

The applications of the risk management & quality function deployment in the Malaysian Construction Industry: A critical perspective

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ABSTRACT

One of the most important tools through which undesirable and uncertain events and risks can be predicted is risk management, which is applied during the project period and before it also during the design and planning phase. One of the most important reasons for the failure of projects in Malaysia is the failure to implement risk management or its poor implementation that does not adopt modern methods and tools, and this situation may eventually lead to the failure of the project in terms of cost overruns, delays in the schedule and poor performance. The aim of this study is to review the level of application of risk management in the Malaysian construction industry and its success, and what is the relationship between risk management and Quality function deployment (QFD), as well as the extent to which QFD is applied in the construction industry in Malaysia. In the project risk assessment process, the traditional tools used fail to provide a complete presentation of the risks. This requires a kind of modernization of these tools or their integration with other systems to enhance their effectiveness, and the deployment of the quality function is one of the appropriate options as it focuses on paying attention to the voice of customers and improving quality.

By reviewing the previous recent literature, the results revealed that there is still a large gap between the management of construction projects in Malaysia and the use of well-known methods of risk management, which means that there is a clear and significant lack and weakness in the application of risk management systems in the construction industry. These results require a full awareness of how to adopt and apply risk management systems and the awareness of specialists in them (such as consultants, designers, project owners, contractors, and engineers) and obligate them to implement the risk management system. The enactment of governmental laws and regulations related to risk management will have a major role in their implementation and obligating all project departments with them, which will reflect positively on the outputs of this industry.

Keywords: Risk Management, Quality Function Deployment, Construction Industry, Customer Requirements, House of Quality.

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1. Introduction

One of the most important parts of countries' economies is the construction industry. This industry contributes directly and significantly to the development of the country's economic growth, which makes it a very important sector. The development of modern civilization was through laying the technological and material foundations for the construction industry. The construction industry creates many opportunities and investment projects for

the purpose of achieving national, economic and social objectives. One of the most important sectors in Malaysia that led and stimulated economic development is the construction industry. On the other hand, there are many and high risks faced by construction projects during the planning, start-up, implementation, control and closing stages. Sometimes the risks that occur during the implementation of construction projects can be considered higher risk than the problems that occur in the economic sector [1].

During the implementation of construction projects, the tools that provide important information and data about uncertain events and risks is risk management. In order to obtain a high level of performance to achieve the project objectives, risk management must be applied to all phases and parts of the project life cycle [2]. Despite this, project management tools are still new in the Malaysian construction industry during the implementation process among the construction players. The uncertain events and risks in the construction industry is a very unique activity and needs specialized management, because the project is linked to various factors that affect it such as the project environment, agreements and stakeholders. The information regarding the process of risk management in the Malaysian construction industry has been obtained from previous literature, and methodologies that are used in the industry, which is presented in this review paper.

In order to reach the project objectives with minimize risk factors are applied QFD. The process of taking the customer's voice into consideration, listening carefully to it, defining and responding to the customer's expectations and needs, is summarized in the methodology of quality function deployment (QFD). In the 1960s in Japan, the quality function deployment was first developed as a form of cause-and-effect analysis, and in the United States of America, this methodology was used in the early eighties of the last century in the automotive industry, it achieved many successes which led to its early and great popularity. Customer satisfaction with a particular service or product is considered a quality measure in the QFD. QFD can be expressed as a systematic method or approach that uses management tools to determine the expectations and needs of customers and prioritize them quickly and effectively.

In this study, the research question discussed with regard to risk management and QFD as the following: (why focus on the construction industry in Malaysia, the level of application of risk management in Malaysia, the extent of using QFD In Malaysia, the relationship and integrating between risk management and QFD). In this study, and through an extensive review of previous literature from scientific theses, books and published research, we were able to determine the research methodology.

2. Literature review

The processes of analyzing, designing and implementing procedures for managing risk in works is called risk management. Through risk management processes, complex activities that increasingly affect a project, company or organization can be anticipated. The meaning of risk can be defined from another perspective as deviation from trends or expectations, which can cause losses. Therefore, it can be said that the risk is the occurrence of something that is uncertain and unexpected and gives negative results, but if it is dealt with correctly and systematically, it can give positive effects and not cause loss to the works [3]. The initial stages of any project have a higher level of risk than the rest of the stages, due to the high level of uncertainty. And when the risk is not identified and addressed in the initial stages of the project, this affects the subsequent phases and creates other risks with multiple effects, and as a result, the proactive steps for managing risks since the start of the project become very important, especially concerning making wise and correct decisions resulting from the correct methodology and application of systems for risk management, which results in good project management as specified and does not cause harm to all partners and shareholders [4].

During the planning and implementation phases of the project, risk management can have an important role in making critical and accurate decisions that reflect positively on the project and to make the status clearer through the preparation of an integrated approach to potential risks [5].

2.1 Risk

There are several definitions of risk presented by the authors, the most important is the possibility of financial loss and reputation or lack of economic profit, which result from participation in construction work. also, can classified risk as a loss exposure only. The Project Management Institute has defined risk as an uncertain event,

meaning that it can cause negative or positive impacts on the project lifecycle (impact on costs, quality, time, reputation, etc.).

In the construction industry, risks are inherent in various forms within every project, and project objectives can be adversely affected as a result of these risks. But on the other hand, these risks can be opportunities with positive impacts. The construction industry is currently the main driver of national economic development, social welfare and development of countries. Because it contributes significantly to creating and providing job opportunities in the job market and includes several different specializations such as consultants, engineers, technicians, accountants and workers. With regard to urban development, it contributes to the preparation of feasibility studies, construction and maintenance services, cost estimates, theoretical designs and cities expansion. From the foregoing, it can be agreed that in order to reduce the uncertainty rate to the maximum extent in construction projects, it is necessary to provide increased attention and specialized research in the field of construction industry. Depending on the different circumstances of the project, the scopes and concepts of uncertainty can vary in each project, and several tools and processes can be used to control the uncertainty events. Undefined and unclear objectives in the project, as well as inappropriate design, project restrictions, vague contracts, and any other unknown matters can be a direct cause of uncertain in the scope of the project. Through this, risks can be defined as uncertainties that translate into danger and cause unexpected events at a rate of less than 100 % [6].

During the risk management process, the approach can be proactive if there is a management of risks before they occur, and on the other hand, if the management is done after the occurrence of the risk, it is a reactive approach. Risk management can be expressed as joint or collaborative efforts to achieve project objectives by conducting some operations to control risks. Also, risk management does not mean that it is possible to control or avoid all risks in the project, but it can identify potential events and reduce the possibilities of their occurrence and their effects. Always, important and appropriate decisions affecting the project must be taken by the construction parties, so the need to take an informed decision requires highly efficient risk management, hence the importance of risk management in the project. Real and clear information, even if it includes some uncertainty, helps to take the necessary decisions, and take proactive steps to confront the risk. (Table 1) shows the risk classifications.

Table 1. Risk Classifications

	Risk Type	Description
1	Known Risk	This type of risk can be identified during the project planning process, meaning that it is known, and it can also be identified during the implementation process but before it occurs. Several types that can be identified during the planning process may relate to the contract, the requirements and needs of customers and external risks. certainly, it is not always possible to predict potential risks for a variety of reasons that may include (lack of information, quality of information, lack of experience, methodology, internal factors of the institution or company, changes unexpected...etc.).
2	Unknown Risk	There are types of risks that cannot be detected during the planning or implementation processes and cannot be managed proactively because of the lack of identification before they occur, and this is what is known as unknown risks.
3	The New Risk or Discovered Risk	During the risk control process, new types of risks can be discovered before they occur, which are called new or discovered risks.
4	Secondary Risk	During the risk response process, other secondary risks can occur that can be identified and controlled.
5	Residual Risk	During the risk management process, some risks that have little impact on the project can be identified and that can be accepted, and they are called residual risks.

