing	18	+2
3	Concrete framing	9	-12

The construction of houses by the Japan Prefabricated Construction Suppliers and Manufacturers Association, a 110 member industry group of housing manufacturers, represent 227,863 units, an increase of 1.1% in JFY 1999. In this respect, most of the prefabricated construction industry concentrated on three major urban markets with constant population clusters, namely, the Kanto region (Tokyo-Yokohama), the Chubu region (Nagoya) and the Kinki region (Osaka and Hyogo). Nevertheless, the sales in this market experienced a decline of 0.8% from the previous year, as a result of the protracted economic recession accompanied by a decline in consumer spending. In spite of that, the Japanese construction industry is still regarded as highly integrative and equipped with facilities for automated production equipment to manufacture house-building components. It also offers home buyers both generic floor plans and custom order capabilities.

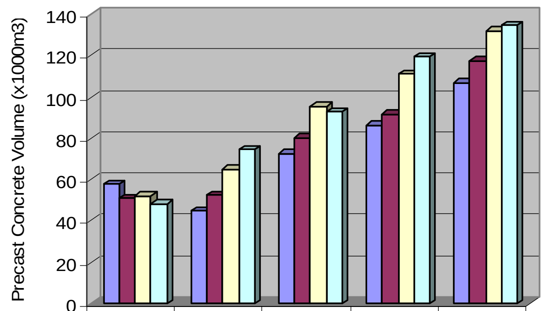
Another classic example where IBS was adopted was that of Argentina's construction industry. During the implementation of IBS in Argentina, the market for IBS was estimated at approximately US 41.5 million in 1995 to US 65.9 million in 1996, an increase of 10% in the annual growth rate. Out of that, the total imported prefabricated materials were US 22.5 million in 1996 of which US dominated 70% of the import market, as presented in Table 3.5 (Fournery, 1997).

Table 3.5: Argentinian market for industrialized system in millions USD (Fournery, 1997)

No	Market	1995	1996	1997	Projected average annual growth rate, %
1	Import market	18	22.5	25.9	12
2	Local production	25	40	44	10
3	Export	1.5	2.8	4.0	8
4	Total market	41.5	59.7	65.9	10
5	Import from U.S.	12.6	15.8	18	15

Traditionally, IBS concentrated on the low-income group because they are more affordable. Indeed the government intended to build a minimum of 150,000 low cost units during the period 1997-1999. In addition, the higher income group still prefers the conventional building method using block and plaster, which can last longer, spanning a lifetime. However, this group is currently moving towards a more industrialised housing method that incorporates features such as thermal and acoustical insulation, which are more efficient and environmentally friendly.

The Singapore Housing and Development Board (HDB) also adopted the IBS system because it wanted to build large quantities of apartments quickly. For example, in 1963, HDB launched the first prefabricated French large panel and fabrication system on **ten,** 16 storey blocks of flats. However, the projects experience**d** numerous technical and management problems, forcing **the** conventional method to be used instead to complete this project. Despite its earlier failures, the HDB has never looked back, it took a brave initiative to use IBS again in 1973 and 1979 because of the need to accomplish the building of 100,000 dwelling units, as envisaged by the Fifth Building Programme of (1981-1985). Thus, the continuous efforts made by the HDB have led to a remarkable achievement in the adoption of IBS in the public housing construction programme. Its on going comprehensive programme and industrial collaboration, using the IBS system has led to substantial gains in the market in the construction industry in recent years, as shown in Figure 3.6.



	1994	1995	1996	1997	1998
1st quarter	57.8	45	72.6	86.3	106.8
2nd quarter	51.2	52.4	80.3	91.7	117.5
3rd quarter	52	65	95.4	110.9	132
4th quarter	48.3	74.5	93	119.6	134.5

Year

Figure 3.6: HDB precast concrete implementation (Tat & Hao, 1999)

The HDB also made many major innovations in the building systems, such as the Ferro Cement Cladding System, prefabricated bathroom system, precast prestressed composite floor system, architectural precast facades and pre-cut and pre-bent reinforcement bars.

However, Thailand has a different story and experience in the adoption of IBS in the construction industry. The usage of IBS grew very rapidly due to the labour shortage and high interest rates. The majority of the prefabricated buildings are in the form of walls or slabs. Another system that has gained popularity in recent years is the autoclave aerated concrete, which is a lightweight brick, known locally as Super block. The annual growth rate of IBS in Thailand was about 30% in 1996. There were about 20 IBS suppliers in the market at that time (Thai Farmers Research Centre, 1996).

