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Tracking Process and Benefit-Ability of Reflection Spectrum of TQM in Construction Industry

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Abstract

Total Quality Management is an important journey in developing the construction industries. Construction firms are working to achieve the aspirations of clients in terms of quality systems, and through adopting a total quality management tracking system, it contributes significantly to achieving the objectives of projects and aspirations of clients too. The primary objective of this research paper is to develop a tracking process for total quality management by identifying restrictions and a model of required actions to overcome these restrictions to ensure the successful implementation of TQM as a basic system in the construction industry. Therefore, the research is divided into two phases. The first phase included identifying and analyzing restrictions by using a questionnaire to survey 102 expert engineers in the construction industry and quality laboratories. The second phase involved developing the main hypothesis and analyzing required actions through analysis using the assumption of Kruskal-Wallis. The opinions of three groups of experts were also relied upon to complete this tracking phase. To evolve a tracking system that includes the actions that are coded in this research paper under (A-TQM). The proposed patch model carries the symbol (MPP) for tracking TQM and has been presented. The MPP consists of three figures that indicate the wheel of TQM, tracking of the required scope of TQM, and packages of scope to meet with TQM pillars.

Keywords: TQM; Tracking Process; Construction Industrial; Restrictions; Possible Actions.

1. Introduction

It is important for construction firms to have a basic strategy regarding the development of a quality management system, as comprehensive quality management is considered one of the most important of these strategies. The process of implementing Total Quality Management in the construction industry contributes effectively to increasing the competitive level of anyone from construction firms when the top management team has already adopted TQM as a major strategy for managing quality totally [1]. Client satisfaction is one of the most important objectives for construction companies in developing countries, as this objective enhances project performance and achieves the best construction outcomes that employers and owners of construction projects, whether government or private, aspire to [2, 3]. Therefore, construction firms of all sizes have begun to realize the importance of adopting a quality system that maximizes the benefits of their human resources while taking into account costs and improving the products and services provided to construction clients and other project stakeholders [4]. Therefore, construction companies have seriously

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begun to develop traditional quality systems that primarily include quality control procedures, material inspection and monitoring within the framework of quality control, and the transition to total quality management. By identifying weaknesses in their management systems and addressing gaps, construction companies are working to consolidate all their capabilities to continue in an evolving cycle of learning and continuous improvement in the quality journey of their construction projects.

2. Literature Reviews

Previous studies and literature surveys indicate that it is important to know the concept of total quality management as a part of developing the construction activities and outputs. A definition can be developed that gives a comprehensive idea of the terms of Total Quality Management [5]. Because Total Quality Management is an approach that is based primarily on theoretical and practical knowledge of quality, it can be said that Total Quality Management is a qualitative and revolutionary comprehensive approach to achieving the best outcomes [6]. The basis for clarifying the basic definition is through the three words that make up TQM: Total indicates that everyone (individuals of the organization at all its levels) is a basic pillar of the management approach [7]. Quality Everyone must meet the employers' requirements and achieve the best level [8]. Management: It is the application of the best management practices (as systematic) to achieve the best outputs in order to satisfy customers (employers) in the construction industry [9, 10].

Desiring to Apply Total Quality Management in Construction: Although the construction sector is an interconnected field in terms of resources, it is considered one of the most complex and convoluted unaligned sectors in terms of its operations [11]. The application of the best approaches related to Total Quality Management in construction organizations involves setting the standards and criteria that must be followed, and achieving goals in any construction activity, whether small or large [12]. The commitment stems from the desire of top management to implement the required standards that achieve the intended goals in the journey of following a TQM methodology. This desire should be reflected in focusing on creating best practices in terms of commitments that contribute to achieving optimal outcomes from applying the concept of Total Quality Management. This includes spreading awareness of the value of quality, maintaining accuracy in work, and making it a standard for providing services in construction projects in the best possible way, in order to meet the expectations of project owners and beneficiaries. In addition, it emphasizes the importance of teamwork, which is considered a fundamental basis in all construction projects, helping to reduce the gap among workers. All of these steps are part of instilling this desire, which all workers in the construction industry must adhere to.

Designating an Intelligible and Clear Path for Implementation of TQM: A strategic plan must be developed that ensures integration by paying attention to all stages of project implementation, including the development of quality and products in industrial plants such as concrete production plants, asphalt plants, iron production plants, and the services provided by consulting offices. This plan should also include a specific future vision and goals classified as short-, medium-, and long-term when applying total quality management in any administrative quality system within the construction sector. Additionally, the plan may identify the most important required stages and necessary steps to achieve these goals. On the other hand, it should develop a mechanism that supports the survival and continuity of companies operating in the construction sector through anticipation and prediction of future challenges. Therefore, strategic planning is considered one of the most important foundations on which total quality management is built across all industries, including construction [13]. The primary focus on the owners of construction projects and the main beneficiaries of these services is essential for achieving satisfaction and gaining their trust, as this becomes the true measure of success in the labor market. It also ensures the continuity of construction organizations at the highest level of competitiveness in the construction sector, while increasing competition through the application of the TQM cycle [14]. However, it is the employers and project owners who determine the quality of implementation and the achievement of its technical and engineering requirements, which are developed by a team of engineers and consultants during the project preparation stages. Thus, focusing on achieving the highest degree of satisfaction for all project beneficiaries, particularly the project owner, serves as a sufficient measure of the success of the implementing construction company, regardless of the complex operations the project undergoes and the efforts of the company’s staff. Ultimately, the primary goal of total quality management is to gain the trust of customers (the project owner or employer) by meeting their immediate and future needs and expectations, which can be measured through maintaining a high-level communication system with construction project owners on a regular basis [15].

Ambition to Achieve the Best Practices of TQM in the Construction and Building Process: The understanding of senior management in any construction organization, along with its genuine awareness of the importance of comprehensive quality, is demonstrated through the support and participation of workers. This contributes to establishing real and applicable principles by individuals within the development process [16]. Their ambition lies

in achieving internal benefits by raising awareness of quality, promoting its dissemination, and striving to satisfy customers in construction projects. In addition, fulfilling the ambitions of senior management requires creating a suitable and healthy work environment while urging and encouraging all engineers, consultants, and workers in the construction sector to participate in decision-making and to develop the best mechanisms for its implementation.

Focus on Competition in the Construction Industry [17, 18]: Certainly, companies operating in the construction industry must have a strategy that focuses on raising the level of competition. This depends on several factors:

i. **Communication:** Effective communication relies on the availability of sufficient information as a criterion for organizing interactions with all employees inside and outside the company in the construction industry. The communication system must be supported by human resources with strong capabilities in understanding and applying Total Quality Management (TQM), along with ensuring transparency in communication systems [19, 20].

ii. **Measurement and Analysis:** The ability to measure and analyze is considered an essential criterion for assessing the quality of projects and/or products in the construction industry [21, 22]. This requires adherence to accurate implementation schedules that comply with the employer's requirements for the construction project [23]. Measurement and analysis must be based on information collected through transparent information systems.

iii. **Application of Scientific Methods:** The ability of construction companies to apply scientific methods in decision-making and error prevention is vital. Since quality management is primarily based on preventive actions, avoiding errors before they occur significantly reduces costs. Preventing errors is far less costly than correcting them after they occur and contributes to ensuring implementation according to schedules approved by supervisory committees or resident engineering departments.