The construction industry faces many common risks such as (economic, financial, political, environmental, contractual, legal, technical, commitments with partners, planning, design, scheduling, safety, logistics, labor, stakeholders, supply, force majeure, etc.).

2.2 Risk management

The process of making the right decision to systematically identify, categorize, manage and control risks is called risk management, which helps the project team to face risks and reduce opportunities for loss, and thus can be considered a planned, structured and systematic process. The direct and main objective of the risk management process is to analyze the benefit and cost and come up with the best value for the project in terms of quality, time and cost by comparing and balancing the risk management processes and the benefits resulting from it [7]. Risk management can be defined as “The proactive attempts aimed to identifying the internal and external events that may affect the success of a project” [8].

Risk management must be implemented in any project from the early stages, during the feasibility design and setting objectives and plans, and therefore it is considered a continuous process from start to finish for the purpose of achieving its required objectives. The construction industry faces several obstacles and problems that can cause delays in the time of completion as well as at the level of cost, quality and reputation, and it can come from sources of uncertainty resulting from (contractual relationships, construction parties, availability of resources, etc.). The completion of the project on time and within the required quality standards and the specified cost are all factors that determine the measure of the success of the project. These objectives are interconnected with each other, and if any factor is affected by them, it can be reflected in the rest of the factors. Here the importance of risk management in the project emerges and becomes a major part of its parts, as by identifying and addressing potential and unpotential risks, there can be an accurate estimate of the cost and no significant deviation from the project budget, as well as adherence to the time schedule for delivery.

Risks can be taken advantage of as opportunities, as well as identifying problems before they occur, and this is the purpose of risk management, and proactive processes (mitigating risks before they occur) are less costly and less effort compared to risks that have already started and need a reaction. Risks that are not managed well can lead to project failure or prevent easy achievement of objectives [9].

In construction project management, risk management has become a key feature because this type of project are full of uncertainty, complex, unique and dynamic, and therefore risks can stem from multiple sources and their consequences are severe if not addressed directly. In a construction project, organizations or individuals may have their interests affected negatively or positively depending on the path of the project from start to finish. Also, the different interests and expectations of stakeholders and project contributors who have diverse experiences and skills can create problems during the implementation process due to overlapping decisions. Many construction companies did not think well into the concept of risk management, because if the risks were identified in advance and given priority in dealing, they could be easily and inexpensively controlled, according to the good organized and mechanism methods. Customers, consultants, contractors and suppliers can benefit from risk management plans to achieve objectives and reduce negative effects and control on the quality, time and cost, and the success of the project is closely related to these three factors.

2.2.1 Risk management process

The process of identifying, analyzing, treating and reducing risks in construction projects is called construction risk management, which leads to the achievement of the project objectives without or with minimal losses possible. In order to achieve the excellent and proper implementation of any project, steps must be taken to manage risks and deal with risk as an important and influential event. Therefore, in the process of construction, risk management systems cannot be ignored whatsoever. The risk management process in construction projects can provide several benefits and advantages such as (reducing cost, increasing value, achieving required objectives, reducing uncertainty, and most importantly, the reliability of shareholders). Determining the undesirable and negatively impacting events of the project (such as cost and time) is the main objective of the risk management process, through which the resulting damages can be reduced or stopped [10]. In general, risk management methodologies and applications are not adopted in many companies, and through long- term researches, it was found that the experience and intuition are those who deal with risks in projects instead of a department specialized in that. To determine options and steps to reduce risks, certain steps are taken and

sequenced during the life of the project, which is considered a risk management system [2]. To improve decision making, risk management processes consist of sequential steps that are performed regularly throughout the project life cycle. These steps attempt to measure unknown events and identify risk mitigation options. Successful risk management includes early identification, analysis, correcting and early implementation of procedures, monitoring, reanalysis, risk assessment, communication, coordination and documentation [10]. These steps show in (Figure 1).

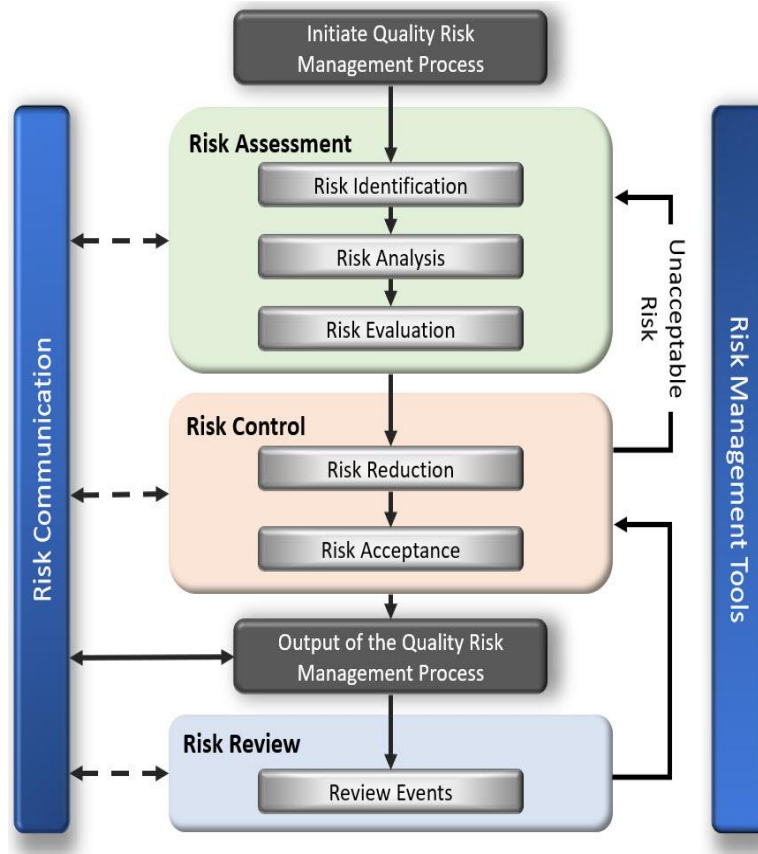


Figure 1. Risk Management process [10]

It is necessary to apply different techniques and methods for the purpose of searching for risks and trying to find them to avoid the effects that may occur on the project. Also, the project team must be completely aware with the methods used and have the ability to apply it correctly, to ensure the effectiveness identifying of the risk. The first step in risk management is the effective identification of risks.

Step 1: Risk Identification

The determining of events that will positively affect (opportunities) or negatively affect (risks) on the project's objectives are the first step in risk management.:

- Project Milestones.
- Financial path of the project.
- Scope of the project .

It can be defined as the activity or effectiveness that examines and checks all components of the program to identify the future reasons associated with it, documenting and preparing the stage to start managing the risk, in successful programs the activity begins to identify the risks from the beginning or before it is occurrence and continue throughout the program. Therefore, higher amounts of contingency are allocated by contractors to face the risks that can effect on the design, procurement, and construction of buildings [7]. As illustrated in (Figure 2), initially, focused on the risks that can affect to whole project, rather than focusing on a specific part of the project.

