

Impact of Safety and Quality Considerations of Housing Clients on the Construction Firms' Intention to Adopt Quality Function Deployment: A Case of Construction Sector

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Abstract—The current study intends to examine the safety and quality considerations of clients of housing projects and their impact on the adoption of Quality Function Deployment (QFD) by the construction firm. Mixed method research technique has been used to collect and analyze the data wherein a survey was conducted to collect the data from 220 clients of housing projects in Saudi Arabia. Then, the telephonic and Skype interviews were conducted to collect data of 15 professionals working in the top ten real estate companies of Saudi Arabia. Data were analyzed by using partial least square (PLS) and thematic analysis techniques. Findings reveal that today's customer prioritizes the safety and quality requirements of their houses and as a result, construction firms adopt QFD to address the needs of customers. The findings are of great importance for the clients of housing projects as well as for the construction firms as they could apply QFD in housing projects to address the safety and quality concerns of their clients.

Keywords—Construction industry, quality considerations, quality function deployment, safety considerations.

I. INTRODUCTION

THE overarching purpose of any housing project is to provide the safe, healthy and comfortable houses to its residents. Safety is one of the basic human needs measured in its objective dimensions, "behavioral and environmental parameters" or subjective dimensions, "terms of the perception of safety" [1]. A number of injuries occur at homes and residential areas either intentionally or unintentionally. According to a recent study carried out in New Zealand, the number of the injuries which occur at homes is about 3.5 times more than the social cost of road injuries [2]. The main purpose of the housing buildings is to provide residents with safe, peaceful, comfortable, conducive, healthy and secure indoor environments where they can carry out indoor activities, e.g. work, study, leisure and family life. To achieve this aim, buildings are designed and constructed by the professionals according to the users' expectations and under the rules and regulations established by the state governments. However, studies show that these rules and specification do not always meet the customer requirements [3]-[5] due to changing nature of customer needs and requirements. Certain reasons might be adduced on why the buildings are unable to

meet users' demands and expectations regarding safety and quality requirements. The main reason is that the designers and other building engineers are not well aware of customers' changing needs and requirements.

To become more customer oriented and to understand customer needs and priorities in effective manners, Cohen and Cohen [6] developed QFD that allows firms to collect information about customer needs in a systematic way. QFD helps a firm to remain continuous in contact with the customer and to collect and analyze information using the house of quality (HoQ) at each stage including product planning and manufacturing and even after delivery of the product. QFD has largely been applied to manufacture the products including car components, wires, and printed circuit boards [7] while Chan and Wu [8] reported the application of QFD in 22 countries across the world in the industries of electronics, services, transportation, telecommunication, and construction. Nevertheless, its application in the construction industry is lesser than manufacturing industry. For instance, Delgado-Hernandez et al. [9] reported that QFD was known by 18% of the total respondents of their survey; however, its awareness was increased since 2001 as [10] who found only 7% of total respondents having information about QFD. In Japan, it was first examined in the construction industry in 1990 by Shino and Nishihara [10] who reported that QFD is equally applicable in the construction industry. In the US, QFD was first considered in 1992 as a tool to improve the processes of project definition, cross-departmental communication and customer need identification and to reduce the lead time [12].

The construction industry in Saudi Arabia is rapidly growing as the worth of the industry is \$1 trillion in 2015 (increased from \$400 billion in 2008), and only the ownership of dwellings contributes 9% towards total real GDP [13]. This big contribution by ownership of dwellings towards the total GDP highlights the demand for houses in Saudi Arabia. Still, the sector has tremendous potential for growth due to urbanization and growing population. As mentioned before, construction firms have lack of knowledge about users' changing nature of demands and requirements; therefore, construction firms try to use different strategies to fulfill the customer needs and requirements out of which QFD has gained extensive consideration by researchers and practitioners. Although QFD is widely used to in construction firms, to best of our knowledge, it has not been previously

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used to promote safety consideration of housing clients.