Therefore, Total Quality Management depends on applying the highest levels of continuous performance monitoring to minimize mistakes in later stages [24].

Distinguishing the Restrictions that Prevent the Application of TQM or Reduce the Chances of Obtaining the Best Outputs from Its Implementation in the Construction Industry: TQM is considered one of the most important management approaches adopted by many companies in the construction industry in industrially advanced countries within their management systems. While some companies succeed in establishing this culture across all levels of the organization, others may face failure in applying or sustaining the TQM approach. This failure can be attributed to several reasons, including obstacles such as insufficient funding, unclear management methodologies, and weak resources [25]. Knowledge, along with the commitment of senior management, is essential. When knowledge-based evaluation is weak, the output levels of construction projects may fail to meet benchmark standards [26]. Additionally, the methods of spreading a culture of quality may be inadequate, and the strategies for motivating employees may not effectively raise performance levels within institutions or at construction project sites. These factors often lead companies to refrain from adopting comprehensive management approaches based on total quality. Furthermore, a lack of focus on training and improving the performance of workers contributes to diminishing quality levels in construction projects. Similarly, insufficient investment in technological advancements negatively impacts performance, particularly in ensuring continuous development.

3. Theoretical Framework of the Research

In this section, the theoretical framework of the research is summarized based on a review of previous studies and surveys derived from the literature. Emphasis is placed on the importance of examining the foundations and principles of applying quality in construction projects in developing countries, as well as identifying the factors that have a negative impact. This enables experts to propose possible solutions to these challenges, thereby contributing to the improvement of quality management systems in construction firms.

3.1. Highlighting of Major Restricts

To highlight the restrictions that negatively impact the journey of TQM implementation in the construction industry, a survey was conducted based on previous studies and interviews with experienced Iraqi engineers. The results are presented in Table 1, which contains 20 restrictions in detail. These targeted factors (restrictions) were later described in the questionnaire in clear terms, with each restriction encompassing more than one dimension under the same umbrella of influence. A set of these factors is summarized as restrictions and reflected as challenges associated with applying TQM in the construction industry in developing countries [27].

Table 1. Highlighting of the major restrictions from the survey of previous studies which making negative impact on TQM in construction industrial

No.	Restricts in Details	In term of Ref.
1	Insufficient understanding of the concept of Total Quality Management.	[27-32]
2	Insufficient understanding of the objectives of TQM.	[17, 24, 27, 32-34]
3	Weakness in the deployment concept of TQM among workers in the construction industry.	[16, 17, 23, 24, 28-31, 35, 36]
4	Weakness - Commitment and support of the top management	[16, 17, 23, 24, 29, 31, 33, 35, 36]
5	Concerns about -High initial costs and fund allocation for adopting a TQM as major quality approach in the construction industry.	[19-21, 23, 24, 27-29, 32, 35, 37-40]
6	Negative impact of environment in the construction industry	[16, 17, 24, 28, 29, 31, 35, 36];
7	Concerns about Nature, laws, routine and regulation related with construction sectors.	[16, 23, 28, 29, 35, 36, 38, 41]
8	Misunderstanding of the economic analysis and competitions aspects.	[10, 22, 24, 28, 29, 36, 38]
9	Weakness in the level of commitment from top management	[24, 28, 31 32, 35, 36]
10	Lack in professional training and lack of sufficient experience.	[17, 24, 28, 29, 31, 35, 36
11	Ineffective organizational structural for construction firms.	[20, 21, 24, 28, 29, 36, 38, 41, 42];
12	Weakness adopting of the measuring & analysis in construction projects.	[20, 21, 23, 24, 28, 29, 35, 36]
13	Non-adopting well-communication methods to ensure the success of the project through the organization's application of QM-system.	[17, 20, 21, 24, 28, 29, 33, 35, 36, 42]
14	unaffected via unadapting of advanced technology and artificial intelligence	[17, 24, 28, 29, 31, 35, 36]
15	Insistence on getting traditional quality procedures of quality control, inspection, testing in construction sector.	[24, 27-29, 36, 42, 43]
16	Weakness on focusing of raising the satisfy clients level	[18, 19, 23, 29-31, 35, 36]
17	Non-adoption of mechanisms that contribute to the continued improvement of competition for projects in a fair manner.	[18, 24, 28, 29, 33, 36, 37, 42]
18	infirmity of assigning the required resources	[24, 29, 31, 35, 36, 44]
19	weakness of interest of partners (subcontractors and suppliers) in implementing of TQM	[24, 29, 33, 36, 42, 44-46]
20	Assigning the required resources	[10, 18, 20, 21, 29, 38, 40, 44-46]

3.2. Problem Statements of the Research

The problem framework was identified from the dimensions that represent the importance of reviewing the scientific literature related to the concepts of Total Quality Management and knowing the gap that construction companies suffer from in the process of applying Total Quality Management in construction projects in developing countries, including Iraq. The following points summarize the dimensions of the problem statements:

- To achieve the theoretical framework as part of analysis aspects of the research by identifying and analyzing the factors and identifying the solutions necessary to implement the requirements of TQM.
- Increased investment in quality and improved implementation of TQM requirements should be made a core policy for construction companies in developing countries. Especially when providing investment budgets that are spent annually on construction projects and infrastructure development, as is the case in Iraq, where the operating budget is available for these construction activities and service projects.
- Identifying appropriate mechanisms that facilitate the implementation of Total Quality Management and enhance the level of commitment of top management in companies and engineers. Expert opinions can be utilized and cumulatively compiled, leveraging technological developments to provide reference solutions for engineers working in the construction sector.

4. Research Methodology

The research focused on many aspects that are considered the basic methodology for reaching the best research outputs [38, 41]. The first steps of the research were to focus on previous research and studies in order to identify a group of challenges that may hinder the application of TQM in construction projects. So the following points refers to major steps of this study:

- Conducting a literature reviews of previous studies and relevant references to obtain a comprehensive definition of TQM and identify the basic pillars of TQM as well as conducting interviews with consultant and experts to get final list of the factors (restrictions) influencing its application in the construction industry.
- After identifying the influencing factors that were called restrictions and linking them to the nature of effective measures namely (Actions) that contribute to overcoming these restrictions.

- Distributing questionnaires (in term of closed) in two stages: the first to determine which restrictions most affect quality implementation, and the second to distribute and analyze the questionnaire on procedures to expert groups.
- Complete the analysis of restrictions as well as required actions.
- Arrange the results in the form of tables and links and figures that illustrate the tracking of TQM.
- Making final conclusions of the study.

