Enabling Quality in Lean Construction: Integrating the Principles of Total Quality Management with 9D-BIM

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Abstract

Recently Total Quality Management (TQM) has been proved to be the most successful continuous improvement system. The total quality management (TQM) process has been considered a modern system in the field of quality, after quality assurance, quality control, and ISO in the Construction sector. Although it was initially implemented in the manufacturing and automobile industries in Japan, later it was adopted by the construction sector. Design and construction are the two important phases of the project life cycle that affect the quality of the outcome of construction projects significantly. The current quality management practice in the construction industry includes issuing quality checklists, site inspection and testing, non-conformance reporting, and corrective action but there is not a systematic way of recording the inspected data, hence, the quality status of construction cannot be determined. The newly emerging technologies such as Building Information Modelling (BIM) and lean construction can be used to control the quality of construction. One of the most popular management system standards among construction companies is ISO 9000—the construction sector has the fourth highest number of quality assurance certificates of all sectors in the world. A positive relationship between ISO 9000 certification and firm performance was observed in 69% of existing cross-sectional studies. TQM and BIM convey some level of association in terms of execution, productivity, information requirements, and quality outcomes throughout the construction process although not much work is done in mapping their common denominators. This research focuses on mapping the TQM elements and BIM dimensions as means of inducing Quality as part of the ninth dimension of BIM (9D BIM). A framework for enabling quality in lean construction through the integration of TQM and 9D-BIM is proposed in this study.

1. INTRODUCTION

This section will shed light on the background of Total quality management, elements of Total quality management, and dimensions of Building information modelling to have a better understanding of the concepts of TQM. This research aims to “Induce quality as the 9th dimension to BIM in construction project management by understanding the various aspects of Total Quality Management”. The key objectives of the research to achieve this aim are (i) to examine the significance of TQM implementation in a construction enterprise; (ii) to recognize stakeholders' and employees' current perspectives on total quality management implementation; (iii) to map BIM dimensions and TQM elements on each other- common and uncommon denominators, and; (iv) examine the benefits and obstacles of TQM implementation

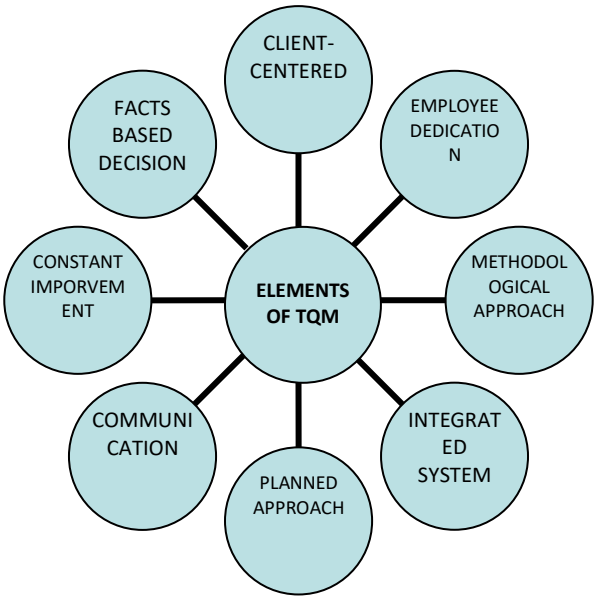
1.1 BACKGROUND

In the construction sector, Quality has emerged to be one of the deciding factors in today's competitive market for tendering, contracting, and designing work [1]. It is important to value relationships with clients, seek their feedback, and provide them with products and services of high standards to remain in business. This can be achieved by maintaining good communication with the stakeholders and employees, showing coordination with all concerned departments on site, and aiming to improve constantly [1]. To fulfill these demands, a framework is required. In recent years, the total quality management framework has proved to be the most successful in overcoming these challenges. Before TQM, ISO was considered to be the basis of quality standards.

1.2. ISO AS QUALITY STANDARD

Standards are significant in local and global commerce because they provide many businesses with a competitive edge in specific sectors. Certain standards generate easily recognisable benchmarks that promote competitiveness and worldwide recognition. Standards help commerce by increasing efficiency, improving goods and service performance, increasing dependability, making upkeep easier, and lowering costs. ISO was first established on 23 February 1947 in London. ISO originated from the Greek term "isos" which means "equal". Since 1947, ISO has issued over 18000 global norms relating to a wide array of industries, including infrastructure, advanced manufacturing, and technological innovation. The initial edition of ISO 9000 norms after many years of negotiation and study was issued in the year 1987 by ISO. ISO standards are established by international teams of researchers who are members of bigger groupings known as technical bodies. All parts of the norm, such as its range, important terminology, and purpose, are negotiated by these technical bodies.

1.3. TQM ELEMENTS



The eight elements of Total Quality management

1.4. DIMENSIONS OF BIM

1. **3D BIM:** BIM's 3D modelling feature allows specialists to examine virtual models of planned projects in three dimensions [2]. This allows the customer, contractor, and all other stakeholders to have a more thorough and accurate picture of the project.

2. **4D BIM:** As the dimensions of BIM increase, the level of detail also increases. 4D BIM has the same advantages as 3D BIM along with scheduling or time elements. This helps to reduce delays and provides an opportunity to properly pan the execution of various tasks [3].

