

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

The aim of this chapter is to introduce, and to present the background of the study. It also presents the problem statement. This will later be followed by research questions, research objectives, research methodology, significance of study, scope and limitations. This chapter also outlines the thesis as a whole.

1.2 BACKGROUND OF THE STUDY

Malaysia, although still regarded as a developing country, is well known for its forward looking policies and strategies. In its quest for global participation in all facets of industry, including the construction, it realizes that serious efforts must be made to adopt new systems and technologies of a standard that would put it at par with developed nations. Malaysia will then be able to pursue further by penetrating the global market directly or indirectly using the country's professional and construction expertise to become a global player as is envisaged in the country's vision 2020, thus, making it a truly progressive industrialised nation (CIDB, 2003; CIDB, 2000).

One current application in the construction industry is the application of Industrialised Building System (IBS), which is a commonly recognized and the preferred system in use today. Studies have indicated that IBS could actually promote labour reduction, cleaner and neater sites, easy installation, fast completion, enhancement of quality finished products and flexibility if properly planned and implemented (CIDB, 2003).

The IBS Roadmap 2003-2010 has been endorsed by the Malaysian Cabinet of Ministers to be a blueprint document for the Industrialization of the country's construction sector. To ensure its success, the Minister of Public Works urged members of the construction industry to heed the call of the Government. It must adopt IBS per se (CIDB, 2003). It must also be in line with Malaysia's aspirations to promote IBS through the following action plan (CIDB, 2003):

“

- i. Moving the industry towards zero defects in construction;
- ii. Promoting modularization and standardization;
- iii. Increasing research and development (R&D) efforts and enhancement of best practice guidelines;
- iv. Integrating the various roles in the industry into one coherent unit;
- v. Developing IBS Roadmap 2003-2010 that is spearheaded by the CIDB Steering Committee and various working groups on IBS. “

It must espouse two aspects: embracing new knowledge and accepting new technologies. This is evident in the realm of CIDB's endeavour to fulfil its role in the construction industry. It must adhere to the following (CIDB, 2003):

“

- i. A strong vision: 'To nurture and mould the Malaysian Construction Industry to become a respected leader in the global construction market by the year 2015'.
- ii. Setting the stage for industry players to embrace new technology.
- iii. Developing programmes that are key sources of new opportunities for innovation and cost effectiveness, e.g., research and development programmes and the application of modular coordination concepts. “

It must also adhere to the objective of the 9th Malaysia Plan (9MP), which is to allow for new knowledge and innovativeness. The five (5) key thrust areas are (CIDB, 2003):

- “ i. To enhance the economy of the value chain;
- ii. To raise the capacity for knowledge and innovation;
- iii. To address persistent socio-economic inequalities constructively and productively;
- iv. To improve the standard and sustainability of the quality of life;
- v. To strengthen the institutional and implementation capacity. “

The CIDB has also launched the Construction Industry Master Plan 2005-2015. The ten (10) year blueprint for the construction sector aims (CIMP 2006-2015, 2007):

- “ i. To drive the industry towards global competitiveness;
- ii. To realign the construction industry;
- iii. To enhance public delivery;
- iv. To enhance human capital;
- v. To ensure sustainable domestic growth (GDP contribution to 5%);
- vi. To realize Vision 2020 (National vision – through RMK9, RMK10 & RMK11)”

In recognizing and realizing the greater benefits of Industrialised Building System (IBS), the Malaysian government has worked relentlessly to bring the IBS to the drawing tables of all professionals involved in the built environment. A summary of the relevant policies is indicated in Figure 1.1.

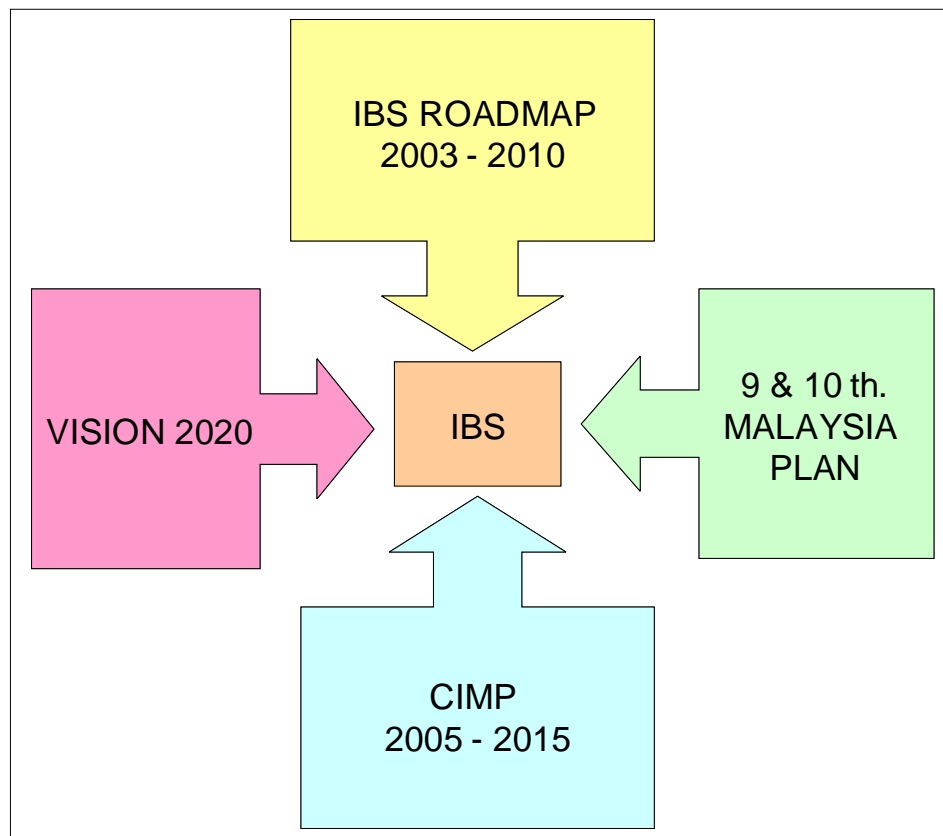


Figure 1.1: Policies promoting IBS in Malaysia (adapted and modified from CIDB, 2003; CIMP 2006-2015, 2007)

The researcher considers that the best way to approach the study is by looking into the customer satisfaction perspective among the IBS house occupiers. To achieve this, first, customer satisfaction in IBS houses must be met. Therefore, initially, the researcher must identify the factors that can increase customer satisfaction and also develop a set of strategies to improve them.

Second, the researcher also proposes to identify the reasons for the delay in fulfilling the IBS adoption in the Malaysian construction industry (IBS Roadmap Review, 2007). Third, the researcher will attempt to determine the success factors of IBS adoption and develop a set of strategies to implement them. The method chosen in conducting the study is by using the Quality Function Deployment (QFD) application (Hill, 1994).