The conditions of a house should ensure the safety, health, and well-being of the people living in it and protect them against injuries or illness. Unsafe and environmentally unprotected houses are the main reason for injuries and illness of their residents [14]. The dilemma is that common people are not much aware even of the basic safety needs such as protection against fire, structural protection, plumbing issues or illness caused by moisture or mold [15]. Therefore, the purpose of current study is twofold. First, the study intends to address the safety and quality considerations of clients of housing projects by creating awareness about the benefits of safe housing. Second, this study urges the construction firms to adopt QFD to address the needs of their customers and provide them safe and quality houses.

This paper aims to examine the safety and quality considerations of the users of housing buildings and to analyze that how the construction firms fulfill these requirements. This study is an attempt to explore the safety and quality concerns such as fire safety, protection against insects, dampness, and structural safety of housing clients of developing countries by collecting data from the users of housing buildings and interviewing project managers, construction engineer, design managers and various other key professionals involved in the construction of housing project. Findings of the current study are likely to offer very useful insights for common people to create awareness, to promote the safety of their houses. At the same time, the findings of the study offer very useful insights for the construction firms and they may be better able to transform the clients' needs and priorities into the features and characteristics of the construction sites/facilities.

To address the aforementioned research gap, the current study intends to find the answer of following research question.

- How do the safety and quality considerations by users of housing projects influence the construction firms' intention to apply QFD to satisfy their needs and requirements?

II. LITERATURE REVIEW

It always has been a big challenge for the government of any country to provide safe and decent houses to its citizens. The necessity of safe housing is the second most important need of human-being after food. In 1980, World Health Organization (WHO) initiated "The international Safe Community" movement which has become very popular worldwide as an organizational process for the promotion of local safety programs [16]. Local communities also participate in these safety promotion programmes, and as a result, local people are much aware of the safety requirements. It is necessary to predict and prevent home-related injuries [17]. In this regard, promoting residential safety interventions among the households may help to improve the injury control and illness among residents. Conversely, the businesses all over the world have become highly competitive due to increasing number of competitors in every industry [18]. Although, today's customers are more concerned about the quality and

safety and well aware of their needs and requirements due to increasing use of information and communication tools, but still there is a need to promote safety and quality considerations so that they can express their exact needs while buying a house [19]. This has led the businesses in every industry to focus more on customer needs and preferences and to deliver high quality customized products and services to ensure customer satisfaction and loyalty [20]. The changing market conditions have relatively higher effects on the construction of housing projects because housing buildings are highly customized and developed according to the exact needs and requirements of the customers. To become more customer oriented and to understand customer needs and priorities in effective manners, Cohen and Cohen [6] developed QFD that allows firms to collect information about customer needs in a systematic way. QFD helps a firm to remain in continuous contact with the customer and to collect and analyze information using the house of quality (HoQ) at each stage including product planning and manufacturing and even after delivery of the product.

QFD was originated in Japan which was an international leader in low-cost steel production that time and the country planned to further expand its business into shipping industry [21]. Mitsubishi was one of the contractors who contacted government for help to develop complex logistics mechanism that was needed to build cargo ships. In result, the government approached professors of various universities to develop such a system that may have potential to consider the customer requirement in each process of overall product development and construction process. The process which was developed with the result of those efforts is QFD [22]. Professor Yoji Akao was the first academician who presented QFD at Tamagawa University in Tokyo since then the process has largely been used in different manufacturing and service industries across the world [23]. Akao defines QFD as the process to

"convert the user demands into substitute quality characteristics, determine the design quality of the finished good and systematically deploy this quality into component quality, individual part quality and process elements and their relationships" [24].

A. QFD in Construction Industry

QFD gained much popularity in manufacturing sector across the world however its application in the construction industry is relatively limited. According to a survey, the proportion of the application of QFD was 10 to 1 in manufacturing to construction industry [25]. However, the authors argue that QFD is equally applicable in the construction industry as the industry is equally concerned to provide safe and quality buildings and other construction projects. It improves the customer satisfaction by considering their needs and priorities carefully and transforms them into the design, construction, and engineering of safe housing buildings. It is also argued that construction companies construct the houses that have to be used for a long time relative to the other types of product. Thus, customers seem to

be more concerned and cautious about the design, engineering, construction and especially about the safe use of such houses.

