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Total Quality Management's Critical Role in Resolving Delay Issue of Construction Projects Submission

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ABSTRACT

Despite considerable advancements and innovations in the construction industry, it continues to grapple with challenging obstacles that potentially impede the timely delivery of projects. Among these impediments, project delays are particularly detrimental. Over the past decades, the industry has seen the design and implementation of various intelligent methodologies aimed at alleviating this issue, with Total Quality Management (TQM) being a notable example. This study was conducted to investigate the beneficial impacts of TQM on addressing delays in diverse construction projects. Three research methodologies were employed in this study: 1) a quantitative approach, 2) a qualitative cross-sectional descriptive approach, and 3) a numerical analysis, which explored the role of Building Information Modeling (BIM) in facilitating quantity take-off with increased accuracy and reduced time. The latter thereby mitigates the delay in construction projects due to the substantial effort, cost, and duration required to estimate the quantity of construction materials. The numerical analysis was carried out using the REVIT software tool. The findings from these three methodologies demonstrated the substantial importance of TQM principles for project managers and senior engineers. These principles can aid in streamlining project delivery and reducing delays. Furthermore, the implementation of TQM resulted in a reduction in quality costs, improved client satisfaction, decreased remedial work, mitigated delays, and fostered a closer relationship between suppliers and subcontractors. In addition, the use of BIM technology was found to enhance the accuracy of construction project cost calculations. Consequently, it reduced the time and cost of estimation and minimized errors, thereby contributing to resolving the delay problem in construction.

1. INTRODUCTION

Total Quality Management (TQM) is a dynamic concept that has been widely implemented across various sectors, including medicine, engineering, marketing, tourism, and diverse businesses to enhance quality, efficiency, performance, and effectiveness, while bolstering employee productivity. Its significance in the construction sector is underscored by its potential to amplify the supervision of activities, construction tasks, workforce efficiency, and overall project management. Importantly, TQM has demonstrated substantial benefits in aiding project managers to meet project deadlines, thereby mitigating the issue of delay [1, 2].

The impetus for this research is derived from an identified research gap concerning the advantageous influences and applications of TQM in the Iraqi construction sector, particularly in addressing the challenge of submission delays. A scarcity of peer-reviewed articles and academic publications specifically addressing the role of TQM in mitigating delay problems within the Iraqi construction sector further substantiates the necessity of this study.

The results of this investigation underscore the significant role of TQM in aiding engineers and project managers in monitoring activity execution on time, thereby avoiding delays in the completion of required construction activities. It was observed that the Iraqi construction sector, according to construction consultants and industry professionals, exhibits a significant dearth of TQM implementation. Thus, a need for enhancing awareness and knowledge regarding this concept was identified.

Four critical components associated with TQM were identified: (A) Quality planning, which involves identifying the project's quality metrics and strategizing their achievement, (B) Quality improvement, a deliberate process aimed at bolstering the resolution or safety of the product, (C) Quality control, a continuous effort to ensure the integrity and security of a process when producing an outcome, and (D) Quality assurance, which encompasses the routine or prescribed measures necessary to provide sufficient confidence that a service or item will comply with specified standards. Furthermore, TQM is integral to the successful execution of short-term projects, owing to its focus on long-term goals and the resulting long-term benefits for construction customers [3, 4].

Construction projects encompass a series of connected tasks executed in a specific order to achieve the project's completion. These projects are transient by nature and typically yield a measurable output or product. The term "construction project" refers to the planned process of erecting, repairing, refurbishing, or building infrastructure. The majority of construction projects are unique, involving a distinct project team, brief, and funding assembled to create a unique design and deliver a singular project [5, 6].

In construction projects, the submission time is of paramount importance to both the client and the executor. Therefore, any delay in the submission process can have far-reaching effects. Several reasons contribute to project submission delays, including a lack of scope definition at the project's inception and poor design, leading to ineffective and incorrect project delivery [7]. The implementation of TQM in managing and controlling these delay issues offers a resolution.