QFD is a concept that was introduced by Professor Yoji Akao in Japan in 1966 (Hill, 1994). It is an approach in design management to achieve competitiveness to acquire the required quality at the appropriate cost within a stipulated time frame. The primary difference between QFD and other conventional quality management tools is the voice of the customer. It must be heeded and taken into account before embarking on design at the conceptualization phase of product development. This way, quality is actually being built into a product and not inspected out of it (Lochner & Matar, 1990). QFD employs a mathematical analysis using a series of matrices that depends on functional relationships, to ensure that the highest level of quality in producing a product is maintained throughout. Through the analysis of the varied relationships of functional components, one is able to quantify quality and establish priority. One of the basic parameters behind the QFD philosophy is quality, which has the greatest influence on a project if implemented during the early phases. It is also much simpler to define it in the early stages (Barrie & Paulson, 1984). In the Malaysian construction industry, most construction stakeholders do not truly understand the benefits of QFD. Therefore, the researcher will also attempt to gauge stakeholders understanding of QFD.

1.3 PROBLEM STATEMENT

There have been cases, where house projects were awarded and constructed using IBS systems but were later found to contribute to project delays, bad quality, and poor consumer preferences (Elias, 2006; Kamar *et al.*, 2010). A common complaint in construction is about its poor quality and the industry itself has not taken quality as seriously as other industries (Shammas-Toma *et al.*, 1998; Karvinen & Bennet, 2006:402). Understandably, this has left the industry with some difficulties when using IBS. As a result, the industry is reluctant to embrace IBS unless it is required and accepted by the clients. According to the IBS Roadmap Review (2007) report, the

adoption of IBS in Malaysia is actually client driven. Clients with a good knowledge and awareness of IBS benefits will surely want to encourage appointed designers to design buildings according to IBS. However, the lack of awareness and understanding of client needs and giving correct information on IBS has contributed to the lack of interest from clients and decision makers (Rahman & Omar, 2006).

The House Buyers Association (HBA) in Malaysia (2002) cited by Mustafa & Ghazali, (2011) noted that buying a house is an important event in a person's life. It is indeed the single and biggest capital investment commitment that a person will want to undertake in his or her lifetime. Therefore, such an experience would bring a sense of achievement and joy to those who pursue it. However, not all house buyers are happy and some have suffered unhappiness in silence. This is evidenced by the dissatisfaction of factors found from research done on housing projects around the world, including Malaysia (Chee & Peng, 1996; Jaafar *et al.*, 2005), the US (Caroline *et al.*, 1998; Varady & Preiser, 1998), Singapore (Chee & Peng, 1996), Australia (Forsythe, 2007), Zimbabwe (Rakodi & Withers, 1995), Nigeria (Ogu, 2002; Ukoha & Beamish, 1997), Tanzania (Nguluma, 2003) and China (Yang & Zhu, 2006). There has also been confusion and continued suffering, when they were let down by the very authorities that were supposedly entrusted to enforce the laws and protect their interests. Other reasons included developers abandoning projects, or not meeting the standards and quality control required or exceeding the specified time allocated. This can be gauged from the newsmedia. Unhappy house buyers might resort to harsh action, such as taking legal action against house developers, just to show how frustrated and dissatisfied they are (The House Buyers Association, 2002, cited by Mustafa & Ghazali, 2011).

The IBS Survey 2003 stated that only 15% of construction projects used IBS in Malaysia (IBS Survey, 2003). The IBS Mid Term Review in 2007 indicated that, approximately, only 10% of the completed projects used IBS in the year 2006 (IBS Roadmap Review, 2007). The actual projection as a percentage of completed projects using IBS ranged from 50% in 2006 to 70% in 2008 (CIDB, 2003). This percentage is lower than expected despite a huge publicity campaign from the government (Hamid *et al.*, 2008). The availability of cheap foreign labour, which offset the cost benefit of using IBS, is the root cause of the slow adoption (Kamar *et al.*, 2009; Haron *et al.*, 2004).

Hence, due to dissatisfaction, as stated above, the researcher believes it is beneficial and timely that customer satisfaction is determined. Thus, the researcher aims to determine the success factors in IBS adoption and to develop strategies on how to improve them.

1.4 RESEARCH QUESTIONS

Based on the discussion from the background of the research study, and the problem statement, this study will attempt to answer the following questions:

- i. What is the extent of customer satisfaction with IBS houses in Malaysia? (RQ1)
- ii. What are the success factors and barriers to IBS adoption in the Malaysian construction industry? (RQ2)
- iii. How to improve customer satisfaction in IBS house construction? (RQ3)
- iv. How to improve the level of IBS adoption in the construction industry? (RQ4)

1.5 RESEARCH OBJECTIVES

In order to answer the research questions, the researcher has established the following research objectives:

- i. To determine the customer satisfaction factors for IBS houses (RO1);
- ii. To determine the success factors of IBS adoption in the construction industry (RO2);
- iii. To develop the strategies to improve customer satisfaction with IBS house construction using QFD application (RO3);
- iv. To develop the strategies to improve the level of IBS adoption in the construction industry using QFD application (RO4).

1.6 BRIEF ON THE RESEARCH METHOD

The research methodology of this study used mixed methods, namely, quantitative and qualitative. The research process is principally formulated based on four (4) different phases that address the research questions at every phase.

The first phase has two (2) parts. In part one (1), the factors pertaining to customer satisfaction for IBS houses was determined through a literature review and pilot study. In part two (2), the factors that lead to success or present barriers to IBS adoption were also determined through a literature review and pilot study. Then, both factors were collected using quantitative study through a questionnaire survey, which became the main study of the research (Cavana *et al.*, 2001). The data collected were analysed and examined using gap analysis (Zeithaml *et al.*,1990) in order to determine the gap between the importance and satisfaction of factors in part one (1) and part two (2). The most critical factors from the findings in part one and part two were used to analyse and examine using QFD application in the second phase.

In the second phase, both customer satisfactions in part one (1) and the IBS adoption factors in part two (2) were separately set as the customer requirements or “What’s” in the QFD application. Through qualitative study using focus group discussion as the data collection method (Cavana *et al.*, 2001), customer requirements from both the IBS house occupiers in part one (1) and construction stakeholders in part two (2), were analysed and examined using QFD application in order to develop the strategies to fulfil the requirements. The QFD application in part one (1) is defined as the Q (Quality) matrix and in part two (2) as the F (Function) matrix.

The third phase of the research process is to combine the customer satisfaction strategies (Q matrix) with the IBS adoption strategies (F matrix) and set these as the new requirements or “What’s” for another stage of QFD application, which is defined as the QF matrix. The objective being to combine both sets of strategies to determine which organization (government and private organizations) is supposed to act towards full implementation of IBS.

The fourth phase of the research process is to validate the entire research process, research findings and the research contributions as content validity, as defined by Cavana *et al.*(2001). Content validity ensures that the measures include an adequate and representative set of items that tap the concept. There are at least three ways to achieve content validity, namely, from the literature, from qualitative research and from the judgment of a panel of experts. The validation process for this study was conducted through structured interviews among professional experts – academicians and construction stakeholders. The validation of research models were also conducted in this study.

1.7 SIGNIFICANCE OF STUDY

This study significantly contributes to the body of knowledge on the strategies to improve customer satisfaction of IBS house development and on the strategies to improve the IBS adoption in the Malaysian construction industry. The significant contributions of the study are:

- i. Development of strategies to address the issue of low quality and low preferences of customer satisfaction in IBS housing construction;
- ii. Development of strategies to address the issue of delay in the implementation of IBS in the Malaysian construction industry;
- iii. The use of QFD application in this study can enhance the planning, management system of the IBS adoption in the Malaysian construction industry and contributes to the discovery of a new knowledge application;
- iv. Development of research models in this study can help for better planning, management and implementation in order to improve customer satisfaction on IBS housing developments and IBS adoption in the Malaysian construction industry.