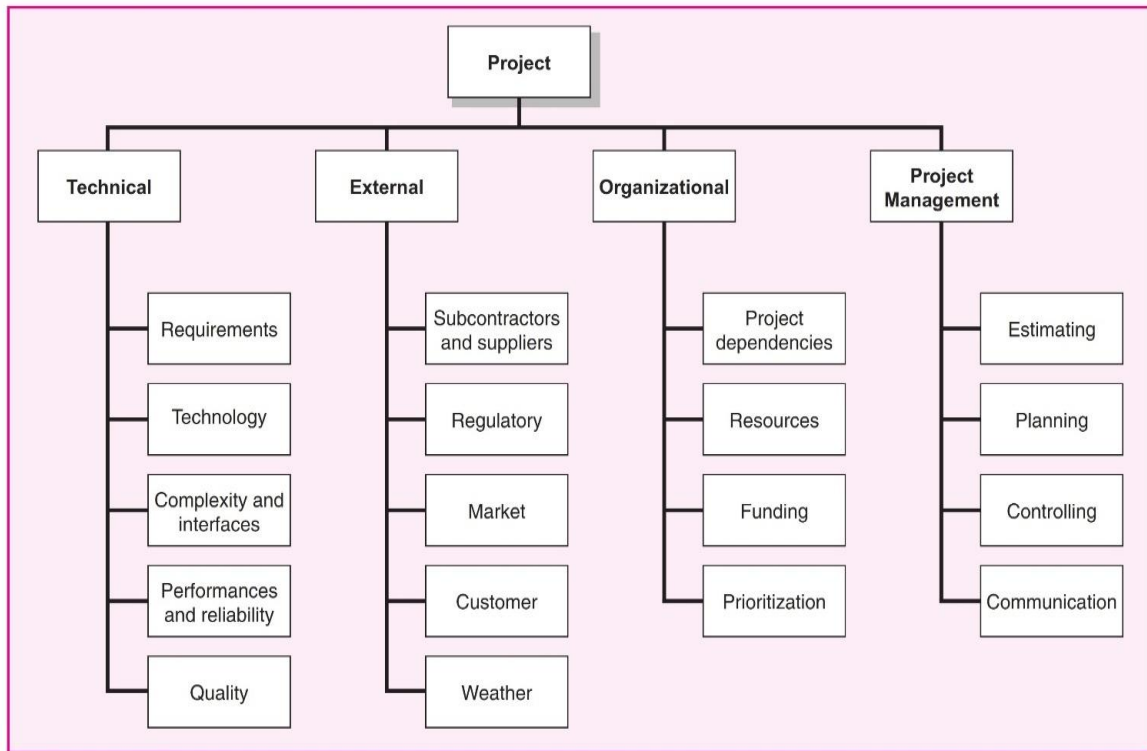


Figure 2. The Risk Breakdown Structure (RBS) [8]

Step 2: Risk Analysis or Assessment

Literatures of risk management defined the risk analysis is the process that identifies and analyses incidents which can give a negative impact on project. Project risk analysts work alongside with specialists in the forecast to minimize future negative impacts which are unexpected. Potential errors must be identified by the risk analyst. After this stage, negative events can be assessed against the probability scale to measure the occurrence probability of the event. The extent of impact that occurs when the event occurs is assessed by risk analysis [11].

To assess risks and identify opportunities, two important and necessary types of comprehensive risk assessment are quantitative and qualitative [10]. Quantitative evaluation focuses on analyzing the financial effects of the event or its financial benefit, while qualitative evaluation analyzes the level of importance depending on the probability and impact of the event. In ref. [8] it was determined the difference between quantitative and qualitative risk analysis as shown in (Table 2).

Table 2. Difference between Quantitative and Qualitative Risk Analysis

Perform Qualitative Risk Analysis	Perform Quantitative Risk Analysis
Conducts a qualitative risk analysis in the whole project processes.	Quantitative analysis identifies just the risks which are marked and have high effect on the project.
This type does not use the mathematical methods to analyses the risks and identify the probability, but using the expert’s judgment.	To characterize the risk probability and impact, it is using the distributions of probability, and use (the model of project, mathematical and simulation methods) to find the impact and probability of risk.
Using the numeric ranking of probability and impact, the risk is evaluated individually, where the numerical scale is used from 0 to 1. 1 has a high impact.	Here the potential results of the project can be expected with respect to time and cost. Can also know the probability of reaching objectives to achieve the required level of performance.

This method is applied in most projects	This method is sometimes not applied to many projects, whether complex or simple.
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Step 3: Risk Evaluation

To help make risk treatment decisions, a risk evaluation process is used. The expected risks are compared against the identified risks for the purpose of determining the significance of these risks [7].

Step 4: Risk Treatment & Control

Through the risk management process, it is possible to identify undesirable events and determine their effects on the project, in addition to identifying procedures that stop these risks or reduce their negative effects. Through the final phase of risk management procedures, the risk control strategy is used, it is developing appropriate procedures to minimize the effects of the undesired risk, to ensure smooth realization of the project, risk can be avoided, transferred or mitigated, etc... [3]. It is necessary to define and develop the treatment plan in order to address the risks, and this comes through identifying the appropriate strategies for developing. It can be preventive measures to reduce the possibility of risk, or mitigating measures to reduce the impact of the risk. One of the most important objectives of the treatment process is to increase the likelihood of obtaining opportunities as well as increasing the benefit from them. The strategy used for the purpose of the response can be determined depending on the opportunity or the nature of the risks.

The following 7 strategies are possible as shown in (Figure 3).



Figure 3. The 7th Risk response strategies [12]

Step 5: Risk Reviews

Regular and periodic reviews of project risks, as well as rapid responses to those risks, are called the process of risk reviews. For further revisions in the future, these responses should be documented for use during subsequent treatments. The risks are reviewed to identify new risks that may arise in the project, as well as to evaluate the current treatments and their results, and to identify the problems arising from those risks, in addition to closing the old risks or those that have been treated. These operations are scheduling in the project documents (project risk management documents) for the purpose of studying all risks and their response to treatment, and comparing the effects resulting from individual and total risks in the project [7].

2.2.2 Risk management in the Malaysian construction industry

One of the most important factors for the success of the project in the construction industry is risk management, and the project can be affected by several types of risks (financial, technical, commercial, political, social, natural) [10]. In the construction industry, risk management possesses several benefits and advantages as follows:

- Objectives attainment
- Shareholders reliability

- Reduction of capital cost
- Uncertainty decreasing
- Value increasing

In order to identify the potential impacts of risks, enhance positive certainty and reduce the effects of negative uncertainty, a series of risk management processes or activities are used that in turn identify, analyses and interact with project risks. When we compare the higher developed countries with other less developed countries, we find that the application of risk management is widespread and effective. Economically, Malaysia ranks 35th in the world, after Indonesia and Thailand in the economies of Southeast Asia. That can be affected by social, technology, economics, politics and environmental risks, so the risk management in projects is not considered a fixed approach that can be adopted and that needs to be developed and continuous research [13].

One of the most important obligations of the Malaysian government is the development of the national economy. To ensure the success of Vision 2020 presented by the Prime Minister of Malaysia (Tun Dr. Mahathir bin Mohammed), various plans and transformations should be implemented. Dr. Mahathir's most important ambitions is for Malaysia to become by 2020, a fully developed country, and for the government's orientations to focus on developing [14]. In the vision of 2020, the main objective is to transform Malaysia from a developing country to a developed country, and this industry has not yet reached its objective, because the specific target for this industry is to contribute 6% of the annual GDP growth rate. One of the most important challenges facing this growth is the risks that impede the progress of construction projects in terms of (quality of work, delivery time, availability of financial support), and the relationship between (owner, contractor, consultant and customer) [15].

The Malaysian construction industry has an important and decisive role in development and is considered a major productive sector, due to the remarkable contribution to the increase in the gross domestic product during the past decades.

Improving project performance comes from good risk management, which is an essential and important exercise in creating value for the project. By achieving these necessary measures to manage risks, the success or failure rates of the project can be determined by measuring the factors of quality, cost and time. Unfortunately, this industry in Malaysia suffers from a clear weakness in its performance, which affects the achievement of project objectives related to quality, cost and time. The weak implementation of the systematic and effective practice of risk management in Malaysia results from poor communication with risk management practices in construction projects, as well as a lack of knowledge [16].