In the construction industry, TQM pertains to the policies, practices, and procedures implemented – typically by management – to enhance an organization's capacity to deliver quality to its customers on a consistent and improving basis. As such, TQM often proves to be the critical component of total construction project management that determines a company's success or failure [8, 9].

The primary objectives of TQM include reducing the number of problems during asset delivery or transfer and identifying problems and defects before clients, thereby preserving the organization's reputation [9]. Prior studies have investigated the role of TQM in construction [10-14], and others have explored the positive contributions and major benefits of implementing TQM in various construction projects [15-17]. These studies demonstrate that the application of TQM principles can contribute to the resolution of delay problems in construction projects, leading to better management and coordination of the project submission process.

The remainder of this paper is organized as follows: Section two describes the materials and methods used in this research, and the major approaches adopted for primary data collection. Section three presents the significant results obtained from the research methods. Section four provides a detailed discussion of the results, and section five summarizes the key research findings. References are provided at the end of the paper.

2. MATERIALS AND METHODS

This research implemented 3 major study disciplines. These research approaches comprise (i) quantitative and (ii) qualitative descriptive cross-sectional studies. In addition, the third research includes numerical analysis of a construction project (representing a case study) is also implemented using the REVIT software. These 3 study methods can offer important data and significant information to address the beneficial role and relevances of TQM in managing the submission process of constriction projects and help prevent any problem or consequences of delay. To shed light on the benefits and principles of each approach. The following paragraphs describe more details related to each study method.

2.1 Quantitative cross-sectional study

This research is considerable for the purposes of this work, as it can support the researcher in gathering important primary data from project managers, construction experts, and chief engineers who worked a lot with TQM and have beneficial points of view that can offer vital data to address the importance of TQM in organizing the submission process of construction projects and avoid delays. This study is executed and applied with the help of a survey questionnaire. The questionnaire can collect important aspects and knowledge from the study sample, representing engineers from different disciplines and qualifications. Thus, they can provide their opinion regarding the significance of TQM in resolving the delay problem in variant construction projects.

Some studies [18-20] conducted a cross-sectional descriptive quantitative analysis to identify the substantial aspects and critical benefits of TQM in mitigating the delay problem. According to the literature, this research approach is also remarkably useful and advantageous to determine the benefits of TQM in mitigating the delay problem with the help of engineering society, depending on a large number of Iraqi construction engineers and specialists in TQM.

2.2 Qualitative cross-sectional study

The qualitative research can be applied by preparing a number of important questions that can be carefully selected and formulated to aid the researcher in predicting some construction consultants' opinions and points of view in regard to the contributions and relevance of TQM to organize the submission and mitigate the occurrence of the delay issue in building construction. After preparing the questions, interviews with some key persons will be carried out to collect primary knowledge and necessary data that can formulate the importance and determine the significance of TQM for resolving the issue of construction projects.

2.3 Numerical modeling and analysis

In this study, the REVIT software tool, which belongs to the BIM principles, is used to specify the critical role of modern TQM methods in calculating the cost and schedule of construction projects with less time, effort, and cost, contributing to significant mitigation of delay issue of construction projects submission. This analysis is implemented by making a quantity take-off of the materials related to the case study of the construction project investigated in this work. Also, a comparative analysis is conducted between this numerical method (using the REVIT software) and a manual or conventional method to validate the contribution of modern TQM techniques in estimating the cost and schedule of construction projects with less effort, time, and cost. Therefore, a considerable alleviation of delay problems related to construction projects can be attained. The case study comprises a project representing a residential building located in Iraq (Baghdad) consisting of a basement floor, ground floor, first floor, two typical floors, and a roof floor. The total building area is 1,682.10 square meters. Figure 1 illustrates the configuration of this building.