The usage of IBS in the UK became very evident in the mid 1900s after the widespread destruction of the housing stock during the Second World War. By, 1960, over 165,000 precast concrete dwellings had been built ranging from small single storey bungalows to large high-rise buildings. In 1999, precast concrete represents about 25% of the market for cement-based products. This includes a wide range of products used in the construction industry, such as suspended floors, structural, blocks, paving, bridges, cast stone, and architectural cladding. Of these products, the suspended floors represent the highest use of output in terms of tonnes or products sold per annum. Furthermore, it was reported that there was a significant 60% usage of precast concrete. Indeed, its utilization doubled its market share between 1994 and 1999. In parallel to this trend, precast concrete is also attempting to penetrate its usage in the upper floor of houses. It is also predicted that the upper floor will take-up 40% of new houses by 2001. However, the conventional masonry construction still dominates the market share of 90% leaving the precast market with a mere 10% share. Therefore, there is great potential for IBS to grab a far bigger market in the UK construction industry (Jacqueline, 1999).

In Australia, the adoption of IBS took a different turn. IBS was used for the first time when the first precast concrete lighthouse was erected in 1904 at Bradley's Head, Sydney. In the early 1950s, the Australian government invited George Wimpey & Sons Ltd of the UK to build houses using the precast 'tilt slab' construction system to help overcome the acute shortage of accommodation in Canberra. The use of IBS in Australia became more evident after the devastation of Darwin by Cyclone Tracy on Christmas Day of 1974. After the incident, about 425 cyclone proof precast concrete houses were built at a rate of one house per day. Despite the fabulous achievement of

IBS, its acceptance is somewhat low in Australia because the public still prefer the conventional construction system (Anon, 2003).

Germany, being a fast technologically developed country, has also influenced the direction of IBS adoption in the construction industry. The IBS in Germany is well established and rivalry and internal competition are fierce because of technological advancement in this field (Jacqueline, 1999). The development and usage of precast units are well recognised, particularly in the area of precast internal and external walls, as well as roof panelling (Jacqueline, 1999). Therefore, economic and viable factories solely dedicated to the production of precast concrete industry could easily be set up (Jacqueline, 1999). It was reported by Jacqueline (1999) that 10% of the 250,000 dwellings in 1998 were using precast concrete elements for 1-2 storey homes. The unification of Germany has also led to a substantial increase in the market share of precast concrete. By itself the precast market share of the former East Germany, was reported to be only at 24% in 1997 (Jacqueline, 1999). The value for precast concrete has increased by 10-15%, the profit is partly due to fierce internal competition from factories based in the former East Germany (Jacqueline, 1999).

The Netherlands has had no problem in adopting the IBS system, with precast concrete representing 10% of the total housing market, however,the conventional brick wall and masonry construction still prevail in the market. Nevertheless, industrialised housing has steadily increased its market share to 30% due to cost savings. This phenomenon is also strengthened and substantiated by standardised components, flexible manufacturing process, and improved industrialised building techniques (Jacqueline, 1999).

The experience that the United States of America had on IBS adoption in the construction industry happened back in the early 1990s. Although IBS received wide spread attention as early as the 1930s, as evidenced by the construction of prefabricated steel houses by General Homes, Inc. (Jacqueline, 1999), the early dreams of rationalizing the IBS faded quickly due to price competitiveness, high capital and inconsistent local codes. However, the trend reversed after the Second World War due to the need to resolve a critical shortage of houses (Jacqueline, 1999). By 1999, prefabricated housing had gained a substantial share of the market with 30% of all housing using this type of construction method (Jacqueline, 1999). However, most low-rise housing still uses a timber-framed, concrete precast system, particularly in areas that are vulnerable to environmental hazards, such as hurricanes and tornados (Jacqueline, 1999). Indeed the adoption of precast concrete faced resistance in the early stages because of the plain appearance of the panels, poor water proofing and difficulty in installing insulation (Jacqueline, 1999). However, the trend has reversed as a result of the advances in technology and methods, such as improved concrete mixing techniques, improved moulds, availability of rigid foams and an improved range of surface finishes (Jacqueline, 1999). A study carried out by the PCA (Portland Cement Association) indicated that 70% of buyers selected their houses on the basis of cost/value alone (Jacqueline, 1999). In other words, the benefits of architectural finishes, flexibility, and thermal insulation were perceived as a secondary concern (Jacqueline, 1999). However, the mindset of buyers has changed and the house buyers consider other factors when purchasing a house as well, such as speed and ease of construction, thus, making IBS a more popular choice (Jacqueline, 1999).

