

Research Article

Implementation of TQM and the Integration of BIM in the Construction Management Sector in Saudi Arabia

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Total Quality Management (TQM) is based on the conceptions of managing and enhancing the success of construction projects. When applied, TQM improves execution of time management of project, satisfies clients' needs, minimizes the expenses and increases the profit of contractor, and fulfils safety regulations on the construction site. This research is aimed at evaluating the impacts of employing the concepts of TQM to the construction projects in Saudi Arabia. The results of the study were obtained through utilization of a descriptive analytical approach, where 300 questionnaires were distributed to engineering firms and companies with a response rate of 200 questionnaires, hence achieving the study sample for this research. The data gathered was analyzed by applying the Statistical Package for Social Science (SPSS) program and calculating the relative importance index (RII) and the mean values. From the research conducted, the outcomes showed that the management's ability to commit using TQM while applying BIM obtained a relative importance of (0.717), while the relative importance for the management's ability to commit using TQM without the application of BIM is (0.552). The results showed that construction projects in Saudi Arabia still sustain setbacks from applying TQM concepts and suffer from the lack of administrative, scientific, and technical applications.

1. Introduction

For the past ten years, the construction industry in Saudi Arabia has endorsed a significant development. Construction developments are globally considered the most productive venture phases of any nation. Aside from the focus of construction projects on traditional endowments, currently, the focus has been extended into quality, cost-efficiency, cutback in cost, time management, and investment [1, 2].

Presently, construction projects face many developments and enhancements, which makes maintaining the projects more difficult and incomprehensible. This is particularly true for the construction projects in Saudi Arabia [3]. Contractors encounter several conflicts when planning and executing construction works such as uncoordinated drawings, specifications, absent pertinent information, and overdue delivery of design material. As a result, the majority of the regions, in Saudi Arabia, were required to apply and implement innovative techniques and principles in project

management and execution. Additionally, they needed to increase the qualifications, requirements such as skills and highly developed technology, and properties of the projects. The application of such approaches enhances production that is more accurate, offering simpler implementing tactics and eases operations. In turn, contractors will become more attentive and contribute to the application of quality insights throughout the entire duration of the projects construction [4, 5].

The growing complications of projects have resulted in many developments within the construction industry. Information and Communication Technology (ICT) is one of the few matters that has developed and evolved at a rapid rate. Over the past decade, the construction industry observed a significant transformation in ICT, which is the initiation of Building Information Modeling (BIM). BIM was developed as a modern prototype for Computer Aided Design (CAD) to be implemented within industrial and academic services [6]. Currently, BIM is recognized to be the

ultimate general compellation for an innovative approach in managing the design, construction, and maintenance of a project/structure. One definition of BIM is “an array of interrelating guidelines, developments, and tools creating an approach to administer the fundamental structure design and project information in a digital system throughout the structure’s life-cycle” [6].

Generally, theoretical progressions within BIM implies that, besides its assistance in geometric display of the structures’ implementation, it also aids the management and functional quality employment of a construction project.

Depending on research in several fields, it revealed that TQM and BIM convey association in execution and productivity of institutions, which also speculated that advanced information would eventually lead to advanced outcomes of quality throughout the construction works [7, 8] (Wheaton et al.).

Accordingly, to determine whether the implementation of TQM concepts within the construction projects in Saudi Arabia can be accomplished, this research will study the evaluation of tangible BIM application. A comparison of the TQM will also be made regarding the outcomes of the project when BIM is applied or disregarded. The results will be obtained by conducting researches, applying evaluation/assessment utilities, and the method used to comprehend the outcomes while acknowledging the primary features of the project that is represented by time and cost is incorporated to acquire the vital quality.

2. Literature Review

The application of Building Information Methodology (BIM) in the construction industry can be viewed as a method in employing Information Technology (IT) [9], which represents the analyzation, enhancement, structuring, maintenance, and processing computer-based data systems. The concept of BIM was initially publicized in 2003 by Autodesk. It was developed as an innovative and sophisticated approach for structure design, building, and management. All over the world, the BIM has been able to transform the method followed by the industrial professionals in anticipating the impact of employing technology for structure design, building and management [8].