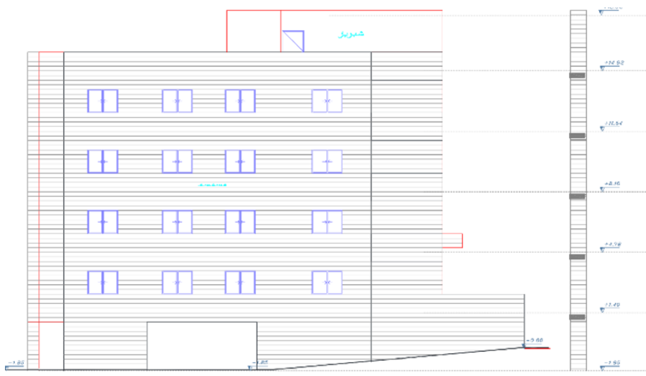

Figure 1. Side northern view of the case study representing a residential building

3. RESULTS

This section illustrates the study outputs attained from the analysis of 3 study methods. The sections below will provide some details on the findings of each research approach.

3.1 Quantitative cross-sectional study results

The research findings associated with the quantitative study method are described in this section.

3.1.1 Results of the study's demographic data

Table 1 describes the demographic data analysis of the study sample based on gender.

Table 1 indicates the percentage and frequency of gender for all participants. It can be indicated from this table that male engineers had the most significant ratio, contributing to a share of 73.3%. On the other hand, female participants had a ratio of 25.7%, as illustrated in Figure 2.

Table 1. The findings of the demographic data for the study sample according to gender

Gender		Frequency	%	Valid %	Cumulative %
Valid	Male	74	73.3	74.0	74.0
	Female	26	25.7	26.0	100.0
	Total	100	99.0	100.0	
Missing	System	1	1.0		
Total		102	101	100	

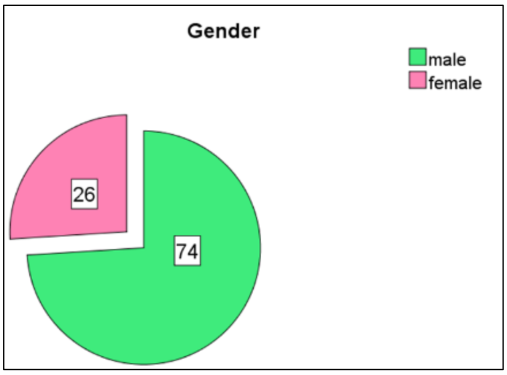

Figure 2. A configuration of the demographic data for the study population based on gender

Table 2 describes the demographic data analysis of the study sample based on age.

Table 2 indicates the percentage and frequency of age for all participants. It can be observed that the most considerable ratio of participants based on age was for ages between 25 and 30, contributing to a ratio of 69.3%. This portion is followed by the age group (31-35), corresponding to a portion of 21.8%. Furthermore, it can be indicated from the information represented in Table 2 that most of the engineers who were surveyed in this cross-sectional study were young and have an age that is lower than 30 years old. At the same time, those engineers with ages that are more than 30 years old present around 30% of the study. Therefore, it is predicted that significant information regarding the major contributions of the TQM can be identified from 30% of the study population due to their higher experience in construction compared with young engineers, who are new and junior in this sector. Figure 3 illustrates the statistical data expressed in Table 2.

Table 2. The findings of the demographic data for the study sample according to age

Age		Frequency	%	Valid %	Cumulative Percent
Valid	25-30	70	69.3	70.0	70.0
	31-35	22	21.8	22.0	92.0
	36-45	6	5.9	6.0	98.0
	More than 45	2	2.0	2.0	100.0
	Total	100	99.0	100	
Missing	System	1	1.0		
Total		101	100.0		

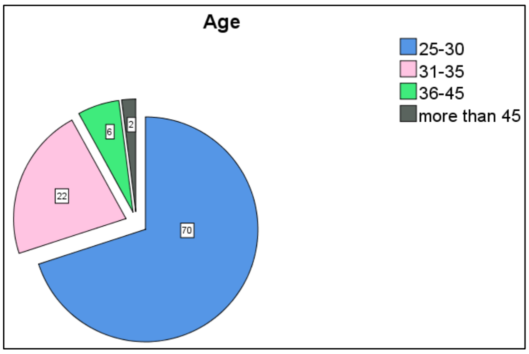

Figure 3. A configuration of the demographic data for the study population based on age

Further, Table 3 describes the demographic data analysis of the study sample based on educational level.