The application of QFD in construction across different countries started later than that in the manufacturing sector. For instance, it is had become known the UK construction industry in the start of the last decade [10] and first time examined in Japanese construction industry in 1990 by Shino and Nishihara [11] and first time explored in the US construction in 1993 by Oswald and Burati, [12]. Various other studies explored the application of QFD in the construction industry. For instance, Mallon and Mulligan [26] presented the application of QFD in a hypothetical renovation/reconstruction project. Furusaka, et al. [27] developed an improved version to simplify inspection and supervision process named as R-QFD in the construction industry of Japan resultantly a guide was provided to the construction project managers to perform surveillance activities. The process of QFD has also been integrated with other theories. For instance, Yang, et al. [28] integrate the process with knowledge management for the development of a system that may help project managers to understand and incorporate fuzzy and blurred inputs by the clients and to create a constructible design. Dikmen et al. [29] considered QFD into another perspective and used it to develop a marketing plan on the basis of the clients' input and feedback in the construction of houses. Delgado-Hernandez et al. [9] are of the view that QFD should be used in construction project to consider most important customer requirements that may create customer satisfaction as well as they report that the construction company finds QFD as a most innovative determinant of customer satisfaction, timely delivery of product by reducing time and improving communication. Further, Wang [30] improved QFD by improving/adding linguistics variables that made it easy for project managers to understand the fuzzy inputs by the client and to translate customer needs and priorities to solution schemes. QFD is very effective for creating a mutual relationship between the construction firm and client by identifying the client requirements and changing them into technical terms [31]. Furthermore, QFD is very useful and effective tool for analyzing the advanced offsite requirements in a construction project by offering the systematic, structured and holistic approach to manage the requirements [32]. Hence, it implies that the housing projects should be designed; engineered and built exactly according to the specific requirements of the clients thus the significance of QFD in construction industry seems very high. Therefore, in accordance with the above literature, we proposed the following two hypotheses;

- H1: Safety considerations of housing customers positively influence the construction firms' intention to apply QFD to meet the customers' requirements
- H2: Quality considerations of housing customers positively influence the construction firms' intention to apply QFD to meet the customers' requirements

III. METHODOLOGY

A. Research Approach

This study has used the mixed-method technique to collect and analyze the data. Quantitative data were collected from the users' of housing projects while the architects, designers, building engineers and other professionals involved in constructing houses were interviewed about how do their firms address the needs of their customers. According to Saunders et al. [33], a mixed method is a general term where both the qualitative or quantitative research approaches are applied either at the parallel level or sequentially. Hence, the authors conducted a survey followed by the interviews to support the results and build sound findings in response to the research question.

Initially, the author explored top ten real estate companies of Saudi Arabia [34]. These companies are carrying out large housing projects and residential towers in the big cities of Saudi Arabia. These companies were requested to provide the information about their clients. These clients were reached by our survey team and requested them to fill the questionnaire. In total, 350 questionnaires were sent randomly to the clients of these housing societies. Out of 350, we received 268 questionnaires. During initial screening, it was found that only 220 questionnaires were valid and ready for data analysis yielding 62.85% response rate.

The current study also followed the qualitative research approach and the author conducted telephonic and Skype in-depth semi-structured interviews. It is believed that semi-structured interviews are useful when detailed information about an understudied phenomenon is required by asking not only predefined questions but repeating and probing questions to dig down the phenomenon [35]. Fifteen front-line managers such as architects, project managers, and construction engineers were approached to collect qualitative data by using non-probability purposive and snowball sampling [33]. Only those professionals were selected who directly interact with the clients to collect information about their needs, priorities and feedback as well as those who have a good understanding about QFD in their construction projects.

B. Measures

Measures for the constructs were adapted from the previous studies. Three constructs, i.e., Safety considerations, Quality Considerations and Adoption of QFD were used in the study. All items were measured on five points Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The construct "safety considerations" was measured on a five items scale developed by [36]. "Quality considerations" was measured on a ten items scale developed by [37]. To measure the adoption of QFD, we developed a three items scale based on the previous literature. Validity and reliability of the new scale were checked before data collection with a pilot survey.