Ever since BIM has appeared, the modeling and documentation of structure projects have endorsed exploitation of a modern approach (Lee et al.). Building Information Modeling (BIM), as a term, was originally formulated to disengage the customary Computer Aided Design (CAD) that has been primarily focused on the drawing production of structures from the previous IT and CAD generations. BIM can be identified as the enhancement and processing of structural statistics by an interoperable and viable method. Therefore, BIM is recognized as a systematic process or a set of systematic processes that lets operators integrate and retrieve structural information and domain data throughout the structures life cycle [10].

Many definitions have been associated to the Building Information Modeling (BIM) approach. The American Institute of Architects (AIA) defined BIM as a “model-based

machinery associated with a databank of project statistics” [11]. The National Building Information Model Standard (NBIMS) stated that the BIM is viewed as an “automated interpretation of substantial and efficient aspects of a facility” [12]. They also claimed that BIM is “a communal information source for data on the facility, establishing a dependable foundation for assessments during the facilities life-cycle; or in other terms from the initial origin up to the demolition of the facility” [12].

BIM has been implemented in the execution of large and high-scale projects. An example of such projects includes the recently constructed [13] Olympic, 6,000 seating, Velodrome cycle track and the 225 meters high, 48 floors, Leadenhall Building “The cheese grater.” BIM is not only implemented within massive projects, but also processed in smaller scale projects on particular components throughout the project. One example of smaller scale projects with BIM application is the new bus post located in Slough, UK. It was opened in 2011 of June, in which BIM was utilized to model and install the modular stairs [14]. Due to the anticipated compensations from BIM employment, with respect to the cutbacks of operation costs and smaller chances of error, the UK government declared that all contracts as of 2014 will compel source chain partners to work jointly by utilizing the “fully collaborative 3D” BIM [15]. The three-dimensional BIM insinuates all resource information, data, and records of all projects in a programmed method. In the United States, both the public and private sectors are collaborating to validate the application of the BIM method [16].

On the contrary, there have been several evaluations that claim that the application of BIM has not yet proven or justified it to be completely effective [17]. Succar provided a definition on BIM that emphasizes its entire aspect, which consists of a software that involves arithmetical modelling and input of information, as well as the utensils and procedures coupled with Project Management (PM). Hence, observing BIM in its complete complexion undeniably classifies it within the structure of the Project Management domain. Structural project managers are capable of employing BIM to develop the involvement among investors, in which the duration needed for documentation is reduced, resulting in profitable project results. From previous literature works on BIM features, some incorporated the detailed record of BIM application on specific project conditions such as the Heathrow Terminal 5 [13] and the Walt Disney Concert Hall [18].

3. Research Methodology

The objective of this research was obtained by manipulating the descriptive and analytical method to analyze the data collected. The data was collected through the distribution of 100 questionnaires to engineering organizations and construction companies that apply BIM concepts, and another 100 questionnaires were sent to firms and companies that do not apply BIM in their work, which totals 200 questionnaires. The sample size was determined by using a sample size calculator found online. The mathematical equation to determine the sample size is as follows:

$$n = N * \frac{Z^2 * p * (1 - p) / e^2}{[N - 1 + (Z^2 * p * (1 - p)) / e^2]} \quad (1)$$

In which n signifies the sample size, N represents the population size, Z is the confidence level, p denotes the sample proportion, and e represents the margin of error. For the following study, the population size is 412, the confidence level is 95%, the margin of error is 5%, and the sample proportion is 50%, which resulted in the sample size of 200. This census was acquired from the Saudi Engineers Association, which was based on the targeted research sample.

To assess the information gathered from the questionnaires, the SPSS program, the relative importance index, and mean values methodologies were employed.

3.1. Statistical Analysis Tools of SPSS. To analyze the data, both qualitative and quantitative data analysis techniques were utilized. The data analysis obtained was collected from the application of the SPSS 23 software. To test the normality of the data, Kolmogorov-Smirnov test of normality was applied. As for the validity, Pearson correlation coefficient for validity was used as well as Cronbach's alpha to obtain the reliability of the statistics. The following statistical tools were also applied: frequency and descriptive analysis, stepwise regression, and one-sample T -test.

The T -test was applied to verify that the mean of an item differs significantly from a theoretical value of three (middle value of the Likert scale). In situations where the P value (Sig.) is less than or equal to the significance level, then the mean of the item is substantially distinctive from the theoretical value of three. The calculated sign from the test value specifies whether the mean is considerably larger or smaller than the theoretical value. Alternatively, when the P value (Sig.) is larger than the significance level, the mean of the item is slightly different from the theoretical three value.