Table 3 indicates the percentage and frequency of educational level for all participants. It can be observed that the most considerable ratio of participants based on educational levels is for engineers who hold a master's degree, corresponding to a ratio of 64.4%. This percentage is followed by a bachelor's degree, reaching 32.7%, as indicated in Figure 4.

Table 3. The findings of the demographic data for the study sample according to educational level

Educational Level		Frequency	%	Valid %	Cumulative %
Valid	Bachelor	33	32.7	33.0	33.0
	Master	65	64.4	65.0	98.0
	PhD	2	2.0	2.0	100.0
	Total	100	99.0	100.0	
Missing	System	1	1.0		
Total		101	100		

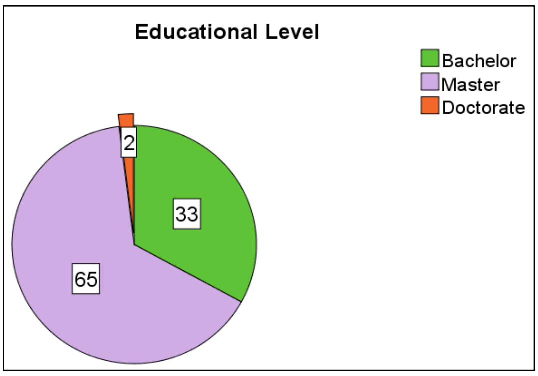

Figure 4. A configuration of the demographic data for the study population based on educational level

Table 4 describes the demographic data analysis of the study sample based on experience years.

Table 4 indicates the percentage and frequency of experience years for all participants. It can be observed that the most considerable ratio of participants based on experience years is for engineers who have an experience (between 10 and 15 years), corresponding to a percentage of 77.2%. This ratio is followed by two fields of experience years, which are (less than ten years) and (from 16 to 20 years), corresponding both to a portion of 9.9%, as described in Figure 5.

Table 4. The findings of the demographic data for the study sample according to experience years

	Experience Years	Frequency	%	Valid %	Cumulative %
Valid	Less than 10	10	9.9	10.0	10.0
	10-15	78	77.2	78.0	88.0
	16-20	10	9.9	10.0	98.0
	More than 20	2	2.0	2.0	100.0
	Total	100	99.0	100	
Missing	System	1	1.0		
Total		101	100		

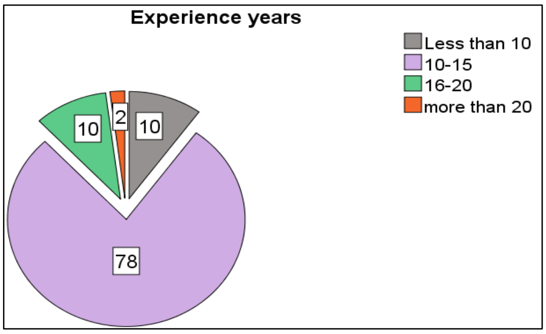

Figure 5. A configuration of the demographic data for the study population based on years of experience

Table 5 describes the demographic data analysis of the study sample based on qualification.

Table 5 indicates the percentage and frequency of qualification for all participants. It can be observed that the most considerable ratio of participants based on qualification is for engineers who have a degree in civil engineering, corresponding to a ratio of 58.4%. This percentage is followed by the architectural engineering discipline, which has a percentage of 24.8%. Further details on the qualification analysis are illustrated and represented in Figure 6.

Table 5. The findings of the demographic data for the study sample according to qualification

	Qualification	Frequency	%	Valid %	Cumulative Percent
Valid	Civil Engineering	59	58.4	59.0	59.0
	Architectural Engineering	25	24.8	25.0	84.0
	Electrical Engineering	6	5.9	6.0	90.0
	Mechanical Engineering	6	5.9	6.0	96.0
	Others	4	4.0	4.0	100.0
	Total	100	99.0	100.0	
Missing	System	1	1.0		
Total		101	100		