The experience of IBS adoption in Canada is one of competitiveness. This experience in the construction industry prompted the Canadian construction players to be proactive in the use of IBS. Although Canada is perceived as among the world leaders in some areas of construction, there is little progress in the area of IBS, partly due to the small housing market with 150,000 units per year (Jacqueline, 1999). This is evidenced by only 3% of Canada's new housing using IBS as compared to 90% in Sweden (Finn, 1992).

Denmark, however, has a different experience in the adoption of IBS. In the mid-1960s, about 80% of the detached houses produced were using IBS, and most were using the panellised system. IBS in Denmark is aimed at the domestic and export markets. For instance, its international contractors, such as Jespersen & Son, and Larsen & Nielsen, have constructed large projects through out the world using a prefabricated concrete system produced in local factories (Gibbons, 1986).

The Swedish experience in IBS adoption is also quite different. The Swedish construction industry is considered as one of the most industrialised and developed in the world. In the mid-1960s, Sweden projected a national mission of producing one (1) million new houses within ten (10) years. The objective was achieved completely when it decided to introduce IBS. By 1983, 90% of all single-family houses were produced using IBS. There are about 55 manufacturers offering IBS in Sweden. In addition to the local market, Swedish manufacturers also export ready-made houses to West Germany, Austria, Holland, Switzerland, Denmark, Finland, the Middle East and North Africa. Sweden's magnificent achievement in IBS is as a result of direct government proactive policies, which include substantial grants for research and development (US 200 million per year) (Gibbons, 1986).

In Finland, about 60% of single-family houses were built using IBS. The growth of the residential construction industry using IBS is 20% annually. The predominant forms mostly use a modular panellised system (Gibbons, 1986). The summary of the various experiences of other countries on IBS application is indicated in Table 3.6.

Table 3.6: Summary of the various experiences of other countries concerning the application of IBS

Country	IBS Application	Author
Japan	Construction of prefabricated units in Japan represented about 20% of all houses in Japanese fiscal year 1999 (April 1999 – March 2000)	Nagahama, 2000
Argentina	The market of IBS was estimated at approximately US 41.4 million in 1995 to US 65.9 million in 1996.	Fournery, 1997
Singapore	Precast concrete volume was estimated at approximately 48,300m^3 in 1994 to 134,500m^3 in 1998.	Tat & Hao (1999)
Thailand	The annual growth rate of IBS in Thailand was about 30% in 1996. There were about 20 IBS suppliers in the market at that time	Thai Farmers Research Centre (1996)
United Kingdom	In 1999, precast concrete represented about 25% of the market for cement-based products.	Jacqueline (1999)
Netherlands	Precast concrete in the Netherlands represent 10% of the total housing market. The industrialized housing is steadily increasing its market share to 30% due to cost saving.	Jacqueline (1999)
United States of America	In 1999, the prefabricated housing gained a substantial market share with 30% of all housing using this type of construction method.	Jacqueline (1999)
Canada	There is little progress in the area of IBS partly due to the small housing market with 150,000 units per year. This is evidenced by only 3% of Canada's new housing using IBS.	Jacqueline (1999), Finn (1992)

Table 3.6: Summary of the various experiences of other countries concerning the application of IBS (Cont'd)

Country	IBS Application	Author
Denmark	In the mid-1960, about 80% of the detached houses produced were using IBS, and most were using the panellised system.	Gibbons (1986)
Sweden	In 1983, 90% of all single-family houses were produced using IBS. There are about 55 manufacturers offering IBS in Sweden	Gibbons (1986)
Finland	About 60% of single-family houses were built using IBS. The growth of residential construction industry using IBS is 20% annually.	Gibbons (1986)