For qualitative data collection, an interview guide has been developed to collect the qualitative data. To develop an interview guide, Saunders et al. [33] proposed that the author needs to maintain the logical order and use comprehensible

language. Following these suggestions, five questions were developed after a thorough review of relevant literature. These questions are about: 1) clients' concern for the safety of the house; 2) clients' knowledge of the company's quality culture, and 3) application of QFD by the firm to satisfy the customer demands.

IV. RESULTS

A. Model Evaluation and Hypotheses Testing

We used Structure Equation Modeling (SEM) method through SmartPLS 3 for data analysis. PLS technique has been used to validate the measures and test the hypotheses which are a widely used technique in social sciences and is suitable for small data samples [38]. It is suitable to use PLS in this study because this study consists of a small data sample. Table I represents the Mean, standard deviation and loadings of each item used in the scale. In Table I, we named the items of the constructs. For example, the items of safety considerations have been named as SC1 to SC4 and the items of quality considerations have been named as QC1 to QC6. The scale proved to be a good fit after removing the items with loadings less than the threshold of 0.70. Following this rule, four items of the construct quality considerations and one item from the construct safety considerations was deleted. The loadings of all other items are greater than the threshold of 0.70.

Initially, reliability and validity of the constructs used in this study were checked. Reliability is reflected by the internal consistency of measures, i.e. the value of Cronbach's alpha and validity is the extent to which a scale measures what it is supposed to measure [39]. The values of Cronbach's α must be above than 0.70 [40]. In this study, the value of Cronbach's

α is greater than 0.70 for all constructs. After the reliability, the data were checked for validity where we have checked the Composite Reliability (CR) and Average Variance Extracted (AVE). The value of CR should be greater than 0.7 [41] and AVE value should be greater than 0.5 [42]. Table II shows that the values of CR and AVE are above the threshold of 0.70 and 0.5 respectively. Furthermore, the square root of the AVE for each construct is greater than the correlations between the construct and other constructs proving that the samples data has outstanding discriminant validity. Considering the results in Table II, we can safely argue that current data demonstrate adequate internal consistency and is suitable for hypotheses testing.

TABLE I
DESCRIPTIVE STATISTICS OF THE MEASURE

Construct	Construct Item	Mean	Std. Deviation	Loading
Safety Considerations (SC)	SC1	2.986	1.226	0.774
	SC2	2.708	1.157	0.844
	SC3	2.694	1.214	0.832
	SC4	2.607	1.179	0.759
Quality Considerations (QC)	QC1	2.694	1.328	0.794
	QC2	2.708	1.252	0.791
	QC3	3.055	1.192	0.704
	QC4	2.932	1.334	0.783
	QC5	2.977	1.225	0.785
	QC6	2.868	1.237	0.730
Adoption of QFD	QFD1	3.292	1.084	0.742
	QFD2	3.169	1.087	0.790
	QFD3	2.781	1.200	0.832

TABLE II
MEASUREMENT MODEL RESULTS

Construct	Composite reliability	Cronbach's alpha	AVE	QFD	Quality Considerations	Safety Considerations
QFD	0.831	0.709	0.622	0.789		
QC	0.894	0.859	0.586	0.435	0.765	
SC	0.879	0.818	0.645	0.406	0.443	0.803

Note: The bold numbers on the diagonal are the square root of the variance shared between the constructs and their measures. Off-diagonal elements are correlations among constructs. For discriminate validity, diagonal elements should be larger than off-diagonal elements. AVE = average variance extracted.

TABLE III
STRUCTURAL PARAMETER ESTIMATES

Hypothesized path	Standardized path coefficients	t-value	Decision
Quality considerations → Adoption of QFD	0.373	4.041**	Supported
Safety Considerations → Adoption of QFD	0.320	3.466**	Supported

Note: * $p < 0.05$. ** $p < 0.01$.