Poor performance in projects is a common situation in the world and not only in Malaysia, and this great risk must be viewed as a critical issue that must receive sufficient attention to be addressed. Ineffective management is the cause of major failures within projects in Malaysia. One of the most important reasons is also the failure to implement risk management during the project life cycle, in addition to making decisions without referring to the risk register. As mentioned earlier, lack of knowledge of risk management practices is one of the most important barriers to good and effective implementation of risk management in Malaysia [16].

Many recent evidence showed that the process of developing risk management in construction companies in Malaysia is still in its early stages, and many risk problems that affected and hindered the smooth project operations were counted. In order to reduce the risk permeating the productivity of Malaysian construction, the need to conduct extensive and specialized studies for risk management in this industry is evident. Compared to other industries, construction companies are considered the most vulnerable to many risks, and starting to implement risk management applications systematically helps greatly to improve project conditions. The unique features of the construction industry are the most important causes of risks in those projects, which can result from (long project durations, financial intensity, rather complex operations, dynamic and organizational matters of the project, environmental constraints and the relationship with investors, stakeholders and customers) [4].

Compared with other industries and fields of work, the sector most exposed to risks is the construction industry, especially companies. Designers, implementers, contractors and consultants can be considered as the main players affecting the project negatively or positively and this can reflect on the reputation, quality, time, cost and obligations. Construction projects have several important and unique features, including (long implementation period, financial density, complex operations, dynamic organizational structures, and legal,

environmental, social constraints) that may affect the project if it is not well managed and this is what has been observed in many projects in Malaysia [17].

2.2.3 Recent critical literary review on risk management in the Malaysian Construction Industry

Recent literature related to risk management in the Malaysian construction industry has clarified many gaps in this industry with regard to quality and risk management, which requires a review of management and performance and the development of correct rules and modern concepts to overcome those risks. (Table 3) summarizes those problems during the past five years.

Table 3. Risk management problems in the Malaysian Construction Industry

No.	Author	Year	Title	Source	Findings
1	Nurul Ain Syafiqah, S. [14]	2018	Impacts of poor management on construction project in Malaysia	Faculty of Civil Engineering and Earth Resources, University Malaysia Pahang.	- Poor project management is the main factor contributing to the illness and delay of many projects in Malaysia. Also, many issues related to underperformance in construction projects are no longer acceptable, such as cost overruns, delays and low quality. These problems will continue to affect the industry and the quality of the project in general due to the lack of required efforts and the failure to identify the root causes of their occurrence.
2	Bakhary, Nor Azmi, et al. [18]	2018	Construction claims problems in Malaysia: from the contractor's perspective	The 4 th International Conference on Engineering, Applied Sciences and Technology (ICEAST 2018)	- Many of the critical problems that are related to claims management are caused by the lack of awareness of the employees on the site and the failure to identify the problems in a proactive manner, as well as the lack of relevant data and documents, in addition to the conflicts that occur during negotiations between the construction parties such as the owner, contractor and shareholders. This is found in almost every project.
3	Omer, Manal Suliman, et al. [17]	2019	Level of risk management practice in Malaysia construction industry from a knowledge-based perspective	Journal of Architecture, Planning & Construction Management	- The practices of risk management in the Malaysian construction industry are not systematically applied by contractors, owners and consultants, this ultimately leads to the emergence of a clear weakness in the project. - Risk management practices are not systematically applied properly in the Malaysian construction works by owners, consultants and contractors, and this leads to poor performance within the project. - Many constraints such as bad decisions by project managers and designers as well as human errors reflect negatively on the Malaysian construction industry which is known to be riddled with such constraints. Of course, this affects the project outputs and the project management functions. - Risk management practices within the Malaysian construction projects have a

No.	Author	Year	Title	Source	Findings
					<p>limited application, and the department of risk management has not been established or adopted by most companies as a basic department within the main project departments.</p> <ul style="list-style-type: none"> - To improving the performance of consultants, contractors and clients in the project, the need to adopt and use a knowledge-based approach is an urgent target.
4	Taofeeq, D. M., & Adeleke, A. Q. [19]	2019	Factor's Influencing Contractors Risk Attitude in the Malaysian Construction Industry.	Journal of Construction Business and Management	<ul style="list-style-type: none"> - The effects of capital, needs, the external environment and project-related factors are the most important risk situations experienced by contractors in Malaysian construction projects. - During discussions of government reports on improving performance within the Malaysian construction industry, the spotlight was shed on quality systems, productivity and poor performance.
5	Omer, Manal Suliman & Adeleke. [4]	2019	Systematic Critical Review of Risk Management in Malaysian Construction Companies	Journal of Humanities and Social Sciences (JHSSS)	<ul style="list-style-type: none"> - Few industries within Malaysia use appropriate risk management tools, while the Malaysian construction industry is considered undeveloped and still in its infancy. - Delays that caused losses to the developer, the customer and the entire construction industry were identified as the economy was affected. The delay rate in the completion of projects reached 45.9%. - The quality in Malaysian projects during the past decade was not up to expectations, and the impact was clear in terms of functionality and quality due to poor risk management. Where the budget was exceeded as well as the completion dates did not fulfill their promises. - The most important problems mentioned by the reports of the Construction Industry Development Board (CIDB) were related to (low quality, delay, low productivity, shortage of manpower, economic volatility, poor image and lack of information and data in Malaysia). - The risk management portfolio is almost unavailable in most of the current construction projects. - In order to bypass the lack of formalities in the risk management of the Malaysian construction industry, there is an urgent need to manage this file effectively, complete contractual obligations within a high-performance indicator.

No.	Author	Year	Title	Source	Findings
					- In practice, low and poor implementation of project risk management leads to failure to perform well, deviation from cost limits, and missed deadlines.
6	Yap, Jeffrey, et al. [20]	2019	Criticality of Construction Industry Problems in Developing Countries: Analysing Malaysian Projects	Journal of Management in Engineering	- In developing countries, the most important problems that cause risks within the construction industry are: (customer needs, cost overruns, changes in design during implementation, poor quality, late completion, late payment and competitive bidding procedures).
7	Yap, J.B.H. and Cheah, S.Y. [21]	2020	Key challenges faced by Chinese contractors in Malaysian construction industry: Empirical study	Journal of Engineering, Design and Technology	- The most important challenges facing the Malaysian construction industry are: (cost control, organization, quality control, risks and contract terms).
8	Moshood, Taofeeq, et al. [1]	2020	Ranking of human factors affecting contractors' risk attitudes in the Malaysian construction industry	Journal of Social Sciences & Humanities	- The risks that occur in construction projects during implementation in Malaysia are considered to have a greater impact and higher damage than the problems that appear in the economic sector.
9	Tze Quan, B. L. [22]	2022	Effects of poor communication in the construction industry in Klang valley, Malaysia	UKM Press	- One of the main reasons for the failure of the project is poor communication. This is evident in the poor performance of the Malaysian construction industry, which has long roots in poor communication.

2.3 Quality Function Deployment (QFD)

QFD was introduced in Japan 1960 and developed at Mitsubishi's Kobe Shipyard Kobe in 1972. In 1960, improving quality with quality control had a distinct manufacturing taste in 1960 and 1970, Joji Akao went with others to work on improving the design process in Japan, it was of High quality when new products were introduced to our factory. The design augmentation process was called QFD. From 1975 to 1995, this method has already been combined with other repair methods to provide opportunities for product developers. After the development of QFD in Japan, Akao and Kogure published "Public Implementation of Quality and Functions of CQWC in Japan, October 1983 Due to Quality Advancement, as QFD's Entry Mark to the United States [23].