3.11 ROADMAP TOWARDS IMPLEMENTATION OF IBS IN MALAYSIA

The success in implementing IBS in Malaysia has a lot to do with the roadmap drawn up by the Government of Malaysia. The endorsement of the IBS Roadmap 2003-2010 by the cabinet on 29th October 2003 also expressed the seriousness and urgency of IBS implementation in Malaysia (CIDB, 2003). It is a blueprint for total industrialisation of the construction industry towards achieving the concept of an Open Building system by the year 2010. The roadmap is a comprehensive document that divides the IBS programme into five main focus areas that reflect the input needed to drive the programme, each beginning with the capital letter M: Manpower, Materials, Management, Monetary, and Marketing (CIDB, 2003). The inputs are then divided into its elements and the activities to be implemented for each element were then identified and included into the time span of the roadmap in order to achieve the mission within the stipulated time frame. About 109 milestones were set to be achieved by year 2010. The content of this roadmap is focused towards achieving the industrialisation of the construction sector and the longer term objective of the Open Building System (OBS) concept. The key elements of the roadmap are as follows (CIDB, 2003):

i. To have a labour policy that gradually reduces the percentage of foreign workers from the current 75% to 55% in 2005, 25% in 2007 and 15% in 2009;

ii. To incorporate IBS/MC in professional courses for architects, engineers and others;

iii. To incorporate a specialized syllabus on IBS/MC in architecture, and building courses in local universities;

iv. To enforce Modular Coordination (MC) by local authorities through Uniform Building by Laws (UBBL);

v. To develop a catalogue of building components and standard plans for housing;

vi. To develop a IBS verification scheme;

vii. To enforce the utilisation of IBS for at least 30% of total government projects (building) in 2004 and gradually increase the usage to 50% in 2006 and 70% in 2008;

viii. To introduce a buildability programme for all private buildings and enforcements from 2008 onwards;

ix. To provide tax incentives for manufacturers of IBS components;

x. To offer a green lane programme for users of the standard plan (designed using standard IBS components and MC);

xi. To start a vendor developing programme, training and financial aid;

xii. To abolish levy for low, low-medium and medium cost houses; and to set a 50% levy reduction.

One of the important milestones in the roadmap is the introduction of the Modular Coordination (MC) concept (CIDB, 2004). MC is a concept of coordination of dimensions and space where building and components are dimensioned and positioned in a basic unit or module known as 1M, which is equivalent to 100 mm (Kamar *et al.*, 2010). The system allows standardisation in design and building components (Kamar *et al.*, 2010). It will encourage participation from manufactures and assemblers to enter the market, thus reducing the price of IBS components. In essence, MC will facilitate open industrialisation, which is the prime target of the roadmaps. The proposed enforcement using MC through Uniform Building by Laws (UBBL) would encourage the adoption through standardisation and the use of IBS components. However, until the end of 2007, the UBBL had yet to be amended to include MC regulations (Kamar *et al.*, 2010).

Another important step taken by the government of Malaysia was to introduce incentives for IBS adopters. The exemption of the levy (CIDB levy – 0.125% of total cost of the project according to Article 520) on contractors that implemented some kind of IBS in 50% of the building components was introduced effectively from 1st January 2007. In the first half of 2007, 24 residential projects qualified for the levy exemption. However, this is a very small percentage from a total of 417 residential projects during that period (Kamar *et al.*, 2010). This shows that awareness among the developers and contractors on the levy exemption is still very low. The IBS Centre established in 2006 at Jalan Chan Sow Lin, Cheras, Kuala Lumpur, will be a one-stop centre of IBS related programmes initiated by CIDB. It will provide the training and consultancy on IBS and showcase IBS technology through demonstration projects. The obligation to implement IBS strategies and activities from this centre serves concurrently to improve performance and quality in construction, and also to minimise the dependency of unskilled foreign labours from flooding the construction market.

The road map for the implementation of IBS in Malaysia has crafted the building capacity of IBS for the customers and the adoption of IBS houses and housing projects, respectively. According to Elias (2006), the CIDB has performed capacity building for both the market-supply as well as demand, which includes:

i. Developing a series of standard IBS building components/modules;
ii. Developing IBS standards (MS, CIS, NOSS), IBS design guide and guides for transportation, stacking and installation;
iii. Incorporating IBS/MC in CPD courses for architects, engineers and others and design a syllabus on IBS/MC in architecture, engineering, building courses in Private Higher Learning Institutes (IPTS);
iv. Developing IBS assessment scheme;
v. Registration of IBS components/modules and manufacturers;
vi. Registration of contractor – specialization in IBS;
vii. Accreditation of IBS skilled workers;
viii. R&D in technical aspects of IBS.