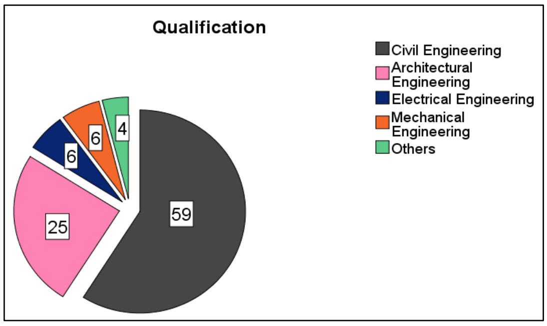

Figure 6. A configuration of the demographic data for the study population based on the qualification

3.1.2 The results of the SPSS of the questionnaire

Table 6 describes the SPSS analysis for the research questionnaire based on the first dimension. This table describes the arithmetic mean, standard deviation, Z-value, and ranking of the paragraphs of the first dimension. The dimension is “the importance of quality management in preventing delays in project delivery.”

Table 6. The SPSS results of the first dimension including arithmetic means, standard deviation, Z-value, and ranking of paragraphs

Paragraph	Arithmetic Mean	Standard Deviation	Z Value	Rank
Adjust project costs	4.66	0.987	16.819	1
Reduce the time required to complete project work	4.55	0.978	15.844	2
Achieving the owner’s satisfaction in accordance with his requirements	4.06	1.469	7.216	3
Develop teamwork between project parties	2.85	1.893	-0.792	4
Compliance with specifications and contract provisions	1.98	1.310	-7.785	5

Table 7. The SPSS results of the second dimension including arithmetic means, standard deviation, Z-value, and ranking of paragraphs

Paragraph	Arithmetic Mean	Standard Deviation	Z Value	Rank
Ensure the quality of construction equipment and materials	4.57	1.112	14.113	1
Ensuring that tests and examinations are carried out accurately to give high quality results	4.25	1.329	9.408	2
Follow-up of workflow and documentation of work	3.80	1.664	4.809	3
Achieving harmony between design and planning processes	2.62	1.825	-2.083	4
Improving communication between project parties	2.31	1.779	-3.878	5
Conformance of project work according to contracts and standards	1.55	1.209	-11.992	6

Table 6 indicates the arithmetic mean and standard deviation of the paragraph of the first dimension, which is "the importance of quality management in preventing delays in project delivery." It can be noted from this table that the most significant paragraph has an arithmetic mean of 4.66, which states that "Adjust project costs." On the other hand, the least significant paragraph has an arithmetic mean of 1.98, which says, "Compliance with specifications and contract provisions." Table 7 describes the SPSS analysis for the research questionnaire based on the second dimension. This table represents the arithmetic mean, standard deviation, Z-value, and ranking of the paragraphs of the second dimension. The dimension is "the project manager in the total quality management of the construction project."

Table 7 indicates the arithmetic mean and standard deviation of the paragraph of the second dimension, which is "the project manager in the total quality management of the construction project." It can be noted from this table that the most significant paragraph has an arithmetic mean of 4.57, which states that "Ensure the quality of construction equipment and materials." On the other hand, the least significant paragraph has an arithmetic mean of 1.55, which says, "Conformance of project work according to contracts and standards." Table 8 describes the SPSS analysis for the research questionnaire based on the third dimension. This table represents the arithmetic mean, standard deviation, Z-value, and ranking of the paragraphs of the third dimension. The dimension is "the risks and negatives resulting from delaying project delivery."

Table 8. The SPSS results of the third dimension including arithmetic means, standard deviation, Z-value, and ranking of paragraphs

Paragraph	Arithmetic Mean	Standard Deviation	Z Value	Rank
Poor quality and efficiency of the project	4.30	1.352	9.61	1
Poor project management ability	4.09	1.558	6.99	2
Disagreements and disputes between the owner, contractor and consultant	3.45	1.833	2.46	3
Increased project work costs (financial risks)	2.37	1.851	-3.40	4
Adding contractual terms to the project work items	1.42	1.112	-14.21	5

Table 9. The SPSS results of the fourth dimension including arithmetic means, standard deviation, Z-value, and ranking of paragraphs