3.2. Relative Importance Index (RII). The assessment was manipulated to determine the most effective factors based on the relative importance integers and the Mean Relative Importance Index (RII) figures. For all the responses obtained from the questionnaire, especially those from the multisection questions, they were categorized in order. This helps in verifying the significance of the respondent's opinion on the placement of the outcomes. By utilizing this weight/ranking tactic, which is the most dependent and precise system, the Relative Importance Index (RII) will be applied to determine the significance of the response selection received from the respondents. [19]. The equation used to determine the RII is shown below:

$$RII = \frac{(\sum w)}{w_{highest} * n} \quad (2)$$

where W : Weight/rank of each response. n : the total amount of responses gathered. W highest: the highest rank/weight that can be acquired.

From the equation, the value of the RII will always be equal to or smaller than one but greater than zero.

Considering this a reference for acceptance, if the value of RII is 0.7 or higher, then it is reliable.

3.3. Data Measurement. The questionnaire was developed in order for the respondents to determine the weights of the factors by using the Likert scale as a rating system. The Likert scale is believed to be the most appropriate method for analyzing data. The ordinal scales (Likert) that were used are shown in Table 1.

3.4. Questionnaire Model. For this research, the questions used for the questionnaire were developed and selected by intensive understanding of previous studies and the perceptions of various experts. The information collected determined that the ten questions applied in the questionnaire are adequate to cover the entire research scope. The questionnaire was thoroughly structured to clarify the gathering process and to enhance the reliability and validity of the gathered information from the respondents. The questionnaire was sectioned into various divisions. The first part was targeted at gathering information on the respondents' details such as place of work, scientific qualification, experience, and employment position. The following sections were established to comprehend the evaluation responses on the higher management's ability to confide in applying the TQM concepts.

3.5. Validity of the Questionnaire. The term validity is applied when referring to the extent that a tool quantifies the item being measured. Validity is comprised of various aspects and assessment methods. Moreover, statistical validity is applied to evaluate the system validity, which encompasses internal and structural validity.

3.6. Internal Validity. The first statistical assessment was implemented to evaluate the validity of the questionnaire, known as the internal validity. A surveying example, composed of 30 questionnaires, was utilized for the measurement procedure. They calculated the correspondence coefficients of each element within a particular subject as well as the whole subject.

The corresponding coefficients of the items and the field total of the questionnaire, "the higher management's ability to commit to applying TQM concepts when the organization does not use BIM," are listed in Table 2. From the table, the p values (sig.) calculated are less than 0.05. For this field, the corresponding elements of the subject are deemed to be important at $\alpha = 0.05$. Therefore, it may be established that all the items of this subject are valid and consistent and can be used as a measuring tool.

Correspondingly, Table 3 illustrates the corresponding coefficient of each item and the field total of the questionnaire: "the higher management's ability to commit to applying TQM concepts when the organization uses BIM." The results depicted that the p values were less than 0.05, which means that the corresponding coefficients of the subjects for this field are significant at $\alpha = 0.05$. As a result, the items presented in this field are highly valid and consistent to be utilized for measurement.

TABLE 1: Likert scale.

Statement	Completely agree	Mostly agree	Slightly agree	Mostly disagree	Completely disagree
Scale	5	4	3	2	1

TABLE 2: Corresponding coefficient and field total of “the higher management’s ability to commit to applying TQM concepts when the organization does not use BIM.”

No.	Item	Pearson correlation coefficient	<i>p</i> value (sig.)
1.	What is your assessment on the performance of the higher management of engineering projects in Saudi Arabia in applying the concepts of TQM?	0.678	≤0.001
2.	What is your assessment on the performance of the higher management of engineering projects in adhering to time schedule for engineering projects?	0.669	≤0.001
3.	What is your assessment on the performance of the higher management of engineering projects in seeking to enhance project implementation?	0.590	≤0.001
4.	What is your assessment on the performance of the higher management of engineering projects in seeking to cut back on expenses?	0.676	≤0.001
5.	What is your assessment on the performance of the higher management of engineering projects in seeking to satisfy the client?	0.588	≤0.001

TABLE 3: Corresponding coefficient for each item and the field total for “the higher management’s ability to commit to applying TQM concepts when the organization uses BIM.”