V. DISCUSSION

The main objective of this study is to analyze that how the safety and quality considerations of housing clients influence the intention of construction firms to adopt some useful techniques to satisfy their customers. Therefore, quantitative data was collected from the customers' of housing projects about the safety and quality concerns of their houses and how they want the construction firms to address their requirements. In the second step, the key professionals from the sampled construction firms were interviewed about how they address

the customer needs.

Our analysis confirmed that safety and quality considerations of housing clients impact the adoption of QFD by the construction firms. Participants of the survey expressed their concerns regarding safety and quality requirements. On the other hand, the professionals from the targeted companies reported how they address the customer requirements. These companies are found to be applying QFD in the complete life cycle of each construction project. Participants are found to believe that the application of QFD helps them to understand

key requirements of the clients in every phase of the project leading them to make better decisions for each phase. As a design manager reported:

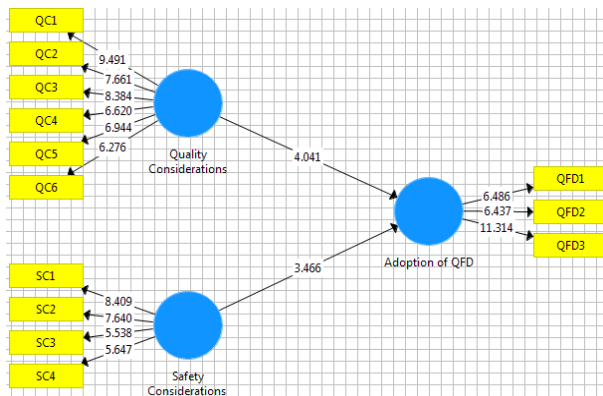


Fig. 1 Measurement model

“We apply QFD house of quality (HoQ) and make use of each of its room in every phase of a construction project. We use QFD as a ranking system in the initial inception phase while the clients are encouraged to communicate a complete list of priorities and preferences about the construction project. After evaluating and comparing these preferences with those of competitors. Client’s needs are also transformed into, and their relationship is developed with the technical terms. In the design phase, continuous communication with the client is ensured so that the building’s design may fulfill a maximum number of the clients’ demands. From design to the completion, we listen to clients continuously. However, we do not address their all needs and preferences because of technical constraints. The clients do not have much technical knowledge about construction, so we guide them about pros and cons if we meet their preferences”. [Design Manager at Al Saedan Real Estate]

The findings seem to be well aligned with the QFD model of Cohen and Cohen, [6] as it is formally applied in the construction industry of Saudi Arabia. It also seems that construction companies follow the suggestions of Delgado-Hernandez et al. [25] who suggest that QFD is the best tool to understand the client’s specific needs and requirements and transform them into the construction project. The quality manager told about the house of quality (HoQ) and its rooms as depicted in the model and they make its extensive use, and they are well aware of how to collect and interpret clients’ information and correlate it with technical terms.

It is found that the client in this era is much prosperous and housing needs have been increased. At the same time, they are very concerned about different features such as safety, luxury, durability, and quality of their houses that is why they are willing to pay more and prefer safety and quality over price. Again, this is due to the broader knowledge about what is going on in the construction field globally and what features

and quality a building can have. However, at the same time, construction companies are well aware of the customer preferences due to intense competition. Therefore, construction firms apply QFD to address the needs of customers. As one of the interviewees reported:

“Today’s customer is more concerned about safety and quality of their buildings. They want state-of-the-art safety mechanisms against fire, earthquake, flood and other possible disasters. An increased awareness across the world about the worth of human life has significantly changed the construction industry as well. Any loss of human life in the result of the inefficiency of safety mechanisms raises direct questions on the efficiency of the construction company which has built the site. Moreover, today’s clients need comfort, facilities, and luxury in their buildings”. [Quality Inspector at Al Ra'idah Investment Company]

Therefore, the clients are well informed about the development of construction industry and to have all advanced features and facilities in their buildings, they are willing to pay more and prefer quality over price. This leads construction companies to address their concerns through ensuring the availability of required engineers, quality construction materials and suppliers and abilities to deliver the product with all advanced features and facilities.