Paragraph	Arithmetic Mean	Standard Deviation	Z Value	Rank
Poor planning and project scheduling	4.07	1.584	6.75	1
Poor financing by the owner (financial problems).	3.65	1.777	3.66	2
Weather conditions	3.20	1.896	1.055	3
Design and schematic problems	2.20	1.781	-4.49	4
Poor performance of the contractor in the implementation of the work	1.44	1.067	-14.63	5

Table 8 indicates the arithmetic mean and standard deviation of the paragraph of the third dimension, which is "the risks and negatives resulting from delaying project delivery." It can be noted from this table that the most significant paragraph has an arithmetic mean of 4.30, which states that "Poor quality and efficiency of the project." On the other hand, the least significant paragraph has an arithmetic mean of 1.42, which says, "Adding contractual terms to the project work items." Table 9 describes the SPSS analysis for the research questionnaire based on the fourth dimension. This table represents the arithmetic mean, standard deviation, Z-value, and ranking of the paragraphs of the fourth dimension. The dimension is "the problems that lead to project delivery delays."

Table 9 indicates the arithmetic mean and standard deviation of the paragraph of the fourth dimension, which is "the problems that lead to project delivery delays." It can be noted from this table that the most significant paragraph has an arithmetic mean of 4.07, which states that "Poor planning and project scheduling." On the other hand, the least significant paragraph has an arithmetic mean of 1.44, which says, "Poor performance of the contractor in the implementation of the work."

3.2 Qualitative research approach results

The construction professionals and TQM experts provided their critical knowledge and points of view regarding the significance of TQM principles and implementation to adopt by project managers, helping them mitigate the delay problem of their construction projects and enhance the organization and performance of the submission process on time. According to the knowledge and experience of those key persons, the following results and important aspects are concluded:

1. The TQM principles are considerably crucial for project managers and chief engineers to support them in organizing the process of project submission, alleviating any problem of delay or retardation in the construction project submission.
2. TQM provides the potential for engineers and professionals to reduce quality costs, achieve more significant levels of client and employee satisfaction, reduce remedial work, mitigate delay issues, and achieve a close connection between suppliers and subcontractors.
3. The use of BIM technology and REVIT software tools helps calculate the cost of the construction project with a higher degree of accuracy. Therefore, the time needed for calculation, cost of estimation, and errors that cause rework in the estimation process can be significantly reduced, contributing to the solution of the delay problem in construction projects caused by retardation period in the quantity survey and take off of the construction project's materials.
4. Adopting TQM in construction projects could help construction organizations and project managers to deliver the required output to their clients and accomplish a higher degree of quality in their construction activities.

3.3 The REVIT analysis results

To explore the significance and relevance of the REVIT software and identify its benefits in making materials' survey and quantity take-off effectively with less time, resulting in lower rate of delay in construction projects, a comparative study is implemented consisting of two calculation methods; (1) hand estimation (conventional approach), and (2) numerical method of quantity survey via the REVIT software package. The results of the comparative analysis of these two methods are described in Table 10.

It can be concluded from Table 10 that the hand calculation method and numerical results of the REVIT software are remarkably closer to each other. Nevertheless, the analysis findings of the REVIT software tool can be considered more precise because of the accurate modeling and fewer personal mistakes that occur during the take-off and the calculation of quantities manually. Therefore, it can be seen that BIM principles, especially the REVIT software tool, are the future for monitoring the current construction beginning from the design stage and ending with the submission of the project. Moreover, it can be observed that through the analysis of manual quantities calculation, which is the most employed method, engineers, contractors, and old experts may find it hard to compute the materials' quantity and make take-off and survey of the construction project with less time, effort, and cost taking into account higher accuracy. Meanwhile, the use of BIM technology, including REVIT, contributes to the completion of the required work quickly and efficiently without human mistakes. Hence, BIM applications are the future of modern construction.