No.	Item	Pearson correlation coefficient	<i>p</i> value (sig.)
6.	What is your assessment that BIM application assists the higher management of engineering projects in Saudi Arabia by applying TQM?	0.967	≤0.001
7.	What is your assessment that BIM application assists the higher management of engineering projects to commit to projects schedule?	0.973	≤0.001
8.	What is your assessment on BIM application in assisting the higher management of engineering projects to improve project performance?	0.960	≤0.001
9.	What is your assessment on BIM application in assisting the higher management of engineering projects in seeking to cut back on expenses?	0.964	≤0.001
10.	What is your assessment on BIM application in assisting the higher management of engineering projects in pursuing customer satisfaction?	0.984	≤0.001

3.7. *Structural Validity of the Survey/Questionnaire.* To guarantee the validity of the structure of the second questionnaire, the second statistical assessment is conducted and is referred to as the structure validity. This is obtained by analyzing each field’s validity as well as the validity of the whole questionnaire. This assessment is also able to identify the corresponding coefficient that has the same ranking as the Likert scale, between the one subject and all the subjects of the questionnaire.

The corresponding coefficient for each field and the entire questionnaire is illustrated in Table 4. From the table, the *p* values (sig.) are all less than 0.05, denoting that the corresponding coefficients are significant at $\alpha = 0.05$. This signifies that the fields are consistent and valid and can be manipulated as a measuring tool, which is utilized to attain the main research objective.

4. Cronbach’s Alpha Coefficient

For the internal consistency to be calculated, the Cronbach alpha was developed, which is also known as the coefficient of reliability. To rephrase, all the elements present and incorporated in the instrument quantify the equivalent entity.

In general, the average range of Cronbach alpha coefficient may vary from any value between 0.0 and +1.0, where the larger the integer, the larger the extent of internal consistency [20]. For this research, the Cronbach alpha for each field in the questionnaire was calculated.

The Cronbach alpha values calculated for the individual subject of the questionnaire and the entire questionnaire are illustrated in Table 5. The results showed that the Cronbach alpha for the fields ranged from 0.970 and 0.988, and as for the entire questionnaire, the Cronbach alpha value was 0.979. This concludes that the outcomes of the fields are highly valid and consistent and that the questionnaire is highly reliable.

4.1. *Normality Test.* The One-Sample Kolmogorov-Smirnov test procedure is manipulated to compare the identified accumulative allocation function for a variable with the quantified theoretical allocation. This test procedure should be applied in cases where the results may be standard, Poisson, or exponential. The vital difference among the identified and theoretical variables is the absolute value calculated by the Kolmogorov-Smirnov Z-value. Moreover,

TABLE 4: Corresponding coefficient of each subject and the total of both questionnaires.

No.	Subject	Pearson correlation coefficient	<i>p</i> value (sig.)
1.	The higher management's ability to commit to applying TQM concepts when the organization uses BIM	0.640	≤0.001
2.	The higher management's ability to commit to applying TQM concepts when the organization does not use BIM	0.970	≤0.001

this assessment looks into the probability that the specific allocation is able to compute such observations rationally. Normal allocated variables are fundamental necessities for the majority of the parametric assessments. Additionally, this form of assessment may be implemented to identify if a particular variable is standardly allocated or not [21].

The results of the normality assessment, other known as Kolmogorov-Smirnov, are shown in Table 6. From the table, the outcomes prove that the *p* value for a particular element is greater than the significance level of 0.05, which signifies that the allocations of these elements are normal. Hence, parametric assessments should be manipulated to perform the statistical data analysis.

5. Results and Discussion

5.1. Occupation of the Participants in the Questionnaire. From the responses gathered, 35% of the participants are site engineers with a frequency of 69, 29% are site managers with a 58 frequency, and 37% of the participants are company managers with a frequency of 73. Table 7 illustrates the results.

Figure 1 further illustrates the results obtained in a pie chart. From the graph shown, it can be concluded that the participants who are company managers have the higher percentage, followed by the site engineers and site managers.