Likewise, to develop a demand, the following are the guidelines by CIDB:

i. Enforce utilisation of 50% IBS contents in government building projects beginning 2005;
ii. CIDB levy exemption for residential building (exemption for residential project that utilises > 50% IBS);
iii. Tax incentives for manufacturer of IBS components;
iv. To enforce the use of modular coordination in design through UBBL;
v. To have a labour policy that gradually reduces the percentage of foreign workers from 75% in 2003 to 55% in 2005, 25% in 2007 and 15% in 2010.

3.12 IBS CRITICAL AREAS

The capacity building developed by CIDB, as mentioned by Elias (2006), paves the way to pursue the IBS critical areas concerning customer satisfaction with IBS houses and the adoption of IBS housing projects. To obtain the best from IBS applications, four critical areas are focused upon (Hussein, 2005):

i. Financial

ii. Quality

iii. Technical

iv. Integration/Management

Finance is a critical area. Profit margins depend on the growth of the industry. Unfortunately, IBS is being undertaken by traditional construction firms that lack a global or international approach. At the same time, the IBS firms have a poor perception of performance from the past. Market security and life expectancy of the construction plays a part in determining the acceptance of the IBS industry. Likewise, the client's perception of life expectancy is also important in making an attractive financial reward for the IBS sector.

Another critical area is quality in IBS application. The qualities include (Elias, 2006; Hussien, 2005):

i. Appearance: ability to customize to suit clients' taste within regional and local context, and the perceived value for money.

ii. Flexibility: to enable free usage of designs, and to allow different systems to be used in different situations.

iii. In service performance: durability and maintenance requirements a perceived durability of traditional material design and materials to increase security and reduce vandalism, and maintenance of saleable value.

On the technical part, it is critical to look at the following areas:

i. Getting the design process right;

ii. Certification of products, processes and people;

iii. Having comparatively robust and precise cost knowledge in terms of initial costs, sustainability and whole life costs of traditional and IBS solutions.

However, the integration or the management of the IBS application is also subject to the following:

i. The use of IBS for one off "messy" projects;

ii. Lack of understanding by designers of the IBS process, and, thus, unwillingness to use it;

iii. Establishing recognizable and valued "brands";

iv. Interfacing and their implications across the whole supply chain.

3.13 SUCCESS FACTORS AND BARRIERS TO IBS ADOPTION IN THE MALAYSIAN CONSTRUCTION INDUSTRY

Evidently, the need for adopting IBS in the Malaysian construction industry is immense and plausible due to strong encouragement from the government and the systematic implementation plans in place. The Government aims to achieve 100 per cent usage of IBS and to reduce to 15 per cent, or approximately 50,000 foreign workers, in the construction industry by 2010. With the current foreign workers totalling 227,000 the remittances of the foreign workers amounted to about 7.5 billion. It is expected that the Government would be able to reduce the remittances with the full implementation of IBS (Haron *et al.,* 2005). At present there is an abundance of cheap foreign workers in Malaysia and contractors prefer to use the labour intensive conventional building system because it is far easier to lay off workers during slack periods. The economic benefits of IBS are not well documented in Malaysia and past experience indicates that IBS is more expensive due to fierce competition from the conventional building system (Thanoon *et al*., 2003; Haron *et al*., 2004).

Din (1984) stated that industrialised building system (IBS) components produce a higher quality of components, which is attainable through careful selection of materials, use of advanced technology and strict quality assurance control (Din, 1984; CIDB 2003). The use of IBS in Japan and Sweden is so successful due to high quality and high productivity.

However, it is the opposite in Malaysia. Previous projects constructed with IBS concept were of low quality, had problems with leakage, and poor consumer preferences (Rahman & Omar, 2006; Elias, 2006; Kamar *et al.*, 2009; Omar, 2003, CIDB, 2003). This has left the industry with noticeable difficulties when using IBS. As a result, the industry is reluctant to embrace IBS unless it is required by the clients.

According to the IBS Roadmap Review (2007) report, the adoption of IBS in Malaysia is client-driven. Clients with a good knowledge and awareness of IBS benefit will surely encourage appointed designers to design buildings according to IBS. However, the lack of an awareness programme to understand client needs and give correct information on IBS has contributed to a lack of interest from the clients and decision makers (Rahman & Omar, 2006).