There are many options available today for the average customers to choose from for specific products or services. Based on the concept of value or quality, most costumers determine their choices, and they always want to get a high value for the product they desire, which means the maximum benefit from money. From this point of view, institutions and organizations must maintain and develop their competitive capabilities and know what motivates the costumer's perception of quality or value in services and products. Customers' perceptions of value and quality should be taken care of by defining characteristics of products and services such as design,

reliability and performance. Successful organizations always try to integrate the design and manufacture of their products and services with the voice of the customer (VoC). Therefore, they focus on the value and quality in their products and services, which customers clearly perceive. In order to define the customers' needs and desires and turn them into specific products that satisfy the customers, companies use organized plans and processes that can meet the needs of customers. This tool or processes that are used are called Quality Function Deployment (QFD) [24].

Quality function deployment (QFD) it can be considered as the methodology that focuses and translates the customers' requirements and needs and transforms them into products or services that meet the aspirations of the customers. QFD is a robust methodology for identifying and capturing customer needs and relating them to designs and technical requirements. Production processes within QFD are scalable and flexible to achieve product requirements as well as identify areas for improvement [25].

In ref. [26], the quality function deployment (QFD) is defined as a technique used to identify and evaluate customer expectations and needs, and these expectations are reflected in product specifications. This technology is available in many industries. This technique has been resorted to in recent years for the purpose of using it in the construction industry.

Many benefits and advantages of QFD in institutions and companies can be determined, including:

- Reduce the time required for the product development process.
- Reducing the amount of variance during the preparation of engineering designs.
- Initial costs are low when the product is put on the market.
- Increasing the level of customer satisfaction and their conviction of the product that meets their desires.
- The ability to create the product is high.
- Creating a culture between the different units of the organization.
- Create a database and information about users and future applications.

2.3.1 Quality function deployment process

There are two main parts of the QFD process as follow:

Stage 1: Collecting the Customer Voice

It is important and necessary in business activities to understand the customer, and this seems even more important in construction projects because neglecting this can lead to the failure of the project. However, construction companies often do not understand their customers and focus on their own objectives. Project managers and construction companies generally have to understand the customer's point of view and what is important to them, and be more sensitive to their customers. For a deep and detailed analysis of customer needs, it is suggested to use the Quality Function Deployment (QFD) methodology [23]. Obtaining a Voice of the Customer (VoC) is the first and essential step in setting up a QFD. This information can be obtained from various sources such as (interviews, surveys, observation and focus groups). The confusion between functional requirements and the physical object is the most prominent characteristic of customer needs, which are often ambiguous. [27].

Stage 2: Construction of Quality House

A set of matrices are included in the QFD implementation, which is 4 matrices. Sometimes the QFD is referred to as the House of Quality and is considered the first matrix. HoQ's role is to translate customer requirements into design and technical requirements. Technical requirements can be divided into partial specifications in the second matrix, which appear in the third matrix in terms of process requirements. In the fourth and final matrix, quality specifications are defined. In the QFD process, the house of quality (HoQ) is the most important stage because it stems from the voice of the customer [27].

As we mentioned earlier, the HoQ is the main part, and it is a graphic matrix that includes 6 main divisions (the voice of the customer, standards, relationship, technical response, correlations and technical evaluation).

Through these divisions, comparisons with competitors who have similar projects or works can be identified, as well as descriptions of the relationships between the various elements. Cross-functional teams are assigned to analyze the QFD. These teams must communicate with stakeholders and customers for the purpose of obtaining the required data from management, customer and industry representatives [28].

(Figure 4) show the design of quality function deployment phases 1 to 4 fit the criteria and conditions [29].

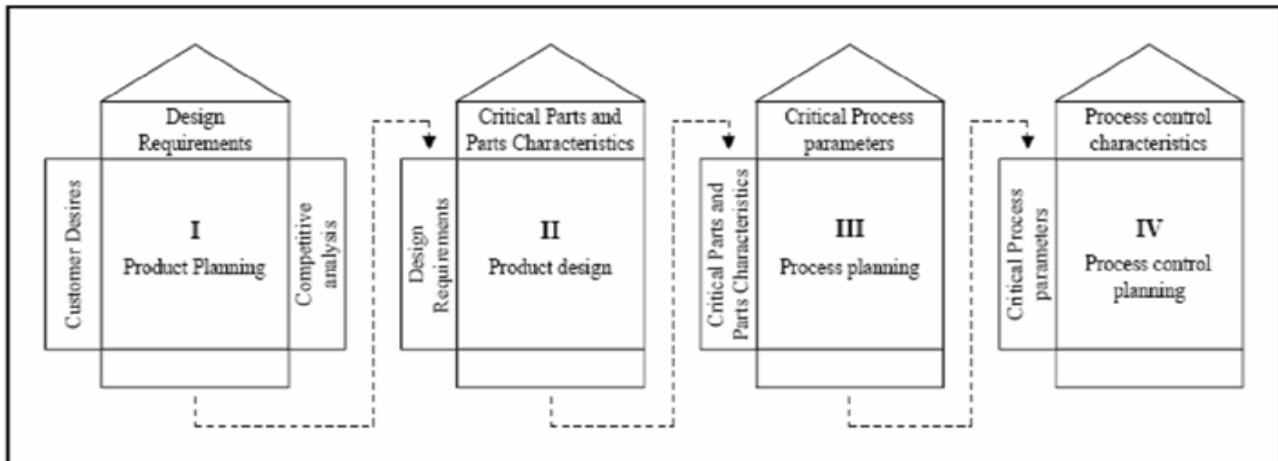


Figure 4. Phases of QFD process [29]

Commitment to resources, performance evaluation and timing are the most important ideas of QFD. The four phases of QFD are:

1. Phase 1 (Product Planning): This phase is concerned with building a house of quality. This stage is led by the marketing department, and many organizations have gone through this stage while implementing QFD processes. The quality of the data documented by this stage is related to (customer requirements, product measurement, competition opportunities, warranty data, the sizes of competitive products, and the technical and technical ability of the institution to absorb and meet the needs of customers). The quality of providing the information required from the customers is a measure of success for this stage.
2. Phase 2 (Product Design): The second stage is related to product design, which is carried out by specialists in the engineering department. The most important keys to success for this stage are the presence of a strong and integrated team that can work under various pressures, and possess innovative ideas and creativity.
3. Phase 3 (Process Planning): The third stage is related to process planning, which is managed by the department of manufacturing engineering. The target value is determined as a process parameter and the manufacturing process is carried out according to a flowchart depending on the value of target.
4. Phase 4 (Process Control): This stage is the last in which the production process is monitored, performance reviewed, maintenance schedules prepared, operators trained and their skills developed. It can be said that this stage is a measure of the implementation of the production process.

[30], explained if we want to follow the principle of (What, How), we can divide the stages of QFD as follows:

- 1- Consumer Needs (What): In the Quality Function Deployment (QFD) method analysis, the first step is to arrange the customer requirements matrix, Quadrant A which includes the customers' needs matrix.
- 2- Technical Descriptor (How's): This stage is the service stage, which shows the answers in the form of technical engineering (How's).
- 3- Developing the Relationship between the What's Matrix and the How's Matrix: In this stage, a relationship will be established between the two matrices (What's) and (How's). Where the question is a matrix (What's) and the answer is a matrix (How's).

- 4- Develop Relationships Between How's Matrix: The How's Matrix is alternative answers to What's questions.
- 5- Develop Prioritized Customer Requirements: This stage is responsible for determining the level of customer satisfaction. The objective of improvement should be clear and reach the objective easily by the company. The percentage of improvement can be determined by the value of the ratio of the specified or required objective to the level of customer satisfaction with the company's performance.
- 6- Develop Prioritized Technical Descriptors: This stage discusses the level of difficulties that the company faces while implementing certain policies to meet the requirements of customers. Policy implementation increases as the value of the technical response difficulty level increases.