The following Figure 1 refers to flowchart of frame of the methodology:

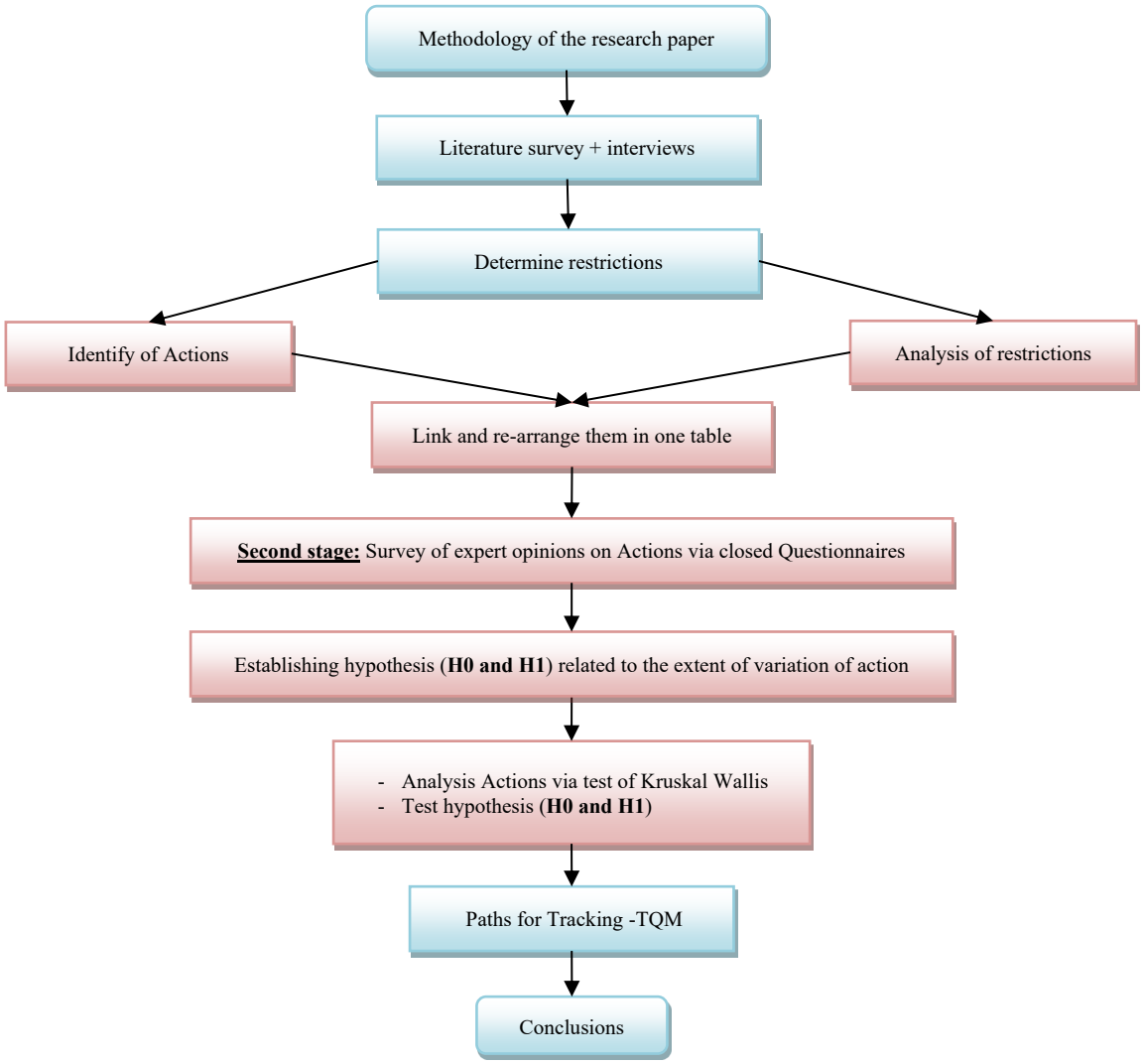


Figure 1. Flowchart of the research methodology

4.1. Design of the Questionnaires

The questionnaire was designed to be clear enough to be distributed to experts and specialists in the construction industry and those who have wide experiences in the field of construction and specialize in quality aspects in construction projects firms. The questionnaire was designed to be easy to understand, clear, and organized in language to help achieve the best results from this study.

4.2. Identifying of Main Restrictions

In this section, the set of restrictions that hinder the implementation of TQM or may obstruct its continued application were identified. The methodology used to determine these restrictions was based on previous studies and the opinions of experts in the field. A general code (R-TQM) *ni* was assigned to each restriction to facilitate follow-up and research organization, where **R** refers to "restriction" and *ni* refers to the number of the targeted restriction. For example, restriction number one is indicated as (R-TQM) 1. Table 2 includes the final list of these targeted restrictions, ranging from (R-TQM) 1 to (R-TQM) 21, in the sequence presented in the table.

Table 2. Illustrate the identified main restrictions which making negative impact on TQM in construction industrial

Symbol or code	Restrictions affecting the adoption of the TQM in construction industries under code (R-TQM)n
(R-TQM) 1	Restrictions related with Insufficient understanding of the concept of Total Quality Management.
(R-TQM) 2	A restriction related to the insufficient understanding of the objectives of TQM.
(R-TQM) 3	A restriction related to the weakness of the comprehensive vision of the benefits of implementing TQM in organizations operating in the construction industry.
(R-TQM) 4	A restriction related to the weakness in the deployment concept of TQM among workers in the construction industry.
(R-TQM) 5	A Restrictions related to commitment and support of the top management
(R-TQM) 6	Restriction- high initial costs and fund allocation for adopting a Total Quality Management approach in the construction industry
(R-TQM) 7	A restriction related to the work environment in the construction industry within companies and on the construction project site
(R-TQM) 8	A restriction related to laws, routine and regulation related with construction sectors.
(R-TQM) 9	A restriction related to the misunderstanding of the economic and bids competitions aspects due to contractors concerns about the cost related with quality.
(R-TQM) 10	A restriction related to weak commitment from top management in adoption of quality system and management sites of construction project.
(R-TQM) 11	A restriction related lack in professional training and lack of sufficient experience
(R-TQM) 12	A restriction related to the lack of time frame for following up on the implementation of TQM.
(R-TQM) 13	A restriction related to ineffective organizational structural for construction companies.
(R-TQM) 14	A restriction related to the weakness adopting of the measuring & analysis in construction projects.
(R-TQM) 15	The restriction is related to non-adopting effective communication methods to ensure the success of the project through the organization's application of comprehensive quality management.
(R-TQM) 16	A restriction related to non-adoption of advanced technology software and artificial intelligence in the application of total quality management to develop project performance.
(R-TQM) 17	A restriction related to the insistence on getting the traditional quality procedures of quality control, inspection, testing in construction sector.
(R-TQM) 18	A restriction related to weakness on focusing of raising the level of performance to satisfy employers and beneficiaries of the construction project in particular.
(R-TQM) 19	A restriction related to the adoption of mechanisms that contribute to the continued improvement of competition for projects in a fair manner.
(R-TQM) 20	A restriction related infirmity of assigning the required resources in operations in construction companies and the operation of construction activities site of the project
(R-TQM) 21	Restrictions related to the weakness of interest of partners (subcontractors and suppliers) in implementing of TQM

5. Analysis of the Study

In this part of the research paper, the analysis process was divided into two main parts. The first stage involved analyzing and rearranging the restrictions and determining the rank of them within the level of influence of each restriction as a negative influencing factor. The second stage of the analysis focused on formulating research hypotheses and analyzing variance.

5.1. Analysis the Targeted Restrictions

As part of the study, it is necessary to determine the level of challenges (restrictions) that construction firms may face during the implementation of TQM. Therefore, 102 experienced engineers in the construction sector participated, and the questionnaire was designed based on identifying basic categories in the first section of the survey.