1.8 SCOPE OF THE STUDY

This research, in particular, is bounded by its own scope. The scope of this study is:

- i. This study focused on three (3) projects as the purposive sampling frame that will represent the low, medium, and high cost of IBS housing projects;
- ii. IBS house occupiers are the respondents by which the customer satisfaction factors are studied;

- iii. Malaysia's construction stakeholders, namely, clients, developers, consultants, manufacturers, and contractors are the respondents by which the IBS adoption factors are studied.

1.9 CONTENT OF THE THESIS

The thesis is organised into seven (7) chapters:

Chapter one (1) is the introduction chapter. In this chapter the author gives a brief description and scenario of the IBS in the Malaysian construction industry. The problem statement, research questions, research objectives, brief on the research methodology, significance of study, scope and limitations of study are specified in this chapter. The overview of the whole thesis is also presented briefly in this chapter.

Chapter two (2) is the background study on Quality Function Deployment (QFD). The researcher includes a literature review on the history, definition, concept, and the application of QFD in industry. QFD is a design management tool to enhance the quality aspect of products and services as well as to increase customer satisfaction. Hence, for this purpose, the application of the QFD concept in the construction industry is presented in this chapter.

Chapter three (3) describes the literature review of the customers in the construction industry, and the factors pertaining to customer satisfaction of housing projects. This chapter also presents the concept, definitions, and classification of IBS. The development of IBS in Malaysia as well as other countries experiences in IBS are also outlined here. Serving as the main focus for the literature review the customer satisfaction factors with IBS housing and the success factors of IBS adoption in the Malaysian construction industry are highlighted here. The selection of customer

satisfaction factors with IBS housing and IBS adoption factors in the Malaysian construction industry are also included in this chapter.

Chapter four (4) describes the research methodology of this study. In this chapter the researcher sets the process and methodology adopted through out this study. The design and implementation of the questionnaire survey as a quantitative study and focus group as qualitative study are presented in this study. The analytical methodology adopted is also briefly described in this chapter.

Chapter five (5) presents the data analysis of the results. In this chapter, the researcher presents the outcome of data collection, analysis of data, and the results from the field study for both the IBS house occupiers and construction stakeholders. The researcher also presents the method of validation used in this research study. The development of a Quality matrix, Function matrix and QF matrix are presented in this chapter.

Chapter six (6) covers the discussion of the findings. In this chapter, the researcher presents the discussion of the findings. The researcher also presents how the findings are related to answer the research questions and directly indicates that the research objectives have been achieved.

Chapter seven (7) completes the thesis with the conclusions and recommendations. The researcher presents the conclusions from the findings of this research. The recommendations for future research study are systematically presented in this chapter.

1.10 Summary

This chapter presents the introduction, background of the study. It also presents the problem statement. The issue of this research study is that the adoption of IBS in the Malaysian building construction industry is still very low when compared to the conventional methods due to lack of customer satisfaction with IBS house projects and inefficiency in the IBS implementation strategy. It is very important to determine the customer satisfaction factors of IBS housing and the success factors for IBS adoption in Malaysia in order to fulfil the Government target of adopting IBS one hundred per cent (100%) by year 2015. This will later be followed by research questions, research objectives, research methodology, significance and scope of study. This chapter also outlines the thesis as a whole.

CHAPTER 2

BACKGROUND STUDY ON QUALITY FUNCTION DEPLOYMENT (QFD)

2.1 INTRODUCTION

This chapter largely dwells upon the literature review on Quality Function Deployment (QFD). The chapter begins with the discussion on the history, definition, concept, functional field of QFD, applied industries of QFD and the application of QFD in the construction industry. It also provides an overview of the background study on QFD as a whole.

2.2 HISTORY OF QUALITY FUNCTION DEPLOYMENT (QFD)

QFD is an innovation that has already been in use for more than two decades (Hauser & Clausing, 1988). Historically, the concept of QFD was introduced by the Japanese in 1967 (Aswad, 1989; Mizuno & Akao, 1978; Terninko, 1997; Chan & Wu, 2002.). It did not emerge as a viable method until 1972 when it was applied at the Kobe shipyards of Mitsubishi Heavy Industries in Japan (Taguchi, 1987; American Supplier Institute (ASI), 1992; Hales *et al.*, 1990; Pardee, 1996). The American Supplier Institute (ASI) and GOAL/QPC (Growth Opportunity Alliance of Lawrence, Massachusetts/Quality Productivity Center) have excelled in publicizing QFD in the United States (Akao, 1990; King, 1989; Prasad, 1998). Prasad (1998) used QFD to develop a coolant sensor, which fulfilled critical customer requirements like “easy-to-add coolant, easy-to-identify unit” and “provide cap removal instructions”. A number of companies using QFD presently include Ford, General Motors, Chrysler, AT&T, Procter and Gamble, Hewlett-Packard, Digital Equipment, ITT, and Baxter Healthcare. However, although its use is appropriate for organizations of any size it has not yet found popularity as a

design technique. Many companies have experimented with QFD ideas and have realized significant benefits (Prasad, 1998).

In the span of the first seven years, between 1977 and 1984, the Toyota Auto body plant (Wilson & Greaves, 1990; Cohen, 1995; Marsh *et al.*, 1991; Hauser & Clausing, 1988; Hill, 1994; Prasad 1998; Sullivan, 1986; Chan & Wu, 2002) employed QFD and claimed that with its use it had achieved the following:

- i) Manufacturing start-up and pre-production costs were reduced by 60%;
- ii) The product development cycle (that is time to market) was reduced by 33% with a corresponding improvement in quality because of the reduction in the number of engineering changes.

2.3 DEFINITION OF QUALITY FUNCTION DEPLOYMENT

There are several definitions for quality function deployment (King, 1989; Ungvari, 1991). The definition by Akao (1978) states that QFD is the converting of customer demands “What’s” into quality characteristics (QCs) “How’s” and developing a quality plan for the finished product by systematically deploying the relationship between customer demands and the QCs, starting with quality elements in the product plan (Mizuno & Akao, 1978; Sullivan, 1986). Later, QFD deploys this “What’s” and “How’s” relationship with each identified quality element of the process plan and production plan. The overall quality of the product is formed through this network of relationships (Prasad, 1998). Another definition of QFD is that of Akao (1992) who defined QFD as “a method for developing a design quality aimed at satisfying the customer and then translating the customer’s demands into design targets and major quality assurance points to be used through out the production phase”. It is a highly effective and structured planning tool that deals with client demands more

systematically and defines precisely what they want to do from the outset (Dikmen *et al.*, 2005).

Low (1998) defined QFD as a quality improvement technique that deals with quality problems from the outset of the product design and development stage and ensures that customers' requirements are accurately translated into appropriate technical requirements and actions (Low, 1998). The emphasis on the "voice of the customer" is the key to QFD (Low, 1998; Kamara *et al.*, 1999).

Sullivan (1986) defined QFD as "an overall concept that provides a means of translating customer requirements into the appropriate technical requirements for each stage of product development and production (i.e., marketing strategies, planning, product design and engineering, prototype evaluation, production process development, production, sales)" (Sullivan, 1986; Chan & Wu, 2002).