Applying QFD, the construction companies in Saudi Arabia are deeply concerned with the clients’ needs and priorities. They are in continuous communication with the clients to know what they want and demand in their buildings or projects. They do not only get such information before or at the design phase rather, throughout the project lifecycle, but they also remain in touch with the clients to communicate about how their needs and priorities are being fulfilled. The participants reported that customer is the key source of a business’s success in the current competitive markets, so they have to be customer oriented to deliver the product of the customers’ choice. A participant reported:

“Overlooking client’s needs and demands in this era can lead to the business failure because today’s clients have many options and there are many construction companies in place to serve their needs. We are not operating in a monopolistic environment. Moreover, the clients are also well aware of what can be added in the building because of increased usage of internet as they often view construction sites, understand their features and then prepare their list of needs and priorities and proposed the design accordingly. It is not the time that they accept whatever we deliver.” [Design Review Manager at Jabal Omar Development Company]

The objective of QFD is to assist organizations to gather information regarding the requirements and priorities of clients. Most important phase is the finalization of contract and design process as in this phase maximum information about requirements of clients is acquired for the particular project. Clients are requested to fill up the form and convey the organization about their requirements. Such forms also have space to mention additional needs that are not covered by

the mentioned options. However, one of the organizations utilizes informal interactions and discussion session with the clients as a source of information. Moreover, it is asked by the company to mention their needs in the formal letter, so everything is recorded in the documentation. As one of the respondents reported:

“We use a well-established form to collect the clients’ needs and priorities. This makes our life easy because it has all possible needs and demands a client can ask for. It also helps the client to understand what can be done because sometimes clients do not know all of their needs and demands. So to ensure the complete information about clients’ needs and priorities, we use such a formal form”. [Construction Engineer at Dar Alarkan Real Estate Development Co]

This keeps with the notion of today’s competitive digital workplace of building & construction industry as mentioned by [43]. Findings of the current study also confirm the findings of previous studies [44], [45] who claimed that QFD is an important procedure that satisfies the clients’ needs and preferences in a construction project.

VI. CONTRIBUTIONS OF THE STUDY

This study has made some important contributions to the existing literature. First, as aforementioned, there is less literature on safety considerations from the customers’ point of view before they buy a residential house. Therefore, this study is a step forward to extend this important stream of literature by focusing on both, customer as well as construction companies’ perspective. We found that clients prioritize safety and quality of their houses and that QFD is a useful technique to analyze the residents’ safety needs. We found that QFD has potential to address the residents’ safety concerns. Therefore, this study will create safety awareness among the people who want to buy houses. Moreover, most of the previous studies are simply a review of the literature [46] or they have presented a HoQ comparing the customer needs with that of technical characteristics of the product [9], [25]. In contrast, this study focused the customers first by surveying to know about their safety and quality concerns. Then, we interviewed project managers, construction engineer, design managers and various other key professionals involved in the construction of housing project and provided the finding based on statistical analysis as well as through the thematic analysis. In the perfectly competing global market, construction companies are well aware of QFD and benefits of its application. Based on the findings of the previous studies [6], [44], [47], it can be stated that construction companies in Saudi Arabia are effectively utilizing QFD in all the phases of projects that enable them to collect information about clients’ needs and preferences even before entering into a formal contract. Through this phenomenon, organizations provide the safe and quality houses for their clients and empower the clients to analyze the performance of the company, quality of output, standards, mechanism, and measurements against their expectations.

VII. CONCLUSION

Common people and construction professionals have different perspectives and requirements on promoting safety and preventing injuries caused in houses. The objective of this study was to explore the safety and quality considerations of common people for their houses and then to find out that how the construction firms address the requirements of these people. Mixed-method research technique was used to draw the results. We developed two hypotheses to measure the safety and quality consideration of the housing clients and used SmartPLS 3 to draw the statistical results. We found that the people prioritize the safety and quality requirements of their houses and as a result, construction firms adopt QFD to address customers’ needs to provide them safe and quality houses. Furthermore, we also found that QFD has potential to promote safety among the residents of housing societies. As the requirement of a safe and quality house is a basic need after the food; therefore, the findings of the study can be generalized towards other countries to address the safety concerns of housing clients to promote the safety among people and control house-related injuries.

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