A) ***Analysis of the Structure of Participants:*** The background of the participants in the questionnaire was analyzed in relation to the structure of the study in the first section of the initial stage of the survey. The analysis included the following elements: age, education, number of years of experience (as part of the CV), as well as job and employment titles. Figures 2 to 5 provide sufficient details regarding these categories.

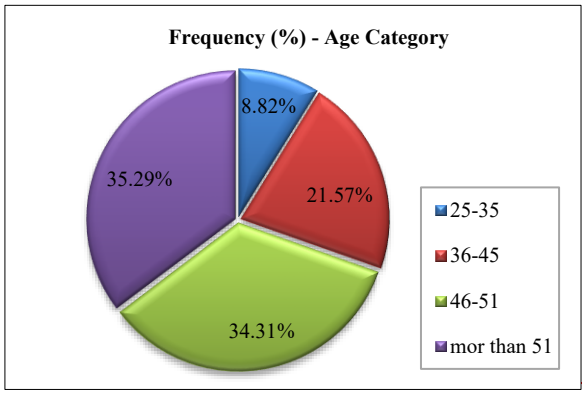


Figure 2. Frequency Age Category

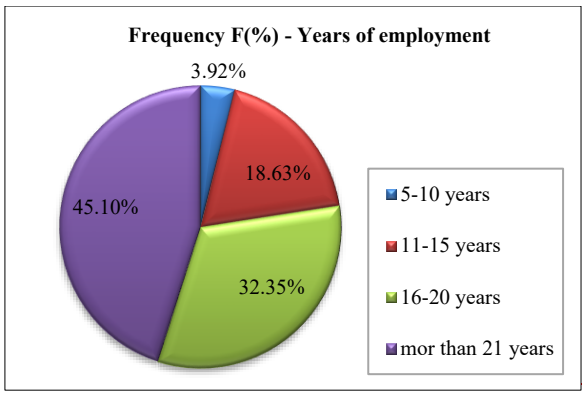


Figure 3. Frequency No. of employment years

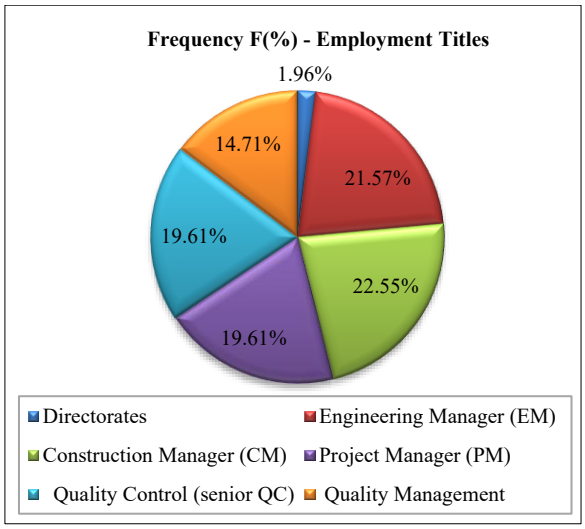


Figure 4. Frequency Employment background

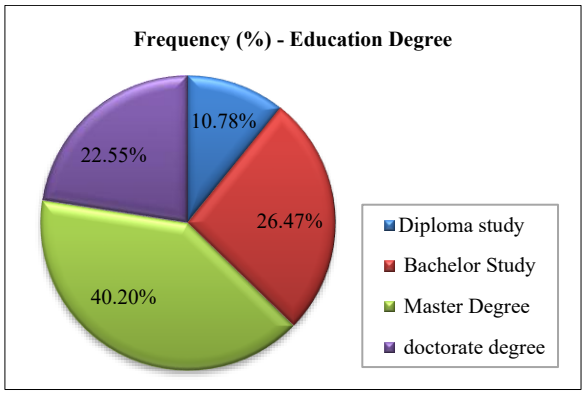


Figure 5. Frequency of Degree of Education

To gain a high level of knowledge about which restrictions have a greater negative impact on supporting the implementation of TQM in construction, the analysis process included 21 entries to calculate the value of the Relative Importance Index (RII). The standard scale used ranged from 1 to 5, following the Likert scale—the most common statistical tool [47]; to test the impact of each listed point. This scale was applied in analyzing responses in this field, resulting in a gradation of values from least to most influential, as follows:

1. No impact restriction (no influence);
2. Slight restriction;
3. Moderate restriction;
4. Normal restriction;
5. Extreme restriction, which indicates a high level of influence.

Accordingly, a restriction rated as 5 is considered to have the highest influence, while a rating of 1 indicates no impact. This evaluation was obtained from 102 participants. To test reliability, Cronbach's Alpha was calculated at 0.8701 for the 21 restriction items at this stage. The determination of arithmetic mean values and the Relative Importance Index was then carried out in this section of the research [37, 48], using the following formula:

$$\text{RII} = \sqrt{\frac{\sum Wi \times Xi}{A \times N}} \quad (1)$$

where *Wi* is indicates the weight assigned to the ith level of the scale of Likert, *Xi* is indicates the frequency of respondents who chose the ith level of the Likert scale, *A* is indicates the highest level on the scale of Likert, and *N* is indicates the total the number of respondents from the participant.

Table 3 presents the ranking of restrictions that affect the adoption of practices in the construction industry.

Table 3. States on the ranking of Restrictions affecting the adoption in construction industries

Symbol	Restrictions affecting the adoption of the TQM in construction industries under code (R-TQM)n	ΣW-total	Mean	% RII (A= 5 Highest , N= 102, A*N= (5×102=510)			
				ΣW-total	AN	RII	%RII
(R-TQM) 1	Restrictions related with Insufficient understanding of the concept of Total Quality Management.	382	3.57	382	510	0.75	75%
(R-TQM) 2	A restriction related to the insufficient understanding of the objectives of TQM.	415	3.49	415	510	0.81	81%
(R-TQM) 3	A restriction related to the weakness of the comprehensive vision of the benefits of implementing TQM in organizations operating in the construction industry.	464	5.71	464	510	0.91	**91%**
(R-TQM) 4	A restriction related to the weakness in the deployment concept of TQM among workers in the construction industry.	461	5.63	461	510	0.9	**90%**
(R-TQM) 5	A Restrictions related to commitment and support of the top management	481	6.35	481	510	0.94	**94%**
(R-TQM) 6	Restriction- high initial costs and fund allocation for adopting a TQM approach in the construction industry.	475	6.59	475	510	0.93	**93%**
(R-TQM) 7	A restriction related to the work environment in the construction industry and the construction sites.	380	1.83	380	510	0.75	75%
(R-TQM) 8	A restriction related to laws, routine and regulation related with construction sectors.	350	2.46	350	510	0.69	69%
(R-TQM) 9	A restriction related to the misunderstanding of the economic and bids competitions aspects due to contractors concerns about the cost related with quality.	401	3.02	401	510	0.79	79%
(R-TQM) 10	A restriction related to weak commitment from top management in adoption of quality system and management sites of construction project.	439	4.68	439	510	0.86	86%
(R-TQM) 11	A restriction related lack in professional training and lack of sufficient experience	481	6.43	481	510	0.94	94%
(R-TQM) 12	A restriction related to the lack of a enough time frame for defining and following up on the implementation of TQM.	472	6.27	472	510	0.93	93%
(R-TQM) 13	A restriction related to ineffective organizational structural for construction companies.	351	2.46	351	510	0.69	69%
(R-TQM) 14	A restriction related to the weakness adopting of the measuring & analysis in construction projects.	424	3.81	424	510	0.83	83%
(R-TQM) 15	The restriction is related to non-adopting effective communication methods to ensure the success of the project through the organization's application of TQM.	368	3.1	368	510	0.72	72%
(R-TQM) 16	A restriction related to non-adoption of advanced technology software and artificial intelligence in the application of TQM to develop project performance.	485	6.67	485	510	0.95	95%
(R-TQM) 17	A restriction related to the insistence on getting the traditional quality procedures of quality control, inspection, testing in construction sector.	340	2.62	340	510	0.67	67%
(R-TQM) 18	A restriction related to weakness on focusing of raising the level of performance to satisfy employers and beneficiaries of the construction project in particular.	426	3.73	426	510	0.84	84%
(R-TQM) 19	A restriction related to the adoption of mechanisms that contribute to the continued improvement of competition for projects in a fair manner.	351	2.78	351	510	0.69	69%
(R-TQM) 20	A restriction related infirmity of assigning the required resources in operations in construction companies and the operation of construction activities site of the project	408	4.37	408	510	0.8	80%
(R-TQM) 21	Restrictions related to the weakness of interest of partners (subcontractors and suppliers) in implementing of TQM	483	6.51	483	510	0.95	95%