QFD is a set of planning and communication routines that focuses and coordinates the skills within an organization to design and construct facilities that satisfy the client's needs and requirements (Ahmed & Kangari, 1996). It is a form of concurrent engineering tool (Low, 1998) that has been successfully applied in the manufacturing sector (Garvin 1988; Daetz, 1989) in the United States and Japan (Kogure & Akao, 1983; Hauser & Clausing, 1988).

QFD is a tool that is able to ensure that the voice of the customer is deployed throughout the product planning and design stages (Balthazard & Gargeya, 1995; Franceschini & Rossetto, 1997; Hause & Clausing, 1988; Zairi & Youssef, 1995; Franceschini & Rupil, 1999). It provides a list of activities and a graphic representation

of the design deployment that allows one to see the relationships between goals (What's) and the means to realize them (How's). At present, QFD is utilized in the following ways:

- i) By customers and design teams to gather product information in a structured way;
- ii) To analyse customer expectations and the characteristics of competitive products;
- iii) To define the prioritization of technical/engineering design characteristics for a new product.

2.4 RELEVANCE OF THE FOUR PHASES OF QFD

QFD was designed originally to take the voice of the customer (VOC) (called customer demands or objectives) and translate it into a set of design parameters that can be deployed vertically top-down through a four-phase process (Sullivan, 1986). The four phases known as American Supplier Institute (ASI) four-phase or four-chart processes are as follows: product planning, parts deployment, process planning, and production planning (Prasad, 1998). The main activity in most current implementations of QFD is the generation of charts that correspond to the four phases as mentioned above (Day, 1993; Mizuno & Akao, 1994).

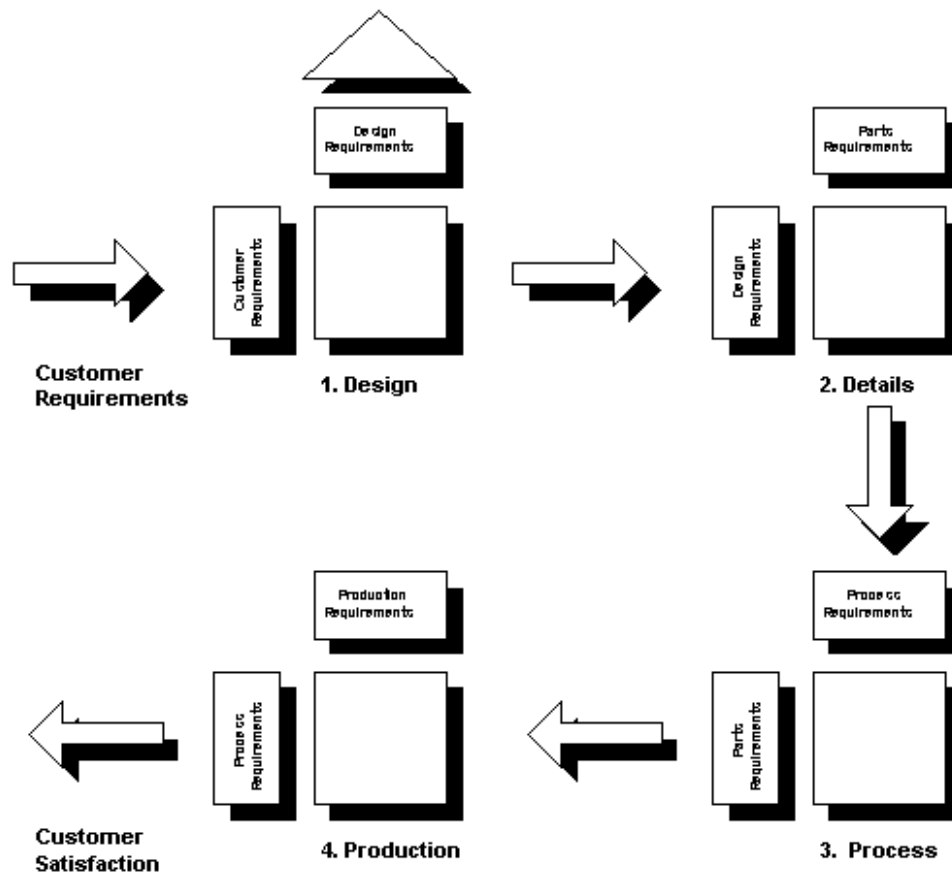


Figure 2.1: The four phases of QFD (Guinta, 1993; Sheng *et al.*, 2007)

As outlined by Sullivan (1988), the “How’s” in the product-planning phase (first chart) become the “What’s” for the second chart, and the “How’s” in the second chart become the “What’s” for the third chart, and the “How’s” for the third chart become the “What’s” for the fourth chart. This cascade-of-charts concept in the QFD system is meant to provide a “constancy of purpose” among the four phases. Sullivan (1988) states that the overall QFD system is based upon the above-mentioned charts. It traces a continuous flow of information from customer requirements to plant operating instructions, thus, providing a common purpose of priorities and focus of attention. Hauser & Clausing (1988) describes the first chart in detail and call this chart the house of quality. This cascade process, however, links the four charts (phases) so that one phase cannot start before the other phase ends.

2.5 HOUSE OF QUALITY IN QFD

The first component of QFD is the quality chart, which is also known as the house of quality (Guinta, 1993; Prasad, 1998; Low 1998; Low & Yeap, 2001). The house of quality can be broadly defined as a quality chart consisting of a matrix or series of matrices used to correlate everything from the product design plan through the quality control process chart (Mizuno & Akao, 1994). It can also be redefined as: a two-dimensional matrix consisting of a demanded quality chart combined with a quality characteristics deployment chart (Akao, 1990). Combining the two matrices expresses the relationship between true or actual quality (as demanded by the customer) systemized according to function, and the quality characteristics as counterpart characteristics. Quality design, as defined by Koichi Aiba (1966), is the entire process of converting the quality as demanded by the consumer or the true characteristics, into counterpart characteristics, by means of reasoning, translating and transferring. The quality chart is the basic chart for quality design.

The objective of drawing up a quality chart is because it serves as a useful graphic device that enables us to (Hauser & Clausing, 1988):

“

- i. Analyse systematically the structure of the true or ultimate qualities demanded by customers in their own words;
- ii. Indicate the relationship between these demanded qualities and certain quality characteristics;
- iii. Convert customer demands into counterpart characteristics expressed in the engineering or design language;
- iv. Develop a design quality based on true market orientation. “

Guinta (1993) described in depth the house of quality as the most commonly used matrix in QFD. Figure 2.2 represents a schematic view of the house of quality. The four rooms in figure form the basic axis of the house: namely, “What’s”, “How’s”, “Why’s” and “How much”. Four other rooms consist of relationships between the lists.