Table 10. The results of the comparative analysis of the hand calculation method and numerical technique using the REVIT software for making materials' take-off for the case study

Steel (kg)		
Element	Manual Results (kg)	REVIT Results (kg)
Slabs reinforcement steel	22,115	21,044
Beams reinforcement steel	28,645	27,468
Columns and walls reinforcement steel	49,856	48,026
Footing reinforcement steel	10,900	10,295
Stair reinforcement steel	2,925	2,623
Concrete (m^3)		
Element	Manual Results (m^3)	REVIT Results (m^3)
foundation	179.31	177.00
Walls & Columns	348.51	326.66
Slabs	323.00	326.56
Other Works (m^3)		
Element	Manual Results (m^3)	REVIT Results (m^3)
Earth Cut	2,273.69	2,168.82
Earth Fill	697.41	669.38
Blinding	80.31	79.83
S.O.G Layer (Boulder)	48.82	49.18
S.O.G Layer (R.C)	32.55	32.79
S.O.G Layer (Asphalt)	6.51	6.56
S.O.G Layer (Sand)	19.53	19.67

4. DISCUSSION

The analysis findings associated with this research revealed that the TQM principles are remarkably important for al project managers and senior engineers to support them in organizing the process of project submission, alleviating any problem of delay or retardation in the construction project submission. Also, the results indicated that TQM provides the potential for engineers and professionals to reduce quality costs, achieve more significant levels of client and employee satisfaction, reduce remedial work, mitigate delay issues, and achieve a close connection between suppliers and subcontractors. Furthermore, it was found that the employment of BIM technology and REVIT software tools helps calculate the cost of the construction project with a higher degree of accuracy. Therefore, the time needed for calculation, cost of estimation, and errors that cause rework in the estimation process can be significantly reduced, contributing to the solution of the delay problem in construction projects caused by retardation period in the quantity survey and take off of the construction project's materials. Moreover, the results indicated that adopting TQM in construction projects could help construction organizations and project managers to deliver the required output to their clients and accomplish a higher degree of quality in their construction activities. These results are consistent with the results in studies [10-14], who found that implementing the TQM approach in the construction sector can contribute to several beneficial impacts for managers, clients, chief engineers, and other stakeholders. Additionally, the results of this study are consistent with the results in studies [15-17], who found that TQM has a critical role and positive contributions to the construction industry mirrored by the mitigation of delay problems and effective management of the submission procedure of construction projects.

5. CONCLUSIONS

The present study delves into the exploration and elucidation of the beneficial impacts and significant advantages of Total Quality Management (TQM) in mitigating the prevalent issues of delays in the submission of numerous construction projects. The research methodology adopted is a trilogy of strategies, namely (1) a quantitative approach, (2) a qualitative cross-sectional descriptive methodology, and (3) a numerical analysis. The latter technique is particularly pertinent in addressing the beneficial role of Building Information Modelling (BIM) technology in expediting the process of quantity take-off with increased accuracy. The delay problem in construction projects, arising from the substantial effort, cost, and duration required to estimate the quantity of construction materials, is thereby addressed. The REVIT software tool was employed for the execution of the numerical analysis.

The synthesis of the three approaches culminated in the following key findings:

1. The principles of TQM serve as invaluable tools for project managers and senior engineers, bolstering their ability to manage the process of project submission effectively. Consequently, problems of delay or retardation in the construction project submission are mitigated.
2. TQM empowers engineers and professionals to minimize quality costs, enhance client and employee satisfaction, diminish the need for remedial work, resolve delay issues, and foster a robust liaison between suppliers and subcontractors.
3. The utilisation of BIM technology, in conjunction with the REVIT software tool, facilitates the calculation of the construction project cost with a higher degree of precision.
4. The time required for calculation, cost of estimation, and errors that precipitate rework in the estimation process can be significantly reduced, thereby contributing to the solution of the delay problem in construction projects. This issue is primarily attributed to the retardation period in the quantity survey and take-off of the construction project's materials.
5. The implementation of TQM in construction projects equips construction organizations and project managers to deliver the required output to their clients and attain a superior degree of quality in their construction activities.

Furthermore, a noteworthy contribution of this research is its significant managerial implications, which are reflected in enhancing project managers' focus on the quality aspects of their construction companies and promoting their engineers' productivity. The managerial implications of this study are underpinned by the significance of TQM in achieving long-term success, instilling cultural quality values, ensuring customer satisfaction, and facilitating continuous improvement, thereby preventing the occurrence of delay issues in the construction project.

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