5.2. Identifying and Analysis the Required Actions

In this part of the research, the main actions were tested, representing the necessary procedures to overcome restrictions and thereby contribute to enhancing the level of required solutions. This means further tracking of positive elements (namely, Actions) in the process of committing to the application of Total Quality Management in construction projects. These required actions were presented to three groups of experts who possess the necessary expertise in construction activities and quality management in the construction industry.

Demographic Analysis: In the second phase of the research, a questionnaire was conducted to survey experts' opinions. Three groups of experts were formed, each consisting of 8 participants, making a total of 24 Iraqi experts. Each group provided scores for the proposed actions (measures to increase the commitment level in construction firms). The first step in analyzing the three expert groups relied on their basic characteristics, which primarily included the following: years of experience (particularly in major jobs related to quality in construction) and education level. The minimum number of years of experience was 16, and the maximum was 38, as shown in Figure 6 for the three expert groups. Table 4 presents the classification of experts based on their academic qualifications. A code was assigned to indicate the level of qualification, ranging from 1 (bachelor's) to 2 (doctorate). All participants held advanced degrees and had extensive practical and theoretical experience in the field of construction.

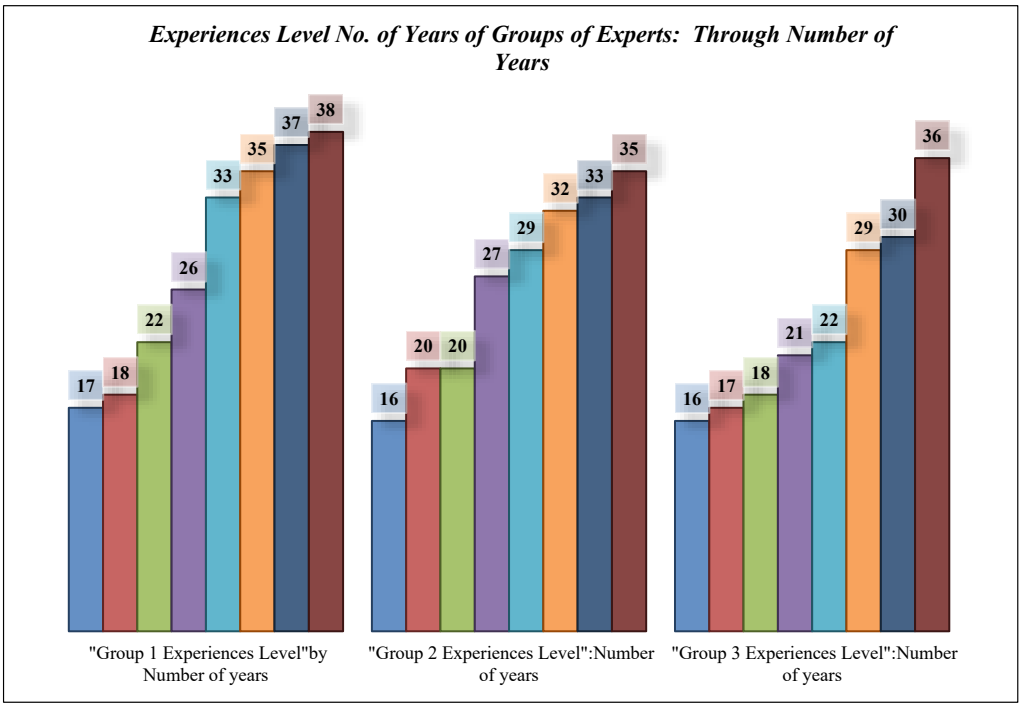


Figure 6. Shows Numbers of Experienced years for three Groups of Experts

Table 4. Jobs, Tasks and Education Level of 3 groups Experienced Experts: (where: 1 refers to Bachelor's degree; 2- Refers to Master's degree; 3-refers to Ph.D.'s degree)

Classification of Experienced Experts and Engineers (EE-i)	Jobs	Major Tasks @Sector	"Group 1 *Education Level*	"Group 2 *Education Level*	"Group 3 *Education Level*
(EE-1)	Seiner Engineering Manager	Managers@ private and public sectors	1	3	2
(EE-2)	Engineering and Mobilizers of QC	Experienced QC-engineers@ private and public sectors	2	3	1
(EE-3)	Construction Managers	CM@ private and public sectors	3	2	3
(EE-4)	Project Manager	PM Accreditation and Quality Trainers	2	1	3
(EE-5)	Managers of Head- Accreditation and Quality Trainers	Engineers and Accreditation and Quality Trainers@ private and public sectors	3	1	2
(EE-6)	Managers of Quality Aspects	Manager@ private and public sectors	2	2	2
(EE-7)	Senior Resident Engineers	Experiences engineers in construction facilities@ private and public sectors	3	2	2
(EE-8)	Heads of Quality Assurance	Experiences engineers on QA@ private and public sectors	2	3	3

For assisting in overcoming the restrictions that hinder construction firms from implementing TQM and to ensure effective tracking, a set of actions must be identified by experts and analyzed in the next section of the research. Table 5 illustrates the restrictions and the corresponding headline actions aimed at increasing the compliance of construction firms in tracking TQM within the construction industry.