Industrialisation involves the rationalisation of the whole process of building. It includes the process of design, the form of construction used, and the methods of building adopted. This is to ensure that the design is well-integrated. There must also be proper co-ordination between the three processes, namely, supply of materials, fabrication, and assembly. All these factors will contribute towards speedier construction, product quality and construction cost savings (Friedman & Cammalleri, 1993, Kumarasivam, 1986; Warszwski, 1999; Peng, 1986, Omar, 2003). Furthermore, the repetitive use of system formwork made up of steel, aluminium, and scaffolding provides considerable cost savings (Bing *et al.*, 2001).

However, many small contractors are reluctant to adopt the IBS system and prefer to continue using the conventional method of construction. This is due to the fact that small contractors are already familiar with the conventional system and for them the technology suits their small-scale projects, and, therefore, they are not willing to switch to a mechanized based system (Kamar *et al.*, 2009). Furthermore, small contractors lack the financial backup and are not able to set up their own manufacturing plants as it involves intensive capital investment. Consequently, financial issues become the main obstacle for small contractors to move forward with the IBS system (Rahman & Omar, 2006; Thanoon *et al*., 2003). In the perspective of components' manufacture, IBS construction requires high initial investment capital for pre-casters to purchase new machinery, moulds, import foreign technology and wages for skilled workers for the installation process (CIDB 2004; Thanoon *et al.*, 2003). However, the Malaysian labour force still lacks skilled workers in IBS implementation (Haron *et al.*, 2009).

According to Peng (1986), an industrialised building system allows for faster construction time because casting of precast elements at the factory and the foundation work at the site can occur simultaneously. This provides earlier occupation of the building, thus, reducing interest payment or capital outlay.

The IBS, which enables on-site prefabricated or pre-cast building components manufactured at factories, offers minimal wastage, less site materials, cleaner and neater environment, controlled quality, safer construction sites, and lower total construction cost (CIDB, 2003). For example, the repetitive use of system formwork made up of steel, aluminium, scaffolding, etc., provides considerable cost savings (Bing *et al.*, 2001).

An industrialised building system allows flexibility in architectural design in order to minimise the monotony of repetitive facades (Warszawski, 1999) including the design of pre-cast elements as well as in construction so that different systems may produce their own unique prefabrication construction methods (Zaini, 2000). However, Rahman & Omar (2006) observed that the term IBS is often misinterpreted with a negative image due its past failures and unattractive architecture. The poor architectural designs of the old pre-fabricated buildings have given the public a bad impression about pre-cast concrete. Even construction professionals have doubts concerning IBS technology and relate IBS with potential post-construction problems. In addition, it is also not popular among the designers as they found that pre-fabrication limits their creativity in the design process (Hamid *et al.*, 2008).

There are cases, where building projects are awarded and constructed using the IBS system but were carried out with many difficulties (Kamar *et al.*, 2009). The most common problems encountered are improper assembly of the components, which normally involve the beam-to-column and column-to-base connections. These problems arise because the parties involved in the construction underestimate the importance of accuracy in setting out the alignment and levelling of the bases. Basically, accurate levelling and alignment of the bases are the two most important aspects for the successful rapid erection of pre-cast concrete components (Rahman & Omar, 2006; Din, 1994).

An IBS system can only be acceptable to practitioners if its major advantages are valuable compared to the conventional system. However, to date, there is inadequate corroborative evidence to substantiate the benefits of the IBS system. Therefore, it is arguable that the implementation of IBS is particularly hindered by the lack of scientific information (Badir *et al.,* 2002), and the lack of R&D in the area of novel building systems that use local materials. The majority of IBS in Malaysia is imported from developed countries, thus, driving up the construction cost. Engineering degrees in local universities seldom teach about the design and construction of IBS (Thanoon *et al.,* 2003; Haron *et al.,* 2004). Research conducted by Elias (2006), identified Malaysia's IBS implementation challenges are as follows:

" i. The industry is not ready;

ii. IBS costs more – no economy of scale;

iii. Consumer preferences;

iv. IBS design – monotonous and stifles creativity;

v. Do not know where to start;

vi. Bumiputeras (indigenous groups) are left out."

The experiences in some developed countries, such as Japan, Germany and the UK indicate that there is a great potential for IBS to progress as evidenced by their growing market share. Indeed, the success of IBS in those countries is prompted by the concern of home buyers about long-term energy saving, indoor air quality, and other health and comfort related issues, commitment and co-operation between the public and the private sectors towards greater technological advancement and innovation. Clearly, if Malaysia wishes to imitate the success of those countries, a long-term comprehensive policy towards the industrialisation of the building and construction sector should be pursued (Thanoon *et al.*, 2003). Table 3.7 shows the summary of previous research study on IBS adoption factors.