5.2. Experience of Participants in the Questionnaire. The questionnaires showed that the participants have a 26% of "1–5 years" with a frequency of 52, 34% have "5–10" years of experience and a frequency of 67, and 41% of the participants have more than "10" years of experience with a frequency of 81. The results are shown in Table 8 and Figure 2 illustrates the results in a pie chart.

From the graph, it can be seen that the participants with more than ten years of experience are the highest percentage at 41%, followed by participants with "5–10" years at 34%, and the lowest percentage are those participants with "1–4 years" experience at 26%.

5.3. Organization of Participants in the Questionnaire. From the responses collected, 22% of the respondents are employed in government organizations, and the frequency is 43, 33% are employed in consultant organizations with a frequency of 66, and 46% of the respondents are employed in contractor organizations with a frequency of 91. The results are shown in Table 9 and Figure 3 illustrates the results in a pie graph.

From the graph shown, the participants who are part of a contractor organization had the highest rate at 46%, 33% were part of consultant organizations, and only 21% were part of government organizations.

5.4. Results of "The Higher Management's Ability to Commit to Applying TQM Concepts When the Organization Does Not Use BIM". Table 10 illustrates the mean of the field "the higher management's ability to commit to applying TQM concepts when the organization does not use BIM." It can be seen that the mean of all the items in this field has a total value of (2.76). Moreover, the proportional mean is found to be 55.16%; the relative importance is equal to 0.552; the test value is -2.404 ; and the *p* value was found to be 0.201, wherein the value is greater than the significance level $\alpha = 0.05$. When compared to the theoretical value of (3), the mean value calculated for this field is insignificantly different, including the relative importance value that is less than 0.7. From the questionnaires, the responses showed that the participants were either uncertain or neutral in their judgements for this field.

Figure 4 indicates that the questions obtained the highest mean and relative importance values, which resulted in question 2 with a mean value of 2.79 and relative importance of 0.558. It also shows that the higher management's ability to commit to utilizing the conceptions of total quality management is extensively smaller than the theoretical value (3) for the mean and smaller than 0.7 for relative importance.

5.5. Discussion of the Higher Management's Ability to Commit Utilizing the Conceptions of Total Quality Management When the Company Not Using BIM. From the research conducted and based on the majority of the respondent's judgements, the results prove that there is weak implementation of Total Quality Management concepts for delivering construction projects. The results showed that the higher management's ability to commit to utilizing the conceptions of total quality management is extensively smaller than the theoretical value (3) for the mean, which was calculated at 2.76, and smaller than 0.7 for relative importance, which was calculated to be 0.552.

This reflects on how much of an influential factor TQM concepts can be on the duration, cost, and customer satisfaction in construction projects in Saudi Arabia, wherein not applying TQM concepts can negatively affect a project. Furthermore, this research advocates that when enhancing the activities of the company's quality systems, the administrative work displays inadequacy. The presence of

TABLE 5: Cronbach alpha value for the individual field of the survey.

No.	Subject	Cronbach's alpha
1.	The higher management's ability to commit to applying TQM concepts when the organization uses BIM	0.988
2.	The higher management's ability to commit to applying TQM concepts when the organization does not use BIM	0.970
All items of the questionnaire		0.979

TABLE 6: Kolmogorov-Smirnov assessment.

Subject	Kolmogorov-Smirnov	
	Statistic	p value
The higher management's ability to commit to applying TQM concepts when the organization does not use BIM	0.224	0.897
The higher management's ability to commit to applying TQM concepts when the organization uses BIM	0.250	0.849

TABLE 7: Frequency and percentage of participants occupation.

Job	Frequency	Percent (%)
Company manager	73	37
Site manager	58	29
Site engineer	69	35
Total	200	100

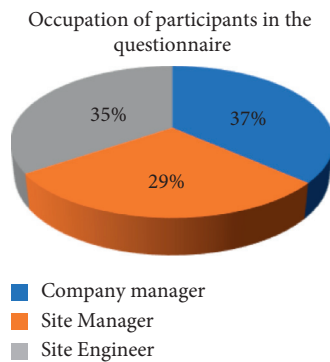


FIGURE 1: Occupation of Participants in the questionnaire.

TABLE 8: Frequency and percentage of experience of participants.