Table 5. Illustrate linking between Restrictions and Actions for conduction possibility of tracking TQM in construction

Symbol Restrictions	Restrictions -TQM	Possibility Tracking (Restriction and Actions)-TQM	Headlines of the required Actions -TQM	Symbol Actions
(R-TQM) 3	A restriction related to the weakness of the comprehensive vision of the benefits of implementing TQM in organizations operating in the construction industry.		Develop a long-term methodology to ensure the best benefits are achieved when adopting TQM	(A-TQM) 3
(R-TQM) 4	A restriction related to the weakness in the deployment concept of TQM among workers in the construction industry.		Developing a methodology that ensures awareness-raising TQM	(A-TQM) 4
(R-TQM) 5	A Restrictions related to weakness in commitment and support of the top management		Ensure the highest levels of commitment of Top management in adopting TQM in the construction	(A-TQM) 5
(R-TQM) 6	Restriction- high initial costs and fund allocation for adopting a Total Quality Management approach in the construction industry		Developing financial control systems and providing financial resources that contribute to ensuring the implementation of TQM.	(A-TQM) 6
(R-TQM) 11	A restriction related to-Lack of professional training and lack of sufficient experience		Adopt scheduled professional training for employees and evaluate their performance to ensure continuous development.	(A-TQM) 11
(R-TQM) 12	A constraint related to the lack of enough time frame for defining and following up on the implementation of TQM.		Commitment to the time frame required to implement the rules of TQM in construction.	(A-TQM) 12
(R-TQM) 16	A restriction related to non-adoption of advanced technology software and artificial intelligence in the application of total quality management to develop project performance.		Developing a logical approach for achieving integration between TQM and Artificial intelligence	(A-TQM) 16
(R-TQM) 21	Restrictions related to the weakness or lack of interest of partners in implementing the project, especially subcontractors and suppliers.		Working to develop the capabilities of subcontractors in the field of comprehensive quality	(A-TQM) 21

5.3. Testing of Hypothesis

By adopting the Kruskal-Wallis assumption to analyze variations among more than three groups based on the scores of Iraqi engineers who are experts in this field [49, 50], the framework of the hypothesis must be identified and tested for the mentioned groups in order to determine the first-degree variation among the expert participants. The actions were found to be consistent with the required hypothesis (H0) and the counter-hypothesis (H1) [51]. The null hypothesis (H0) essentially examines whether there are statistically significant differences or variations that may appear during the analysis among the targeted groups. This provides a clear understanding of the importance of establishing procedures that allow for possible and non-contradictory actions as required solutions, tested under the following terms.

$$H0= \bar{X}1= \bar{X}2= \bar{X}3 \quad (2)$$

$$H1\neq \bar{X}1 \neq \bar{X}\,2\neq \bar{X}3 \quad (3)$$

where $\bar{X}1$; $\bar{X}2$; $\bar{X}3$ are arithmetic mean for targeted groups.

5.4. Statistical Analysis

Expert answers were collected in the form of scores. The required test, based on the Kruskal-Wallis assumption, was applied to all targeted groups since the sample size was less than 30. Table 6 contains the scores obtained from the expert responses to evaluate each action, aimed at creating positive measures to overcome restrictions and ensuring that the tracking of TQM progresses smoothly within the systematic management of construction firms.

Table 6. Illustrates the collected scores from 3 targeted groups

Symbol of Actions	The Possible Actions –TQM	Testing the possibility of evaluating compliance as part of the commitments for construction Firms	Scores for 3 Groups from Local Expert-Rates		
			Groups 1	Groups 2	Groups 3
(A-TQM) 3	Develop a long-term methodology to ensure the best benefits are achieved when adopting TQM		88	87	89
(A-TQM) 4	Developing valuable approaches to ensures awareness-raising TQM		91	79	90
(A-TQM) 5	Ensure the highest levels of commitment of Top management in adopting TQM in the construction		74	93	95
(A-TQM) 6	Developing financial control systems and providing financial resources that contribute to ensuring the implementation of TQM.		96	95	80
(A-TQM) 11	Adopt scheduled professional training for employees and evaluate their performance to ensure continuous development.		97	94	84
(A-TQM) 12	Commitment to the time frame required to implement the rules of TQM in construction.		98	81	83
(A-TQM) 16	Developing a logical approach for achieving integration between TQM and Artificial intelligence		82	97	85
(A-TQM) 21	Working to develop the capabilities of subcontractors in the field of comprehensive quality		99	86	100

For getting the results from assumption of Kruskal Willis the following formula is used to find value of H:

$$-3(N+1)H = \frac{12}{N(N+1)}\left[\frac{\sum(R1)2}{n1} + \frac{\sum(R2)2}{n2} + \frac{\sum(R3)2}{n3}\right] \quad (4)$$

where H is value of statistical test (Kruskal Willis test), R1, R2 and R3 are the sum of the ranks for each group separately, N is total number of whole groups, n1, n2 and n3 are Total number of samples in each group, and N is 8 × 3 =24 totally.

After combining the samples of the three groups to form a single sample arranged from smallest to largest, the ranking of each group's sample scores is required. The total sum of the ranks for each sample separately is as follows: sum of group one = 114, sum of group two = 93, and sum of the last group = 91. The scores for the three targeted groups of local experienced engineers and experts are presented in Table 7.

Table 7. Illustrates the scores for 3 targeted Groups from Local Experts and Experienced Engineers

Groups 1	Groups 2	Groups 3
88	87	89
91	79	90
74	93	95
96	95	80
97	94	84
98	81	83
82	97	85
99	86	100

Then all response scores were combined into a single dataset covering all groups, in order to determine the frequency and ranking according to the ascending sequence of each score. Table 8 presents all the details of the rankings for each group separately, as well as their total after being directly combined for analysis purposes. The value 75 was already calculated to reflect the final part of the above formula 3(N+1).

Table 8. Shows Ranks and its sum for each group

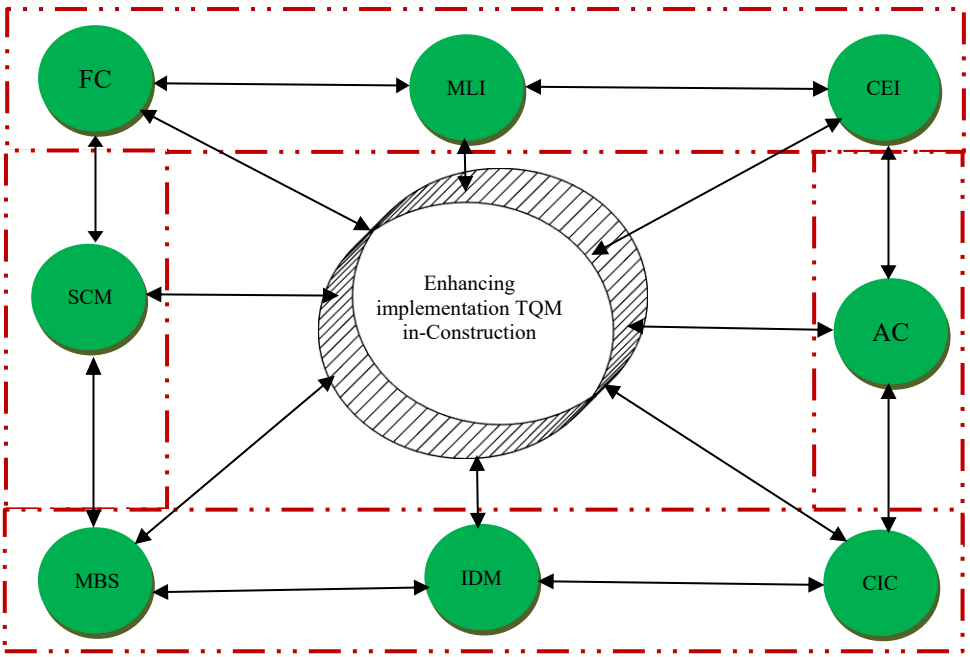
Groups 1	Rank for Group 1	Groups 2	Rank for Group 2	Groups 3	Rank for Group 3
88	11	87	10	89	12
91	14	79	2	90	13
74	1	93	15	95	18
96	19	95	17	80	3
97	20	94	16	84	7
98	21	81	4	83	6
82	5	97	20	85	8
99	23	86	9	100	24
-	**114**	-	**93**	-	**91**

The value of H was obtained from the analysis of expert response scores, where H = 0.185. For a degree of freedom (df) equal to 2 and under a p-value of 0.05, the Chi-square value from the critical value table is 5.99. Since there are no significant statistical differences between the values of the groups, the null hypothesis (H0) is accepted.