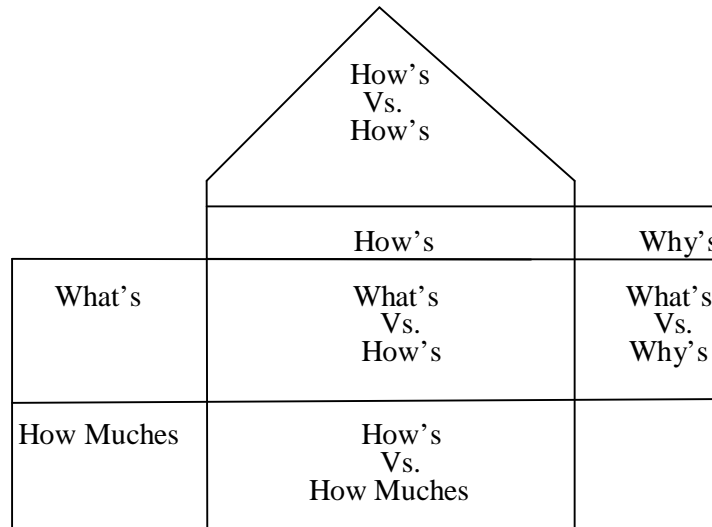


Figure 2.2: House of Quality (Source: Prasad, 1998; Low, 1998, Abdul-Rahman *et al.*, 1999; Cohen, 1995; Hernandez *et al.*, 2007b)

The Table 2.1 shows house of quality terms of reference.

Table 2.1: House of Quality Terms of Reference
(Source: Prasad, 1998; Low, 1998; Abdul-Rahman *et al.*, 1999)

| | | |
|----|------------------|--|
| 1. | Whats | This outlines what the customer wants to see in a product. |
| 2. | How's | This shows what the company can measure and control in order to satisfy customer requirements. Also known as quality characteristics or design requirements. |
| 3. | Why's | This describes the current market and indicates what data one will use to prioritise the list of “whats”. |
| 4. | How much | This specifies how much of each how is required to satisfy the “whats”. |
| 5. | What's vs. How's | This relationship correlates what the customer wants from a product and how the company can meet those requirements. It is the core matrix of QFD. |
| 6. | What's vs. Why's | This is used to prioritise the whats based upon market information. Usually, the data here consists of how important different customers perceive each of the whats to be ratings of how well competitive products are perceived to meet each of the whats can also be included. |

Table 2.1: House of Quality Terms of Reference (Cont'd)
 (Source: Prasad, 1998; Low, 1998; Abdul-Rahman *et al.*, 1999)

| | | |
|----|--------------------|--|
| 7. | How's vs. How Much | This helps to determine the next step in a project. It includes calculated values that identify the relative importance of each how. This information can lead to realistic and measurable target values that, if met, will ensure that customer requirements are met. |
| 8. | How's vs. How's | This matrix forms the roof of the house of quality. It identifies the interactions between different hows. The relationships here are rated as strong positive, positive, negative, strong negative and none. If two "hows" help each other meet their target values, they are rated as positive or strong positive. If meeting one how's target value makes it harder or impossible to meet another how's target, those two "hows" are rated with negative or strong negative relationship. |

The house of quality includes the following components: the voice of the customer, importance ratings, a customer competitive assessment, the voice of the supplier, target goals, a correlation matrix, a technical assessment, probability factors, a relationship matrix, absolute score, and relative score (Guinta, 1993; Prasad 1998; Low, 1998; Low & Yeap, 2001; Abdul-Rahman *et al.*, 1999).

2.5.1 Objective Statement

As mentioned by Guinta (1993) the objective statement is an important component of QFD. The QFD methodology begins with the objective statement, which usually ends in question form and defines what you are trying to accomplish. A well-defined objective keeps the team focused on customer requirements through a single, manageable task.

The first step in the QFD process is achieving consensus on a common objective. Therefore, the development of a focused objective statement requires time and commitment from all participants. The team should spend as much time as required to develop a good objective statement (Guinta, 1993; Shen *et al.*, 2001).

Customers might or might not participate in the development of an objective statement. If the product or service that has been targeted to a specific market and expansion to new markets is desired, customers should participate. Otherwise, customers should be brought in after the team has established the objective statement (Guinta, 1993).

A good objective statement should consist of a product component and a customer component. The product component should clearly state what the product or service is, such as (What are the important qualities of a commercial-grade half-inch power drill?). This ensures that all members of the team understand what product is being developed. The customer component identifies the customer, such as “What’s” qualities of a commercial-grade half-inch power drill are important to our external customers. This ensures that all members of the team focus on a particular customer group (Guinta, 1993; Shen *et al.*, 2001). A poorly defined objective statement is one that is unclear or defines many problems. Poorly defined statements will result in back tracking, adding more time to the QFD process.

The voice of customers is another aspect where QFD becomes part of the overall Total Quality Management (TQM). When a tentative objective statement has been developed, a QFD session can be used to capture the voice of the customers. The major feature of QFD in TQM is its emphasis on voice of customers. It provides a systematic means of ensuring that customers or marketplaces are translated into accurate technical requirements and actions that form the product development of each of the stages. This uses a set of matrices quality chart or the house of quality (Guinta, 1993; Shen *et al.*, 2001).

The voice of the customers is a list of customer requirements. The Japanese refer to customer requirements as customer-desired qualities. Qualities may also be thought of as attributes. Qualities, attributes, and customer requirements are all “What’s”. The voice of the customer is what the customer wants. QFD is essentially a method to capture the voice of the customers by identifying individual characteristics of the product, service, or problem (Shen *et al.*, 2001).

A QFD session should include the QFD team, a customer focus group, management, and representatives from relevant departments, such as sales or marketing. A focus group is a representative sample of customers who would use the product or service. QFD sessions should include twelve to fifteen customers with a maximum of twenty-four. A QFD session should always have more customers than employees, including the facilitator. The role of the facilitator is to help participants communicate more effectively (Guinta, 1993; Shen *et al.*, 2001).

Each “What’s” should represent a single requirement. Requirements should be limited to five words or less when possible, with a ten-word maximum. It is important not to change the meaning when limiting the length of the statement. When statements are paraphrased, it is possible to lose the customers’ true voice. Often, team members translate requirements into their own terms. An experienced facilitator can help to ensure that the meaning of the original statement is not lost. Customers can be asked to rephrase or clarify their responses (Guinta, 1993; Shen *et al.*, 2001).

When all of the requirements have been captured, the list can be refined and sorted. Similar items can be grouped into categories to make the list more manageable. This will help focus the QFD process (Shen *et al.*, 2001).

2.5.2 Assessment of Customers Requirement through Importance Ratings

QFD provides a systematic method to identify which customer requirements are more important than others. This can be achieved through importance ratings that serve both as weighting factors and as multipliers for other numbers in the matrix, thereby affecting certain statistical conclusions (Guinta, 1993).

The original Japanese importance ratings used the symbols shown in figure 2.3 (Guinta, 1993). These symbols provide icons for quick reference when reviewing complex matrices and were common languages when QFD was conducted with non-Japanese speaking people.

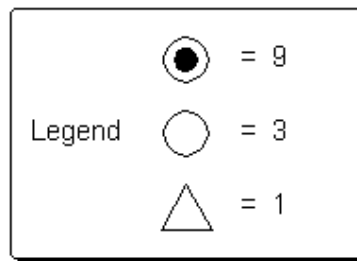


Figure 2.3 Japanese QFD Symbols (Guinta, 1993; Shen *et al.*, 2001; Franceschini & Rupil, 1999)

However, as QFD migrated to North America and teams became familiar with the symbols, practitioners found little difference in representing values as pictures or as numerals, therefore, importance rating scales may vary. Overall, for all scales, whole numbers are preferred with the lowest number representing low importance and the highest number representing high importance (Guinta, 1993; Shen *et al.*, 2001).