Experience	Frequency	Percent (%)
1-5 years	52	26
5-10 years	67	34
More than 10 years	81	41
Total	200	100

inefficiency in setting methods and techniques for reaching a critical observation could assist in guaranteeing that TQM is manipulated in construction projects. All of the aforementioned results prove that the higher management is unable to commit to manipulating the conceptions of total quality management when they do not utilize BIM in construction projects.

5.6. Results of "The Higher Management's Ability to Commit Applying TQM Concepts When the Organization Uses BIM". Table 11 illustrates the mean of the field "the higher management's ability to commit to applying TQM concepts

Experience of participants in the questionnaire

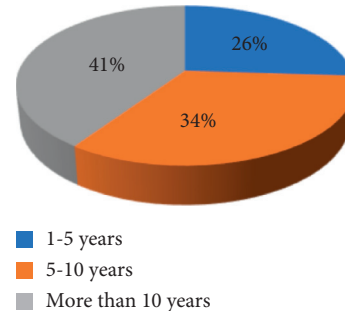


FIGURE 2: Frequency and percentage of experience of participants.

TABLE 9: Frequency and percentage of organization of participants.

Organization	Frequency	Percent (%)
Government	43	22
Consultant	66	33
Contractor	91	46
Total	200	100

Organization of participants in the questionnaire

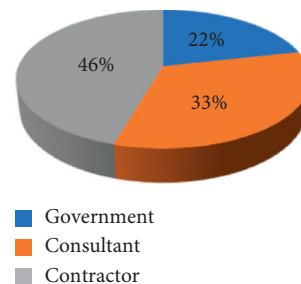


FIGURE 3: Percentage of organization of participants.

when the organization uses BIM." The results in the table show that the mean of all the items in this field has a total value of 3.59. Additionally, the proportional mean is calculated to be 71.71%; the relative importance is found to be 0.717; the test value is 0.860; and the p value was calculated to be 0.402, wherein the value is greater than the significance

TABLE 10: The values of the means and test quantity for “the higher management’s ability to commit to applying TQM concepts when the organization does not use BIM.”

No.	Item	Mean	Proportional mean (%)	Relative importance	Test value	<i>p</i> value (sig.)	Rank
1	What is your assessment on the performance of the higher management of engineering projects in Saudi Arabia in applying the concepts of TQM?	2.76	55.16	0.552	-2.537	0.105	3
2	What is your assessment on the performance of the higher management of engineering projects in adhering to time schedule for engineering projects?	2.79	55.81	0.558	-2.031	0.125	1
3	What is your assessment on the performance of the higher management of engineering projects in seeking to enhance project implementation?	2.75	55.00	0.550	-2.544	0.355	4
4	What is your assessment on the performance of the higher management of engineering projects in seeking to cut back on expenses?	2.72	54.35	0.544	-2.781	0.322	5
5	What is your assessment on the performance of the higher management of engineering projects in seeking to satisfy the client?	2.77	55.48	0.555	-2.128	0.098	2
All items of the field		2.76	55.16	0.552	-2.404	0.201	

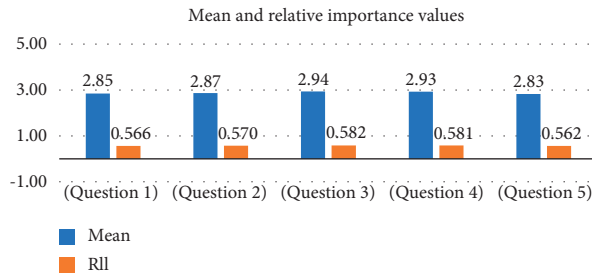


FIGURE 4: Mean and relative importance values of “the higher management’s ability to commit to applying TQM concepts when the organization does not use BIM.”

TABLE 11: The values of the means and test quantity for “the higher management’s ability to commit to applying TQM concepts when the organization uses BIM.”