6. Model-Proposed Patches for Tracking and Enhancing the Implementation of TQM in Construction Sector

To enhance the implementation of TQM in the construction sector, particularly in developing countries, a Model of Proposed Patches (MPP) is introduced in this section to conduct valuable investigations on the impact of the main restrictions related to TQM, as well as to suggest actions and arrange scope packages for implementing construction

projects. This model also aims to form a hub that stimulates the process of identifying actions in a cumulative manner, thereby contributing to continuous improvement. The proposed figures in this section represent parts of the MPP. Figure 7 illustrates the negatively influencing restrictions and the positive influence of actions, both of which contribute to the process of investigation and the identification of possible actions.



The symbol in the figure	Its Interpretation
	Chain of restrictions Each cycle refers to main pillars of TQM as following: (FC: Focus Customer; MLI: Management and Leadership Involvement; CEI:Construction Employee Involvement; AC:Approaches of Construction; SCM:Systematic of Construction Management path; CIC: Continues Improvement in Construction; IDM:Impact of Decision Making; MBS:Mutually Beneficial -Subcontractor Relationships
	Double Arrow: refers to The interconnectedness and systemic sequencing of the impacting of possible Action to improve implementation TQM in construction.
	The wheel of Enhancing TQM and the continuous improvement in construction

Figure 7. Shows the negative influenced restrictions and the positive influencing of Actions on TQM wheels

6.1. Numeric-Path for Tracking Possible Actions on TQM

By adopting the required actions that contribute to the integration of TQM application in the construction industry, the suggested scope packages refer to the project monitoring process, ensuring that the necessary documentation procedures become part of the overall quality monitoring requirements. Project preparation processes, as a fundamental product in the construction industry, require a detailed quality assessment. The project scope covers the concept, feasibility studies, detailed design, tendering and contracting, implementation, initial and final acceptance by the client, project entry into operation, and subsequent maintenance.

A hub of TQM in construction firms is based on initiatives related to creativity and innovation, which serve to support actions aimed at achieving valuable outcomes and ensuring timely updates. In this phase of the study, and to determine a benchmark for tracking success in applying TQM requirements and sustaining continuous improvement in the construction sector, a TQM hub in construction firms is suggested to align possible actions with the required scopes of construction projects. To ensure that these actions are validated, experts and experienced engineers in construction firms or projects can conduct timely reviews and develop each solution to

suit the scale of the expected restrictions. Thus, a TQM hub in construction firms relies on initiatives linked to creativity and innovation to reinforce possible actions, ensure timely updates, and remain under the supervision of experts and experienced engineers to guarantee process validation. Therefore, the following diagram, Figure 8, illustrates the tracking of scope and its compatibility with the overall quality management system in the construction industry.

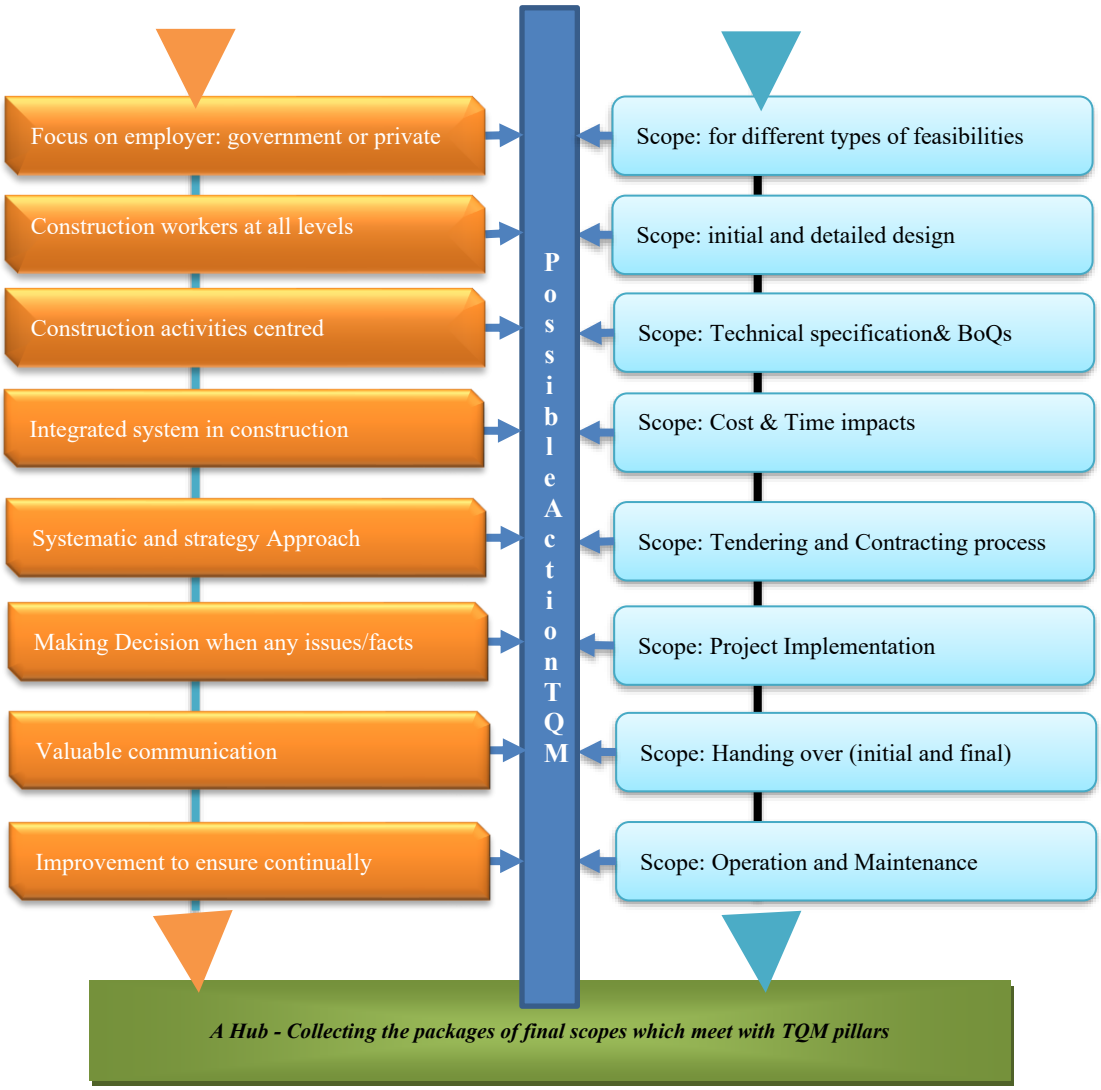


Figure 8. Shows illustrates the tracking of scope and its compatibility with TQM-journey in the construction industry

6.2. Alignment of the Research Findings

The research revealed results that need to be highlighted due to their importance in developing the quality system of the construction industry in developing countries. The following points provide an overview of these findings:

- It is appropriate for decision-makers in the construction industry to enhance the performance of construction projects by upgrading all project scopes to align with each pillar of TQM. Accordingly, the flowchart in Figure 9 presents the suggested idea as part of the MPP.
- The research findings indicate that AI applications represent a key component in improving the efficiency aspects of TQM. Figure 10 illustrates how AI outputs can be utilized in this context.
- The commitment of top management—including contractors, project owners, and investors in the construction industry—to implementing TQM requirements significantly contributes to the adoption of tracking systems by ensuring the availability of competent and professional personnel in this field.