The team can use a variety of techniques to assign the importance ratings. Methods such as multiple passes, uniform distribution, and priority inversion provide a way to review the list of “What’s” and rank them according to importance (Guinta, 1993; Shen *et al.*,

2001). Multiple passes is a technique in which the facilitator takes the team through the list several times. This encourages the team to refine and compare ratings. At least three passes is recommended to properly assign ratings. Uniform distribution is a technique used to distribute ratings more evenly. Guidelines are calculated for the number of times a value should be assigned to a requirement. This method helps to show whether the team has assigned too many high values or too few low values. Priority inversion is a technique in which a dependence hierarchy is established. Requirements are identified for which other requirements must be satisfied first and ratings are adjusted accordingly (Guinta, 1993; Shen *et al.*, 2001).

2.5.3 Measuring Customer Perception through Customer Competitive Assessment

The measuring of the customer perception is a vital aspect in customer satisfaction and it can be done through customer competitive assessment. As such, the customer competitive assessment measures the customer perception of the product relative to the competition. Data collected from customers are used as a basis for comparison (Guinta, 1993; Shen *et al.*, 2001). The data are presented graphically to show how well competitors meet the requirements established by the customer focus group.

The customer competitive assessment helps the team to (Guinta, 1993; Shen *et al.*, 2001):

- “ i. Verify that the list of requirements is important to the customer population;
- ii. Capture additional customer requirements;
- iii. Discover the strengths and weaknesses of the product;
- iv. Identify weaknesses in competitors’ products. “

The team should identify which competitors will be used for comparison. Competitors who should be selected are those that have successfully offered a similar product or service, or those recommended by the customer. The same scale used for importance ratings should be used for the competitor's product and the team's product (Guinta, 1993; Shen *et al.*, 2001).

A combination of methods can be used to verify the "What's" established by the initial focus group. These methods might include additional focus groups, customer interviews, existing market survey data, or any other form of available market research (Guinta, 1993; Shen *et al.*, 2001).

2.5.4 Voice of the Supplier: A Way to Achieve Customer Satisfaction

Customer satisfaction of IBS houses is an important factor to IBS adoption in construction projects. One of the ways to achieve this is through the voice of the supplier. The voice of the supplier captures the "How's" (Guinta, 1993; Shen *et al.*, 2001). "How's" are ways of achieving "What's" and consist of processes, facilities, and methods. Emphasis shifts from identifying the problem to solving the problem.

The facilitator will hold a brainstorming session for ways to achieve the customer requirements. This is an opportunity for all team members to offer possible solutions to the "What's". Although the process is often more technical at this point, the team should still include representatives of all functions in the organization. Technical people should be equally balanced by non-technical people (Guinta, 1993; Shen *et al.*, 2001).

2.5.5 Technical Assessment a Way to achieve Technical Competitiveness

The technical assessment includes a technical competitive assessment and objective values or “How Much”. The technical competitive assessment is similar to the customer competitive assessment but involves technical details of the product or service rather than customer requirements. Objective values are used to establish engineering specifications (Guinta, 1993; Shen *et al.*, 2001).

The technical competitive assessment is used to compare “How’s” to competitors’ technical standards. Whereas, customers provide the data for the customer competitive assessment, engineers and technical people provide the data for the technical competitive assessment (Guinta, 1993; Shen *et al.*, 2001).

Objective values are quantifiable measurements for each “How’s”. Objective values are created according to industry and company standards. The team evaluates what the customer wants and what the competition offers, and then decides on a standard. Objective values represent how much must be done to be competitive in the marketplace and to what extent each “How’s” must be improved (Guinta, 1993; Shen *et al.*, 2001).

2.5.6 Measure of the Perceived Probability of Achieving “How’s”

Probability factors represent the perceived probability of achieving each “How’s”. A low probability factor can indicate that a current solution will not be competitive. This implies that new technology, systems, or methods, must be adopted or developed (Guinta, 1993; Shen *et al.*, 2001).

Probability factors are used to weigh each “How’s” and affect the final QFD results. Numeric scales are typically used with higher numbers representing higher probabilities. To determine the probability factor for a “How’s”, team members should ask “What’s” is the probability of accomplishing this “How’s”? (Guinta, 1993; Shen *et al.*, 2001).

2.5.7 Analysis of “How’s” to Fulfil “What’s” through the Relationship Matrix

The relationship matrix is central to the house of quality. The matrix is used to analyse how each “How’s” will fulfil each “What’s”. When a relationship exists between a “How’s” and a “What’s”, the “How’s” will satisfy a particular customer requirement or solve a problem (Guinta, 1993; Shen *et al.*, 2001).

Team members should first ask can this “How’s” help us achieve this “What’s”?” If the answer is no, a zero is entered in the matrix. If the answer is yes, then the relationship must be categorized as strong, medium, or weak. Numeric values for strong, medium, and weak are based on the numeric scale used. Each column should be completed by the team before proceeding to the next “How’s”. To calculate a score for each cell in the matrix, the importance rating is multiplied by the number in the cell for a particular “What’s” (Guinta, 1993; Sheng *et al.*, 2007).

2.5.8 Sum of the Weighted relationship Value for each “How’s” (Absolute and Relative Score)

The absolute score is the sum of the weighted relationship values for each “How’s”. The relative score is the rank. The absolute score is calculated by summing the relationship matrix scores for each column of “How’s”. Absolute scores represent the

importance of each “How’s” in relation to the “What’s” (Guinta, 1993; Sheng *et al.*, 2007). The calculation to measure absolute importance and relative importance is shown below (Abdul-Rahman *et al.*, 1999):

i. Average degree of importance =
$$\frac{\text{Sum of all the scales given by respondents}}{\text{No. of Respondents (n = x)}}$$

ii. Average level of satisfaction =
$$\frac{\text{Sum of all the scales given by respondents}}{\text{No. of Respondents (n = x)}}$$

iii. Absolute importance =
$$\sum (\text{Degree of importance} \times \text{correlation value})$$

iv. Relative importance (%) =
$$\frac{\sum (\text{Degree of importance} \times \text{correlation value}) \times 100}{\sum (\text{Absolute importance})}$$

Note: Correlation value is the value of “What’s” vs “How’s” in the QFD house of quality matrix.

2.6 FUNCTIONAL FIELD OF QFD

QFD was originally proposed, through collecting and analysing the voice of the customer, to develop products with higher quality to meet or surpass customer needs. Thus, the primary functions of QFD are product development, quality management, and customer needs analysis. Later, QFD functions were expanded to wider fields such as design, planning, decision-making, engineering, management, teamwork, timing, and costing (Chan & Wu, 2002).