The role of matrix diagrams is to help facilitate the improvement process as well as organize the data collected. To meet expectations arising from customer requirements, these diagrams can be used to display information about the rate of meeting expectations and the resources available to meet those expectations.

Figure 5 shows the parts of house of quality.

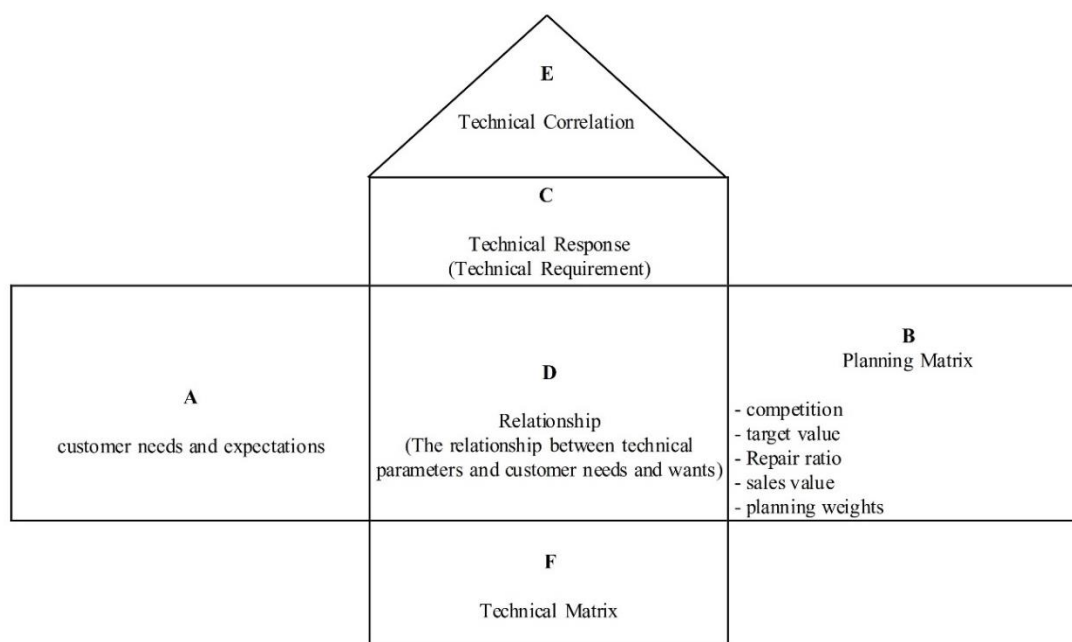


Figure 5. House of quality parts

The house of quality is in the form of a house and focuses on the needs of customers, during which the design and development processes are consistent with the customer's desire for new innovation in technology. This means the need to get more information and data from customers. In the development projects, the time of initial planning may be larger and longer, but this will later be reflected in the reduction of design time during the manufacturing process [25]. Determining objectives that are technical requirements shows the importance of the relationship between customer desire and technical information. This comes in order to ensure that the current product or service competes with similar products and services in the market and so that it can meet the needs and desires of customers. The correct selection of the information and data used is very important to obtain better results, because the results obtained in each section affect and overlap with the results of other sections. Another task of the QFD is to evaluate the results and compare them with the results of competitors to determine the purpose of the product.

After the process of identifying all the requirements, it should be assisted in making the trade-off decision and starting the operations by answering the design of the product that meets the required requirements [24]. [28], showed that linking design objectives to customers' desires and needs is the benefit of quality function deployment and its main objective is to satisfy consumers. In order to ensure the development of quality during the production process, the main points of quality are used. QFD is a way to ensure the quality of the design while the product is still in the design stage. Properly implementing QFD gives an important side benefit which

is the reduction of development time by half to a third. The three main objectives in implementing QFD can be described as follows:

- The spoken and unspoken needs and desires of customers are given priority.
- Requirements are translated into technical characteristics and specifications.
- By focusing on customer satisfaction, high quality services and products are provided.

2.3.2 QFD in construction industry

Recently, the construction industry has adopted customer-driven strategies. These strategies are sufficient to meet or exceed customer expectations, and are represented in providing high quality projects at a lower cost and committed to the deadline. This can be achieved more broadly by informing and accommodating the design teams with integrated information, this information can include the customer's initial data and knowledge of the information related to the design that the customers are want. One of the very important things to reach an improved design that can be implemented according to customer requirements and a high percentage of satisfaction is the effective and early sharing and utilizing the integrated information among the design team members [31].

One of the most important aspects in the real estate sector is the value provided to customers, and this is what companies in the construction industry have agreed upon. The term “value” means offering different things to different people, so companies explain the meaning of value to their customers in different ways. Construction projects are complex and this complexity is rapidly increasing, which means that designers within the construction industry need to develop a more comprehensive vision. This vision can be centered around (durability, constructability, energy efficiency, environmental impact, life cycle maintenance, and economic and social impact), as well as more traditional concerns such as (initial cost, structural integrity and aesthetics). The complexity of modern project design requires a more rational approach to the design phase, and the need to make decisions with comprehensive and fundamental effects on performance, appearance and costs.

Many industries use QFD technology for the purpose of evaluating customer expectations and thus this evaluating appears in the form of a specific design or product specification. Here, the importance of reflecting the requirements and needs of customers on the technical specifications of the company [26]. These advantages of this technique led to the start of its use in the construction industry.

In order to facilitate marketing decisions in construction projects, QFD can be adopted and implemented as a strategic tool to implement those decisions. Customer expectations are considered one of the most important factors that affect the financial objectives of the project, in addition to other factors related to the project management team and contractors. Delays can be effectively reduced and prioritized within the project when using QFD and considered as a long-term approach for all stakeholders in the construction industry [32].

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. 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 [33]. In [30], explained that communication in project teams can be improved through the use of QFD, which is reflected in the success of the project. One company found start-up costs 20-60% lower, design cycles 30-50% shorter, engineering changes reduced 30-50%, and warranty claims 20-50% lower when using QFD.

In general, the traditional approach of QFD is followed in construction projects with a few exceptions, this distinguishes technical solutions from customer requirements and translates them into components. Emphasis should be placed on functional and non-functional requirements as well as an urgent need to investigate the concept of QFD, especially the need for a functional approach within QFD that captures complex customer requirements in the construction industry. This will lead to an investigation of the organizational structure of quality recruitment requirements by integrating the different perspectives of stakeholders [32]. With the great importance of QFD, the previous and recent literature does not directly refer to its spread in the Malaysian construction industry, and we note that it is used more in the fields of food industries, various types of products, electronic products, quality management systems, plastic products...etc.

3. Relationship between risk management and quality function deployment

In general, engineering projects of all kinds (large and medium-sized) enjoy large investments and for long-term periods. It can interfere and be affected by many factors, these factors carry with them a large part of the uncertainty, and this effect extends over the duration of the project. The project cycles have risk effects starting from setting objectives and feasibility studies to the end of production stage, include (mistakes in investment decisions, delaying the construction period, poor planning and implementation, property damage, personal injuries, low investment returns, abnormal production and operation and last but not least other serious consequences) [34].

The concept of risk in recent years has widened to many areas of business management. Substantially born in the economic-financial and industrial safety sectors, today, risk management covers entire business and organization management fields. Lastly, in the latest edition of ISO 9001, the concept of enterprise risk has been introduced as a tool for the design and development of a management system. One of the most important sources of risk is the requirements and needs of customers. Therefore, to involve the customer sanctification in the design of the product and match it with technical requirements to provide a more reliable and better product, the QFD must be applied. In order to reach positive results related to the quality of the product, the risks arising from the customer's requirements and methods of controlling them must be taken into consideration and that comes from the integration between risk management and QFD [35].