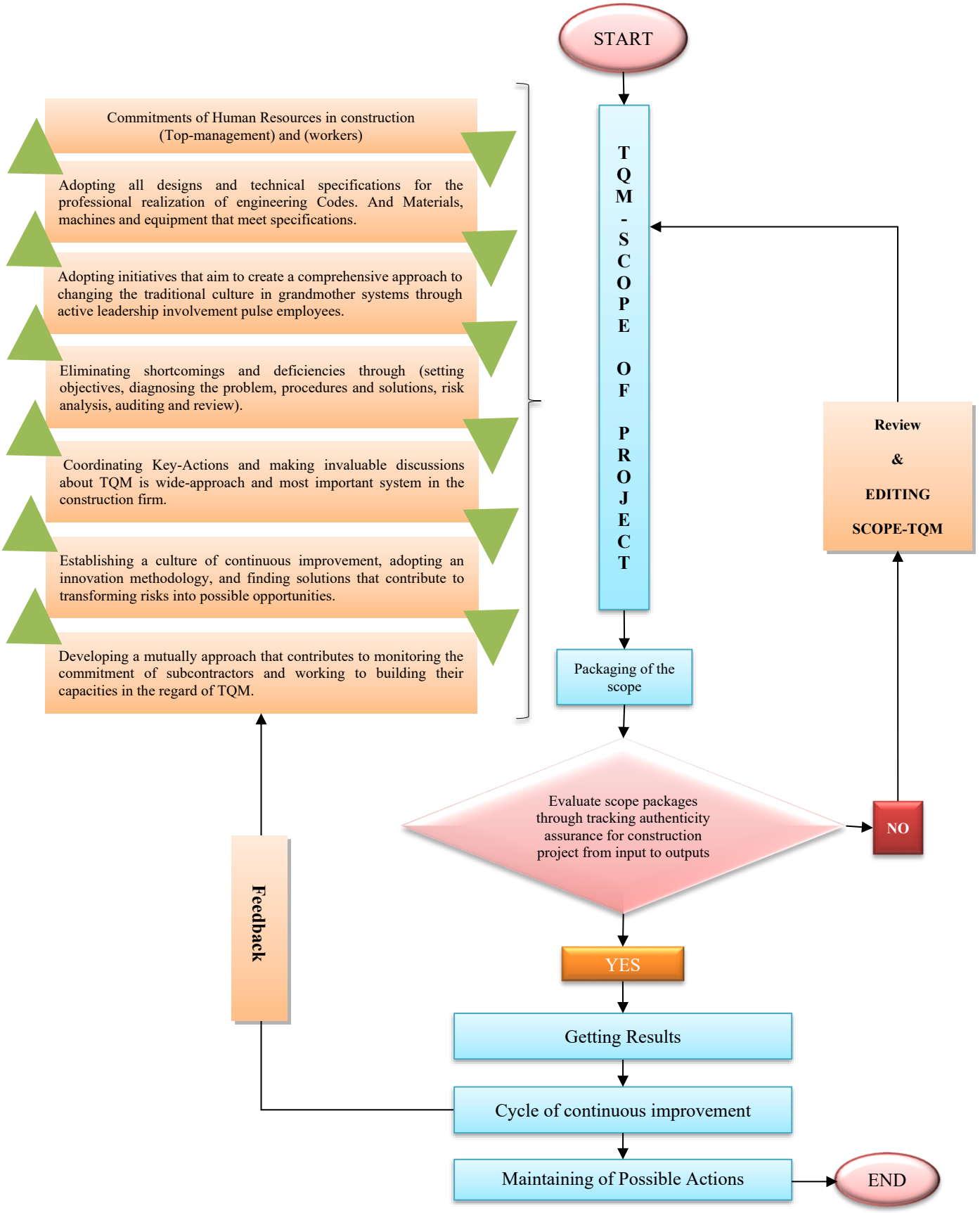


Figure 9. A proposed flowchart for processing the packages of scope to match with TQM pillars in construction sector

Figure 10. illustrates Main path of AI to contribute on TQM in construction

7. Conclusions

The study concluded that every management system in firms operating in the construction industry must include a TQM system as the most important and fundamental axis upon which these companies rely. To achieve the best outcomes from implementing a TQM system, all construction firms must establish a tracking system that helps identify restrictions and develop effective actions (solutions). Continuous tracking of this system is an essential part of realizing the concept of continuous improvement and development. The study revealed several important outcomes and facts that contribute to ensuring the application and development of management systems, while also encouraging firms in the construction sector to adopt TQM. These outcomes are as follows:

- Focusing on the commitment of top management and individuals to contribute to achieving maximum benefits and long-term objectives.
- Emphasizing the importance of following all necessary steps to enhance the culture of quality and comprehensive quality, primarily through awareness programs, periodic training, and practical evaluation of workers in this field.
- Raising awareness by listening to the demands of construction industry clients (as major customers), while also adopting the concept of listening to employees' voices in construction projects and involving them in the decision-making process related to quality systems.
- Allocating sufficient budgets to accelerate the implementation of TQM systems and overcome initial costs, which often represent a concern for construction company owners due to their anticipated increases.
- Recognizing that Total Quality Management is an advanced methodology that enhances the competitive position of companies in the construction industry, improves the performance of construction projects, and achieves client satisfaction. Firms must also evaluate their level of commitment with the goal of ensuring satisfaction for employers and project owners.
- Expert opinions and experienced engineers highlight the necessity of adopting advanced technological systems and integrating comprehensive quality with construction outputs in coordination with Artificial Intelligence (AI).
- Adopting a culture of total quality among construction staff requires sufficient financial allocations to involve them in development and research programs, thereby contributing to long-term objectives, ensuring continuous improvement, and bridging gaps that affect construction quality outputs.
- Establishing a hub within continuous improvement programs in construction firms is a key factor—especially in developing countries—for sustaining feasible and scalable actionable solutions over time. This enables managers and decision-makers in the construction industry to address challenges that hinder the implementation of Total Quality Management (TQM) requirements.

8. Declarations

8.1. Author Contributions

Conceptualization, R.T.H.; methodology, R.T.H; software, R.T.H.; validation, R.T.H. and A.H.H.; formal analysis, R.T.H.; investigation, R.T.H. and A.H.H.; resources, R.T.H. and A.H.H.; data curation, R.T.H.; writing—original draft preparation, R.T.H.; writing—review and editing, R.T.H.; supervision, R.T.H. All authors have read and agreed to the published version of the manuscript.

8.2. Data Availability Statement

The data presented in this study are available in the article.

8.3. Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

8.4. Conflicts of Interest

The authors declare no conflict of interest.

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