Essentially, there is no definite boundary for the potential fields of QFD applications. There are quite a large number of applications of QFD in various fields, such as in planning: supply chain planning (Li *et al.*, 2001), engineering: system engineering (Brady, 2001), decision making: improvement priorities (Barad & Gien, 2001),

management: strategic performance (Hauser, 2001), teamwork, timing, costing, and others: improving the visualization of the design attributes (Hallberg *et al.*, 1999). There are also examples on the application of QFD in functional fields, as follows:

2.6.1 Product Development

One of the applications of QFD is product development (Govindaraju & Mital, 2000; Shen *et al.*, 2000). In this field there is some similarity to the application of QFD, which is the development of courses and curriculums (Bier & Cornesky, 2001) model-change products (Hoque *et al.*, 2000), new products (Dawson & Askin, 1999; Rosas-Vega & Vokurka, 2000), products and processes (Verma *et al.*, 1998), product concept (Schmidt, 1997), reliability test methods (Kwon & Han, 1999), software (Barnett & Raja, 1995), strategic performance (Hauser, 2001) and metric systems (Stylianou *et al.*, 1997).

2.6.2 Quality Management

Another popular field of QFD applications is quality management, which is an important part of the QFD process and is essential for successful product development, and many publications can be found in this field (Hassan *et al.*, 2000; Ho *et al.*, 2000, 2001; Lim & Tang, 2000). In particular, QFD has been applied to expert systems for quality management (Bird, 1992), process improvement (Richardson, 2001), quality control (Prasad, 1997), quality information systems (Lin & Fite, 1995), quality systems (Kanji, 1998), service improvement (Barnes & Vidgen, 2001; Chin *et al.*, 2001), service quality management systems (Chang & Lin, 1991), and software process improvement (Herzwurm *et al.*, 2000).

2.6.3 Customer Needs Analysis

Quality management and product development are achieved in QFD through customer needs analysis, which, in fact, is always the very first step of a QFD process, and, thus, is an important functional field of QFD. Publications in this field are quite rich, focusing mainly on the two key aspects of customer needs analysis: collecting and translating customer needs (Hwarng & Teo, 2001) and satisfying customer needs (Askin & Dawson, 2000).

There are also QFD applications addressing certain specific aspects of customer needs analysis, such as customer involvement (Huovila & Seren, 1998), customer preference (Lai *et al.*, 1998), customer responsiveness (Atkinson, 1990), customer services (Graessel & Zeidler, 1993), data collection (Casey *et al.*, 1993), defining quality requirements (LaSala, 1994), processing client requirements (Kamara & Anumba, 2000), and prioritizing customer needs (Persson *et al.*, 2000).

2.7 APPLIED INDUSTRIES OF QFD

The first two reported applications of QFD were in the ship building (Nishimura, 1972) and electronics (Akao, 1978) industries. The early applications of QFD focused on such industries as automobiles, electronics, and software. The fast development of QFD has resulted in its application to many manufacturing industries. Eventually, QFD has also been introduced to the service sector, such as government, banking and accounting, healthcare, education and research. Now it is hard to find an industry to which QFD has not yet been applied.

2.7.1 Transportation and Communication

Ship building is one of the two earliest QFD application sectors (Nishimura, 1972), and Lyu & Gunasekaran (1993) report another such QFD application. The automobile industry is an earlier and important industry to which many authors report their QFD applications (Fuxin *et al.*, 2001; Wang, 1999).

QFD applications can also be found in aircraft (Delano *et al.*, 2000), airlines (Ghobadian & Terry, 1995), automotive parts (Liker *et al.*, 1996), car audio (Ngai & Chow, 1999), commercial vehicles (Franceschini & Rupil, 1999), container ports (Johnston & Burrows, 1995), motors (Taylor, 1997), railways (Herrmann *et al.*, 2000), pedestrian crossings (Beckwith & Hunter-Zaworski, 1998), satellites (Ho, 2000), telecommunications (Sansone & Singer, 1993), transportation (Henderson, 1994), transportation equipment (Conley, 1998), and voice mail systems (Hales, 1995).

2.7.2 Electronics and Electrical Utilities

Akao (1978) applies QFD to electrostatic copying machines, and, thus, makes electronics another of the earliest QFD application tools. QFD tools have been applied by such electronics-related companies as AT&T (Brown & Harrington, 1994), DEC (Van-Treeck & Thackeray, 1991), Hewlett-Packard (Williams, 1994), IBM (Wood, 1998), Intel (Kerr, 1989), Motorola (Bosserman, 1992), and Philips (Groenveld, 1997).

Other electronics-related products or parts include automated teller machines, (Riffelmacher, 1991), blend door actuators (De Vera *et al.*, 1988), chips (Mehta, 1994), climatic control systems (Franceschini & Rupil, 1999), computers (Rosas-Vega & Vokurka, 2000), hard disk drives (Mrad, 1999), integrated circuits (Philips *et al.*, 1994), robotic workcells (Yang *et al.*, 2000), and sensors (Beckwith & Hunter-Zaworski, 1998; Maier, 1996). Other QFD applications in electronics have also been included (Tse,

1999). QFD has also been applied to electrical utilities such as batteries (Halbleib *et al.*, 1993), Florida Power and Light (Hofmeister, 1995), gas burners (Remich, 1999), Pacific Gas and Electric (Tessler *et al.*, 1993), power systems (Rajala & Savolainen, 1996), and wind turbines (Schmidt, 1997).

2.7.3 Software Systems

Another early popular sector of QFD application is software systems. There were many reported QFD applications in software, such as Herzwurm *et al.* (2000); Liu *et al.* (2001) and Richardson (2001). Other related QFD application areas include decision support systems (Sarkis & Liles, 1995), expert systems (Ngai & Chow, 1999), human-machine interfaces (Nibbelke *et al.*, 2001), information systems (Han *et al.*, 1998), integrated systems (Wasserman *et al.*, 1989), management information systems (Eyob, 1998), profiling systems (LaSala, 1994), and Web pages (Tan *et al.*, 1998).

2.7.4 Manufacturing

Manufacturing is also an earlier area of QFD applications, which can be found, e.g., in the papers of Sullivan (1986). Along with its fast development, manufacturing has witnessed the usage of more and more QFD applications (Barad & Gien, 2001).

QFD has also been applied to diversified manufacturing areas, such as assembly lines/plants/stations (Mrad, 1999), braking systems (Nickerson, 1993), capital goods (Pfohl & Ester, 1999), chocolate (Viaene & Januszewska, 1999), composite material (Karbhari *et al.*, 1991), computer-integrated manufacturing (Boubekri *et al.*, 1991), cork removers (Reich, 1996), engine filters (Zhang *et al.*, 1999), equipment (Matzler & Hinterhuber, 1998), foods (Costa *et al.*, 2000), furniture (Acord, 1997), helmet-

mounted displays (Cadogan *et al.*, 1994), and hybrid bicycles (Govindaraju & Mital, 2000).

Others are instrumentation (Rice, 1989), meat (Dalen, 1996), medical devices (Hauser, 1993), metals (Crowe & Cheng, 1996), metrology probes (Parr, 1995), peas (Bech *et al.*, 1997), pencils (Askin & Dawson, 2000), plastic components (Yeung & Lau, 1997), power protection equipment (Gershenson & Stauffer, 1999), printing (Finley, 1992), pultruders (Steiner *et al.*, 1992), quick release top nozzles (Crow, 1999), safety shoes (Bergquist & Abeysekera, 1996), tea (Wu & Wu, 1999), and tractors (Reed, 1995).

2.7.5 Services

QFD is a customer-oriented quality management and product development technique originally used for hard products, however, its ideas are by no means inapplicable to soft services. Indeed, it has gradually been introduced into the service sector to design and develop quality services (Partovi, 2001).