Table 3.7: Summary of previous research studies on IBS adoption factors

IBS adoption factors	Source
<u>Quality</u> -IBS provides higher quality than the conventional system. -IBS provides higher productivity than conventional methods. -IBS does not consider consumer preferences.	Thanoon *et al.* (2003) Din (1984) CIDB (2004) CIDB (2005) Omar (2003) Elias (2006) CREAM (2007) Kamar *et al.* (2009)
<u>Cost</u> -IBS reduces overall construction cost due to the reduction of site works. -IBS reduces overall construction cost due to reduction in construction wastage. -IBS reduces overall construction cost due to faster completion of construction projects -IBS increases construction cost compared to conventional system due to less competition in tendering process. -IBS increases cost due to imported technology or products. -IBS increases cost due to higher interest rates because of higher capital investment -IBS needs higher capital investment to start production.	Bing *et al.*(2001) CIDB (2004) CIDB (2003) Elias (2006) CREAM (2007) Kamar *et al.* (2009) Haron *et al.* (2004) Haron *et al.* (2005) Thannon *et al.*(2003) Rahman & Omar (2006)
<u>Time</u> -IBS reduces completion time of construction projects due to the usage of standardized pre-fabricated components and simplified installation process.	Friedman & Cammalleri, (1993) Peng (1986) CIDB (2004) Elias (2006) CREAM (2007) Kamar *et al.* (2009)
<u>Design</u> -IBS provides flexible design. -IBS provides highly aesthetic end product through the process of controlled pre-fabrication and simplified installation. -Uncertainties of IBS to meet aesthetic design. -IBS designs are monotonous and stifle creativity. -IBS has problems with connections and jointing methods.	Din (1984) Warszawski (1999) Zaini (2000) Elias (2006) CREAM (2007) Kamar *et al.* (2009) Hamid *et al.* (2008) Kampempool &Suntornpong (1986) Tan (1997)

Table 3.7: Summary of previous research studies on IBS adoption factors (Cont'd)

IBS adoption factors	Source
Policy -IBS reduces the dependency on foreign workers. -IBS execution must be given levy exemptions. -IBS encourages policy on the investment in technologies, techniques and process of construction -IBS encourages action plans to ensure the successful upgrading of the construction industry -IBS adoption does not attract enough incentives from the government. -IBS policies are not strict enough. -IBS education and training is not sufficient in universities and institutes of higher education. -Inadequate R&D undertaken to substantiate the benefits of IBS. -Lack of R&D in the area of novel building systems (IBS) that use local materials. -Abundance of cheap foreign workers to use conventional construction system compared to IBS.	Thannon *et al.*(2003) CREAM (2007) Kamar *et al.* (2009) Haron *et al.* (2004) Haron *et al.* (2005) Elias (2006) CREAM (2007) Kamar *et al.* (2009) Badir *et al.* (2002)
Management -IBS contributes to cleaner site conditions due to less construction wastage. -IBS provides safer construction sites due to the reduction of site workers, materials and construction wastage. -Limited number of local IBS manufacturers. -Lack of skilled workers to adopt IBS methodology. -Do not know where and how to start using IBS methodology. -The industry is not ready for IBS adoption. -Bumiputera participation is left out in the adoption of IBS. -Construction players still lack scientific information about the economic benefits of IBS.	Thannon *et al.* (2003) Elias, (2006) CREAM (2007) Kamar *et al.* (2009) Haron *et al.* (2004) Haron *et al.* (2005)

3.14 SELECTION OF IBS ADOPTION FACTORS

The second step for this research study is the selection of success factors and barriers to IBS adoption, which will focus within the context of housing projects and Malaysia's construction industry. From the review of literature and Table 3.7, the researcher determined the list of IBS adoption factors. These are:

i. Quality
ii. Cost
iii. Time
iv. Design
v. Policy
vi. Management

The conceptual framework of the factors that affect IBS adoption is illustrated in Figure 3.7. The researcher will use this conceptual framework to conduct the quantitative study as explained in the research methodology chapter.