Many companies, contractors and participants in the construction industry believe that QFD is used for industrial purposes only, and this is the main reason for its lack of use in the construction industry, and Malaysia is one of the countries where this belief is active. One of the most important aspects of QFD is collecting customer voice (VoC) by asking customers what they need in the service or product, and focusing on the principle "why" until the customer gives the same answer every time. The starting point of QFD is when clients express their requirements in their own language through interviews and surveys with potential clients [36]. Focusing on customer needs and requirements in implementing of QFD is better than using traditional tools and concepts such as (SWOT analysis, brainstorming, cause and effect diagrams in risk management, checklist, MCDM and FMEA) because the use of QFD ensures a customer-oriented approach to risk management.

The risk assessment methods are divided into quantitative analysis and qualitative analysis, through which the tool is applied individually to a single risk event, and each risk event is dealt with separately in its potential impact and probability of its occurrence. The bad thing about these methods is that they ignore a risk event whose impact can exceed the individual event. In traditional risk analysis, the effects on parallel schedule activities or subsequent activities are not included.

In order to evaluate the development risks of customer requirements, quality function deployment (QFD) is implemented by building multiple systems. A special approach should be designed to capture and measure subjective risk judgments and reconcile them with raw risk assessment data from specific designs while using the QFD application. QFD allows for an early evaluation between risk mitigation efforts and customer requirements before a specific functional basis for customer requirements and design solutions is adopted.

4. Results and discussions

The Malaysian construction industry is in constant growth despite the local and global challenges it faces. In 2021, the market size of Malaysia construction was \$27 billion. During 2023-2026, the market is planning to achieve an AAGR of more than 6%. In order to stimulate Malaysian economic growth within Malaysia's 12th plan for the period from 2021 to 2025, the Malaysian government announced in September 2021 a plan to establish a partnership between the public sector and the private sector to establishing a specialized mechanism to fund the infrastructure projects [15].

Therefore, the construction industry can be effect on:

1. Economic growth Human development.
2. Investment.
3. Increase in tourism.
4. Job opportunities & employment rate.

Through this economic growth resulting from the increase of projects in the construction industry, many problems related to risk management are sure to arise. The results show that there is still a large gap between the management of construction projects in Malaysia and the use of well-known methods of risk management, which means that there is a clear and significant lack of risk management application systems in the construction industry, this means that risk management is a completely new management concept and is applied within a standard Low done by traditional methods such as brainstorming, checklists and staff experience. The implementation of the risk management process in the Malaysian construction industry is still at a low level and the reputation is not good, and the Malaysian construction environment suffers from many problems and has not always been up to expectations. This is the result of several reasons, including (most companies did not establish departments dealing with risk management, lack of awareness and intuition among project staff and lack of specialists in this field, not all contracting companies set up their own risk management department, not making the necessary efforts to develop this concept in the both sectors (public and private), the method of searching for the root causes of risks is futile and traditional, the methodology used by contractors, owners and consultants is not clear).

The literature on quality function deployment (QFD) within construction management were reviewed in this paper. By reviewing this literature, it is clear that the QFD methodology is not widely used within construction projects for the purpose of making strategic decisions. This result within the construction industry is surprising due to the widespread use of the QFD methodology and success it in other industries. The wide using of QFD in areas other than the construction industry, means that this methodology has not been properly disseminated in the Malaysian construction industry, and there is not enough literature that addresses this problem and spreads sufficient awareness of its application.

The integration between the risk management tools and QFD leads to reducing risks and showing the project in a better position in terms of (time, cost, quality, reputation, reliability with customers). But at the same time, we note that this integration is limited to one or two tools, which requires the generation of more effective modern models.

5. Conclusion and recommendation

This study dealt with the research efforts during the past ten years related to the status of risk management in Malaysian construction industry and the rate of it using, in addition to QFD and trying to identify the gaps in them, and then presenting future suggestions for treatments. Given the importance of the construction industry in the Malaysian economy, this study is important for all stakeholders and contributors to the construction industry. In order to study the relationship between risk management and QFD, this study provides an important ground for researchers in this field. This study has not only academic dimensions, but is also important for project managers, engineers and contractors trying to manage and control the risks in the construction industry.

Previous literature, in addition to the research results, found that the Malaysian industry still needs a lot of effort to develop performance in terms of risk management, and that many companies and contractors are trying only to apply the minimum and traditional ones, due to the lack of an approved methodology or lack of awareness or financial reasons related to the cost of managing Risks, which can lose huge amounts of money if they are ignored and not applied in addition to the bad reputation and the time limit for completing the work.

Through the current study and determined the gaps and weaknesses in the Malaysian construction industry, it becomes clear that there is an urgent need to address many gaps and problems, which we recommend as follows:

- Establishing a regular department for risk management in each project and to be a major part of it, and consisting of specialized consultants and engineers with extensive experience in this field, or the use of consulting offices or companies that can manage this work perfectly.
- By implementing good and systematic practices for risk management in construction projects, contractors should reconsider their approach to risk management within their projects and companies, and they will be able to anticipate the occurrence and impact of adverse events that may affect the overall performance of projects.
- Enact laws and legislation that oblige companies and contractors to adopt the application of modern methodologies for risk management in their projects and the necessity of presenting risk management

practices in projects within periodic reports adopted by the competent authorities for the purpose of evaluating these practices and knowing the extent of their expansion or decrease.

- Project managers in particular and construction companies in general need to be more sensitive to customers, and understand what is important to them and how they think.
- The government should encourage the application of risk management in all construction projects within Malaysia, and one of the reasons for not applying modern risk management systems is the satisfaction of companies and contractors with the current system that is not financially costly, in addition to the unwillingness to change (resistance to change).
- Risk management processes need to integrate with a new function within the project to ensure obtaining high quality at the lowest time and lowest costs, and integration with QFD is a modern approach and needs more application to show the effectiveness of results and its impact on the project.
- In addition to traditional risk management tools, such as (probability-impact matrix, risk-return chart, decision trees, etc.), the QFD should be adopted and considered as a standard tool for risk assessment.
- Working on finding a new model that link risk management tools with customer needs and QFD.