No.	Item	Mean	Proportional mean (%)	Relative importance	Test value	<i>p</i> value (sig.)	Rank
6.	What is your assessment that BIM application assists the higher management of engineering projects in Saudi Arabia by applying TQM?	3.56	71.13	0.711	0.568	0.571	5
7.	What is your assessment that BIM application assists the higher management of engineering projects to commit to projects schedule?	3.60	72.10	0.721	1.080	0.282	2
8.	What is your assessment on BIM application in assisting the higher management of engineering projects to improve project performance?	3.57	71.45	0.715	0.736	0.463	4
9.	What is your assessment on BIM application in assisting the higher management of engineering projects in seeking to cut back on expenses?	3.61	72.26	0.723	1.126	0.262	1
10.	What is your assessment on BIM application in assisting the higher management of engineering projects in pursuing customer satisfaction?	3.58	71.61	0.716	0.792	0.430	3
All items of the field		3.59	71.71	0.717	0.860	0.402	

level $\alpha = 0.05$. By observing the test value, it is seen that the value was a positive integer, which means that the average of this field is significantly greater than the theoretical value (3) and is larger than the relative importance value. From the questionnaires, the responses showed that the participants

were fond of and accepted the field “the higher management’s ability to commit to applying TQM concepts when the organization uses BIM.”

Moreover, Figure 5 illustrates the questions that obtained the highest and lowest values of mean and relative

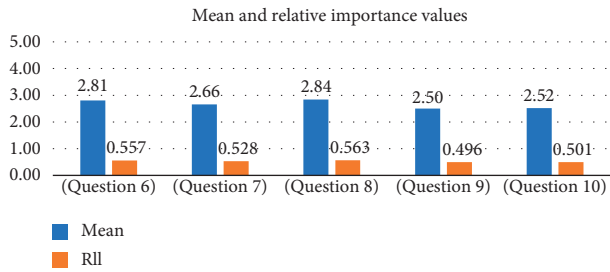


FIGURE 5: Mean and relative importance values of “the higher management’s ability to commit to applying TQM concepts when the organization uses BIM.”

importance. Based on the figure, it is concluded that the question with the largest values is question 9 with a mean of 3.61 and relative importance of 0.723. The question that has the lowest values is question 6, with a mean value of 3.56 and relative importance value of 0.711. Furthermore, it depicts that the mean and relative importance of “the higher management’s ability to commit to applying TQM concepts when the organization uses BIM” is significantly greater than the theoretical value (3) for mean and greater than 0.7 for relative importance.

5.7. Discussion of the Higher Management’s Ability to Commit to Utilizing the Conceptions of Total Quality Management When the Company Uses BIM. The results showed that a large part of the respondents support the question of the engineering departments’ ability to apply the concepts of TQM when utilizing BIM in their companies. The question with the highest value is question 9, “What is your assessment on BIM application in assisting the higher management of engineering projects in seeking to cut back on expenses?” which acquired a mean of 3.61 and relative importance of 0.723.

In addition, the results proved that the companies that applied BIM were capable of adhering to project schedule, cost, and customer satisfaction unlike those companies that do not apply BIM in their projects. Moreover, all the results gathered from this study prove that the higher management is unable to commit to applying TQM concepts when BIM is not used in the construction projects. Hence, the mean and relative importance of “the higher management’s ability to commit to applying TQM concepts when the organization uses BIM” is considerably higher than the theoretical value (3) for the mean that is 3.59 and higher than 0.7 for the relative importance, which is 0.717.

6. Conclusion

Total Quality Management (TQM) represents the management method for continuous success through client satisfaction. By applying the concepts of TQM, operators or project owners are able to adhere to time schedule, meet all the clients’ demands, increase revenues, minimize expenses, and accomplish safety protocols. Moreover, they are able to maintain management and reliability within the

fundamental constraints, which are time, cost, and quality of a project.

The results collected were dependent on the dominance of the respondent’s judgements and showed that applying the TQM concepts when implementing construction projects is inadequate and incomplete, and the higher management cannot commit to applying TQM concepts within projects. The majority of the respondents judged that, within the construction divisions, accomplishing the administrative, scientific, and technical abilities while applying TQM is weak and insufficient. This study proposes that the organizations lack a sufficient committee to manipulate the TQM concept.

The aim of this research was to focus on the significance and assess the influence of TQM application within the construction industry. This was completed by using descriptive and analytical approaches, as well as the SPSS program, the relative importance, and the mean values. The results were gathered by distributing questionnaires to engineering organizations and companies, which discussed the significance of TQM concepts on construction projects in Saudi Arabia [22–24].

Data Availability

The data are available upon request to the corresponding author.

Disclosure

The authors acknowledge that this paper has been submitted as a preprint in Research Square (NOT PEER-REVIEWED) on 17th March 2021.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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