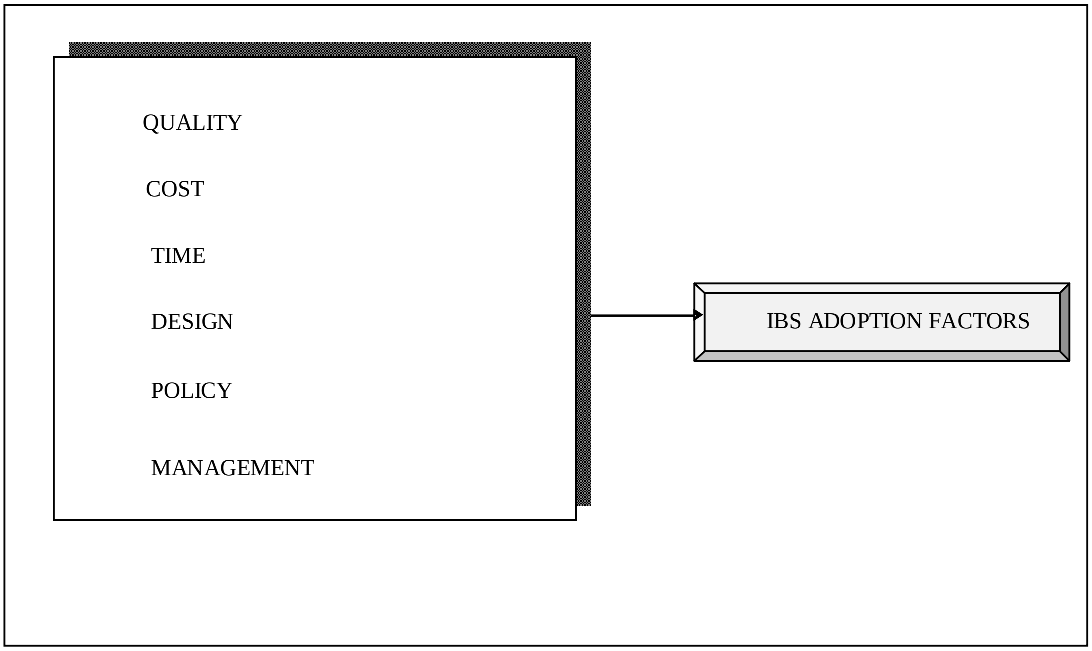


Figure 3.7: Conceptual Framework of the Factors Affecting IBS Adoption in the Malaysian Construction Industry

The conceptual model of strategies to improve customers' satisfaction on IBS houses and IBS adoption is illustrated in Figure 3.8. In order to develop new strategies to improve customer satisfaction with IBS houses and IBS adoption in the Malaysian construction industry, the researcher will use QFD application in the qualitative study. The detailed explanation of the research methodology and the research process will be covered in the next chapter.

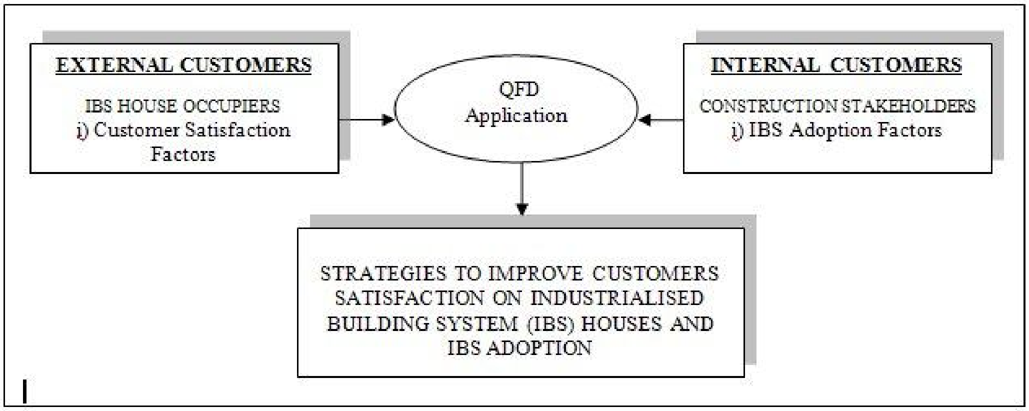


Figure 3.8: Conceptual model of strategies to improve customer satisfaction with IBS houses and IBS adoption

3.15 SUMMARY

This particular chapter presents the literature review on customer satisfaction factors and industrialised building systems (IBS). Based on the literature review, there are nine (9) main factors for customer satisfaction and six (6) main IBS adoption factors that have been selected. Using these lists, the researcher was able to generate a number of questions to form the questionnaire survey for this study. In the course of the literature review the researcher was able to filter the relevant and pertinent items and questions for this study.