References

- [1] Moshood, Taofeeq & Adeleke, A.Q. & Nawanir, Gusman & Mahmud, Fatimah. (2020). Ranking of human factors affecting contractors' risk attitudes in the Malaysian construction industry. *Social Sciences & Humanities Open*. 2. 1-17. 10.1016/j.ssaho.2020.100064.
- [2] Adam, B & Redzuan, Zukhairi & Fikri, Muhammad & Haron, Nuzul. (2019). A review of application of risk management in Malaysia construction industry. *IOP Conference Series: Earth and Environmental Science*. 357. 012030. 10.1088/1755-1315/357/1/012030.
- [3] Susanto, A., & Meiryani (2018). The Importance of Risk Management in An Organizations. *International Journal of Scientific & Technology Research*, 7, 103-107.
- [4] Omer, Manal Suliman and Adeleke, A.Q, Systematic Critical Review of Risk Management in Malaysian Construction Companies (September 30, 2019). *Journal of Humanities and Social Sciences Studies (JHSSS)* Vol. 1 Issue 5, P (60-70). Retrieved from <https://al-kindipublisher.com/index.php/jhsss/article/view/204>.
- [5] Fauzilah Salleh, Salani Palaniappan, Ivy Leong Pooi Theng, Huda Nasuha Mohd Helmi, Amira Abd Hamid, Nabihah Md Kassim (2020). A Review on Risk Management Implementation in the Construction Industry. *Journal of Critical Reviews, JCR*. 2020; 7(11): 562-567.
- [6] Baraka, Haytham. (2019). Risk in The Construction Industry. *Current Trends in Civil & Structural Engineering*. 2. 10.33552/CTCSE.2019.02.000541.
- [7] Srinivas, K. (2019). Process of Risk Management. 10.5772/intechopen.80804.
- [8] Clifford F G. and Erik W. L. (2018) Project management the managerial process. New York, NY McGraw-Hill Education.
- [9] The Standard for Risk Management in Portfolios, Programs, and Projects (2019).
- [10] Al Tekreeti Ahmed Muneer Abdulrahman, (2019). Risk Analysis and Control in Construction Industry (Residential Complexes in Iraq) (September 10, 2019). *International Journal of Civil Engineering and Technology* 10(7), 2019, pp. 153-161, Available at SSRN: <https://ssrn.com/abstract=3451007>.
- [11] Sinha, Tanmoy. (2019). Risk Assessment and Management. 10.13140/RG.2.2.13427.48160.
- [12] Marie BELGODERE, Jérémie CLAUSTRE, Capucine COMTE, Alioune DIALLO, Emmanuel LATGE, Jessy MIGNOT, Ingrid NGOBAY, Pierre PETILLON, Louann SUGDEN, Chris WAMAL (2021). The Risk Management Process:4 Essential Steps. 27 September 2021, article. <https://www.migso-pcubed.com/blog/pmo-project-delivery/four-step-risk-management-process/>.
- [13] (All Answers Ltd. (November 2018). Risk Management in the Construction Industry. Retrieved from: <https://ukdiss.com/litreview/implementation-of-risk-management-in-malaysia.php?vref=1>).

- [14] Nurul Ain Syafiqah, Sabri (2018) *Impacts of poor management on construction project in Malaysia*. Faculty of Civil Engineering and Earth Resources, Universiti Malaysia Pahang.
- [15] Dehdasht, G., Ferwati, M.S., Abidin, N.Z. and Oyedeji, M.O. (2022), "Trends of construction industry in Malaysia and its emerging challenges", *Journal of Financial Management of Property and Construction*, Vol. 27 No. 2, pp. 161-178. <https://doi.org/10.1108/JFMPC-08-2020-0054>.
- [16] Mazurina Mohd Ali & Sakinah Zahra Norman & Erlane K. Ghani* & Noor Hasniza Haron, 2018. "The Influence of Risk Management on Construction Project Performance: A Case Study," *The Journal of Social Sciences Research*, Academic Research Publishing Group, pages 936-942:5.
- [17] Omer, Manal Suliman and Adeleke, A. Q. and Lee, Chia Kuang (2019) *Level of risk management practice in Malaysia construction industry from a knowledge-based perspective*. *Journal of Architecture, Planning & Construction Management*, 9 (1). pp. 112-129.
- [18] Bakhary Nor Azmi, Adnan Hamimah, Ibrahim Azmi, (2018). Construction claim problems in Malaysia: from the contractors perspective. *MATEC Web Conf.* 192 02004 (2018). DOI: 10.1051/mateconf/201819202004
- [19] Taofeeq, D. M., & Adeleke, A. Q. (2019). Factor's Influencing Contractors Risk Attitude in the Malaysian Construction Industry. *Journal of Construction Business and Management*, 3(2), 59–67. <https://doi.org/10.15641/jcbm.3.2.668>
- [20] Yap, Jeffrey & Chow, Ian & Shavarebi, Kamran. (2019). Criticality of Construction Industry Problems in Developing Countries: Analyzing Malaysian Projects. *Journal of Management in Engineering*. 35. 04019020. 10.1061/(ASCE)ME.1943-5479.0000709.
- [21] Yap, J.B.H. and Cheah, S.Y. (2020), "Key challenges faced by Chinese contractors in Malaysian construction industry: Empirical study", *Journal of Engineering, Design and Technology*, Vol. 18 No. 3, pp. 705-726. <https://doi.org/10.1108/JEDT-05-2019-0124>.
- [22] Tze Quan, B. L. (2022). Effects of poor communication in the construction industry in Klang valley, Malaysia. UKM Press.
- [23] Ginting, Rosnani & Ishak, Aulia & Pitaloka, Dyah. (2020). Application of Quality Function Deployment (QFD) Method in Meeting Customer Satisfaction in the Bookshelf Industry. *IOP Conference Series: Materials Science and Engineering*. 1003. 012005. 10.1088/1757-899X/1003/1/012005.
- [24] Hsu, Chih-Hung, Ru-Yue Yu, An-Yuan Chang, Wan-Ling Liu, and An-Ching Sun. 2022. "Applying Integrated QFD-MCDM Approach to Strengthen Supply Chain Agility for Mitigating Sustainable Risks" *Mathematics* 10, no. 4: 552. <https://doi.org/10.3390/math10040552>.
- [25] Erdil, Nadiye Ozlem & Arani, Omid. (2018). Quality function deployment: more than a design tool. *International Journal of Quality and Service Sciences*. 11. 10.1108/IJQSS-02-2018-0008.
- [26] Wahjoedi, Tri. (2022). Improve customer satisfaction by quality functions deployment: Case in Indonesian SMEs. *World Journal of Advanced Research and Reviews*. 13. 700-709. 10.30574/wjarr.2022.13.1.0093.
- [27] Hamzah, Zulfadli & Purwati, Astri & Hamzah, Muhammad Luthfi. (2019). A Servqual and Quality Function Deployment (QFD) Approach in Measuring Total Quality Management at Private Universities in Pekanbaru, Riau, Indonesia. *Journal of Economic Info*. 6. 1-4. 10.31580/jei.v6i1.487.
- [28] Ishak, A., Ginting, R., Suwandira, B., & Fauzi Malik, A. (2020). Integration of Kano Model and Quality Function Deployment (QFD) to Improve Product Quality: A Literature Review. *IOP Conference Series: Materials Science and Engineering*, 1003.
- [29] Galetto, Maurizio & Franceschini, Fiorenzo & Maisano, Domenico & Mastrogiacomo, Luca. (2018). Engineering characteristics prioritisation in QFD using ordinal scales: A robustness analysis. *European J. of Industrial Engineering*. 12. 151. 10.1504/EJIE.2018.090617.
- [30] Dharma Suhada, Bambang Syairuddin (2020). Analysis of Customer Satisfaction in Construction Companies Using QFD Method. *IPTEK Journal of Proceedings Series No. (1) (2020)*, ISSN (2354-6026).
- [31] Yang, Yi & Wang, Shou Qing & Goh, Bee. (2022). adaptations of QFD for constructable designs within a concurrent construction environment: an information modelling approach

- [32] Gunduz, M. and Al-Naimi, N.H. (2022), "Construction projects delay mitigation using integrated balanced scorecard and quality function deployment", *Engineering, Construction and Architectural Management*, Vol. 29 No. 5, pp. 2073-2105. <https://doi.org/10.1108/ECAM-12-2020-1082>.
- [33] Haq, Saif. (2019). Impact of Safety and Quality Considerations of Housing Clients on the Construction Firms' Intention to Adopt Quality Function Deployment: A Case of Construction Sector.
- [34] Wang, Qinru & Yang, Qing & Chang, Mingxing. (2021). Project Clustering and Risk Monitoring based on QFD and MDM. 10.35199/dsm2021.5.
- [35] Albarami, Mohamed & Thiruchelvam, Sivadass & Saadi, Ahmmed. (2019). Factors Affecting Client's Involvement in Construction Projects. *Test Engineering and Management*. 81. 3802 – 3810.
- [36] Hari, Priya & Saleeshya, P.G. (2019). Integrating FMEA, QFD and Lean for Risk management in hospitals. *IOP Conference Series: Materials Science and Engineering*. 577. 012040. 10.1088/1757-899X/577/1/012040.