The wide acceptability of the QFD technique can be shown from its reported applications in various service areas, such as accounting (Booth, 1995), administration (Hofmeister, 1992), banking (Ko & Lee, 2000), contracting process (Hybert, 1996), engineering services (Pun *et al.*, 2000), food distribution (Samuel & Hines, 1999), government services (Lewis & Hartley, 2001), hotels (Dube *et al.*, 1999), on-line bookshops (Barnes & Vidgen, 2001), mortgages (McLaurin & Bell, 1991, 1993), professional services (Adiano, 1998), and the public sector (Curry, 1999). In addition, real estate appraisal (Ferrell & Ferrell, 1994), retail (Nagendra & Osborne, 2000), technical library and information services (Chin *et al.*, 2001), wholesale (Keenan, 1996) and, in particular, healthcare (Chaplin & Terninko, 2000).

2.7.6 Education and Research

Among the broad service areas, academic organizations are special and have witnessed a number of QFD applications for conducting quality education and research based on QFD customer driven planning principles. In the educational area, QFD applications also include colleges, universities (Bier & Cornesky, 2001), and distance learning education (Murgatroyd, 1993).

Also in the educational industry, QFD has been applied in educational institutes (Singh & Deshmukh, 1999), kindergartens (Moura & Saraiva, 2001), public schools (Tribus, 1993), training centres (Franceschini & Terzago, 1998), vocational secondary schools (Starbek *et al.*, 2000) and, interestingly, business schools too (Hwarng & Teo, 2001). QFD has also been applied to R&D (Delano *et al.*, 2000) and research programme design (Kauffmann *et al.*, 1999).

2.7.7 Other Industries

QFD principles set no prerequisites about the type of products or services and the producing or serving organizations. Indeed, the applications of QFD in the industry are freely applied beyond the six general industries above. QFD has also attracted the attention of many other industries, such as aerospace (Jacobs *et al.*, 1994), agriculture (Reed, 1995), beauty enterprises (Chan, 2000) and construction (Kamara & Anumba, 2000).

In addition, disaster prevention (Kara-Zaitri, 1996), environment protection (Halog *et al.*, 2001), indoor air quality (Park & Kim, 1998), management culture (Angeli *et al.*, 1998), military (Filling *et al.*, 1998), national security (Mann & Halbleib, 1992), packaging (Li *et al.*, 2001), peacekeeping forces (Partovi & Epperly, 1999), police

stations (Selen & Schepers, 2001), political elections (Mevorach, 1997), socio-economic development (Madu & Kuei, 1994), technologies (Chiou *et al.*, 1999), and textiles (Temponi *et al.*, 1999).

2.8 APPLICATION OF QFD IN CONSTRUCTION

Chan & Wu (2002) carried out a literature review of QFD and reported its application in 22 countries worldwide. In fact, they found references in other sectors, such as telecommunications, transportation, services, electronics and construction. However, the proportion of manufacturing to construction documents was 10 to 1; until 2002, its application in the construction industry was rather limited (Ahmed & Kangari, 1996; Low, 1998; Low & Yeap, 2001; Hernandez & Aspinwall, 2007a). Nevertheless, interest in this area has been growing and there exists a steady stream, albeit small amount, of literature that can assist in understanding the application of the concept in the construction sector (Low & Yeap, 2001; Dikmen *et al.*, 2005).

Gargione (1999) used QFD to test the applicability of QFD to construction involving companies from different backgrounds. QFD was used as a tool in this case to prioritize important points that could offer potential for improvements in accord with the requirements and needs of the clients. The objectives of using QFD in the middle-class apartment units of the construction project are (Gargione, 1999):

- “ i. Defining the design and specifications for residential units so that they meet the highest level possible of customer requirements and satisfaction;
- ii. Ensuring consistency between customer requirements and products measurable characteristics, such as dimensions, features of rooms and finished materials used in the construction work;

- iii. Ensuring consistency between the design phase and the construction work. QFD can minimize the problems that usually were detected on the interaction between design and construction phases (including “constructability” problems and construction reworks);
- iv. Optimizing the integration of the perceptions and variables of customers that can affect the RoI (Return on Investment), such as construction cost, speed of sales, schedule and cash flow;
- v. Reducing the time to perform quality features throughout product development.”

Mallon & Mulligan (1993) used QFD on a hypothetical renovation of a personal computer workroom. Armacost *et al.* (1994) applied QFD to integrate the customer requirements in an industrialized housing component: a manufactured exterior structural wall panel. Serpell & Wagner (1997) used QFD to determine preferences on the design characteristics of the internal layout of a building apartment. QFD was also applied to construction (Huovila *et al.* 1997) involving different players working together in three construction projects: a structural design firm and two contractors.

In Japan, Shino & Nishihara (1997) examined the application of QFD in the construction sector for the first time and concluded that it could be used in such a sector. In the US, Oswald & Burati (1992) found that the methodology improved both the project definition process and the identification of customer requirements while reducing cycle time and enhancing cross-functional communication. Also in the US, Mallon & Mulligan (1993) demonstrated the applicability of the HoQ in a hypothetical renovation project. Huovila *et al.* (1997) implemented the QFD methodology in a flat, a restaurant and an industrial building and showed that in spite of the extra work involved, even its partial implementation could bring about benefits (better designs,

better communication with customers). Serpell & Wagner (1997) successfully applied the HoQ to determine the technical characteristics of the internal layouts of flats in Chile. In the same country, Alarcon & Mardones (1998) utilized it for identifying improvement tools that could help to alleviate design defects in construction projects. Abdul-Rahman *et al.* (1999) applied the QFD to determine the factors influencing the quality of a low-cost flat.

A multinational team led by Yang (Yang *et al.*, 2003) combined QFD with knowledge management to generate a system that was able to support the creation of constructible designs, which included the fuzzy theory outlining the management of vagueness of the design inputs. The advantage of this approach is that it may facilitate the development of an intelligent system, based on QFD, which professionals can use to improve designs. Thus, application, usage and awareness of QFD and its benefits were limited to the primary or core players in the industry, namely, architects and engineers.

2.9 SUMMARY

QFD is a group work approach designed to ensure that everyone works together to give customers what they want. It was first adopted in Japan, and has brought significant benefits to the manufacturing industry. QFD helps improve the quality of products, satisfy customer needs, shorten development time, and at the same time reduces cost. QFD also changes the way people think. It brings quality into products and their manufacturing processes. It helps to achieve high quality products by improving process quality.

Although incorporating customer requirements into a final product may not be a totally new idea, QFD helps companies to achieve this goal in a more disciplined structured

manner. This is done through a series of matrices to achieve specific objectives by translating customer requirements into design and production parameters. In this sense, QFD is not only an engineering system but is also a documentation and communication system.

Construction has lagged behind other industries in implementing total quality function deployment because of the perception that QFD is solely for manufacturing purposes only. However, that perception is rapidly changing. QFD is the key towards achieving the philosophy of obtaining overall satisfaction through continuous improvement of products, processes and services. For the purpose of this study the researcher proposes to use QFD application as a planning and management development tool in order to develop a set of strategies to improve customer satisfaction in IBS housing construction and the strategies to improve the level of IBS adoption in the Malaysian construction industry.