3. **5D BIM:** 5D BIM is 3D BIM along with time and cost. 5D BIM provides additional detail of cost estimates which can be modified as the project progresses [4]. This helps to visualize an estimated cost before the start of the project. Any modifications in the model will change the estimates, which would help in decision making and alienate any kind of budget Offshoot.

4. **6D BIM:** This BIM dimension provides detailed information for facility management and maintenance [5]. It is also called integrated BIM. This helps in making faster and better decisions and preparing for any maintenance and detailed analysis of the operational aspect of the project.

5. **7D BIM:** From the design stage through the destruction stage, 7D BIM aids in the management of the facilities or assets [6]. This helps to ease the repairs task at any stage of the project. It also provides a guide for the maintenance of the project and makes the whole process sustainable.

6. **8D BIM:** During the planning and operational stages of a project, 8D BIM incorporates safety data into the visual model of the structure [7].

2. QUALITY MANAGEMENT

Mohammad Abazid, Huseyin Gokçekus, and Tahir Çelik (2021) in their literature have worked towards the integration of BIM and implementation of TQM in Saudi Arabia. They have used a questionnaire survey to collect data from companies that use BIM and companies which do not use BIM to compare the relative importance between the two. The outcome of the literature showed that for implementing TQM, the companies which use BIM have a higher relative importance index than companies that do not use BIM.

A. M. Alawag, et al (2020) have researched the benefits of TQM implementation in an organisation. They have identified that customer satisfaction is one of the major benefits of TQM implementation. TQM emphasizes constant improvement to set higher standards of quality. Some of the other benefits include a better relationship with clients, referrals from clients for new opportunities, product quality, and market share.

Nguyen T. T. (2017) surveyed Vietnamese firms to find further insights into the relationship between TQM and organisational culture. The survey was conducted using validated survey instruments and survey had 104 respondents. It was found that clan or adhocracy cultures are not favourable for the implementation of the TQM framework. Furthermore, this research also found a strong and favourable link between TQM adoption and improved company performance.

Before TQM came into existence, ISO was considered as standard for quality. The latest version of ISO 9000: 2000 was released in the year 2000. This is discussed more in the next section.

2.1 9D BIM

The 9D BIM dimension of BIM also referred to as lean construction, optimizes and streamlines all the processes involved in the implementation of a project through the digitisation of processes. On a building site, poor planning can cause project delivery delays, which increases the initial budget. The 9D BIM method was created to effectively eliminate waste, maximize all of the resources used during construction, and boost productivity.[12]

The principles lean construction uses are:

- optimising, reducing, or eliminating activities that do not add value to the process – To achieve process improvement, special attention is paid to all aspects of the supply chain (from production to transportation of materials to the construction site). The entire production chain is analysed, unnecessary or repetitive processes are identified, and strategies are devised to simplify or replace them. For example, the use of means of transport is planned to be optimised and perfectly matched to the quantities to be transported. With this in mind, the use of larger trucks for transporting materials is preferred, reducing the number of trips required;
- considering the customer's needs – Before starting any project, it is necessary to identify the customer's needs using market research and satisfaction surveys, even on projects that have already been delivered. Activities that do not add value to the process are not of interest to the client and therefore the client is not willing to pay for them. On the other hand, focusing on the customer's needs is more likely to make all operations run smoothly;
- standardising processes – Construction is one of the sectors with the highest rate of unforeseen events: each project is unique and unique are the conditions that come into play at the construction site (completion time, labour, local conditions, availability of equipment, materials, etc.). To minimise site diversification, standardised construction processes should be adopted, reducing the possibility of problems and improving the ability to manage unforeseen events. Reducing these variables allows the construction company to maintain a predefined standard and ensure a smoother and safer process;
- optimising time – The time variable is influenced by the activities of transport, waiting, processing, inspection, etc. Optimising all these activities has an impact on the quality of the work and client delivery times;
- increasing the transparency of the process – This principle contributes to greater participation of all those involved in the process, who can actively and more consciously intervene in the development of improvement solutions.

How the construction process is managed differs between traditional and lean construction methods. In the lean method, activities are divided into:

1. activities that add value to the project
2. activities that do not add value to the project.

The concept of value is directly linked to the degree of customer satisfaction: therefore, if the customer is not willing to pay for a given activity, it is categorised as an activity that does not add value to the final product

According to this criterion, lean thinking aims to eliminate as much waste as possible already in the project management phase. In the traditional method, however, activities are divided into sub-processes and the yardstick is not the degree of customer satisfaction. There is no careful management of waste, nor is there any planning of activities in the preliminary phase.

2.2 The International Organization for Standardization's ISO 9000

The ISO maintains ISO 9000 as a series of quality control framework guidelines that concentrates on designing, developing, manufacturing, implementation, and maintenance. ISO 9000 was created to make global trade of products and services easier by establishing a single standard of quality norms. It was initially developed in 1987 and focuses on quality management. It specifies continuous enhancement as an organization's use of methods and processes to satisfy clients' expectations. As a result, ISO focused further on fault discovery than mitigation (ISO, 2000). ISO 9000: 1994 was released in 1994, and it focuses on quality control in areas of flaw mitigation to provide client satisfaction and expense reductions. In 2000, the ISO released ISO 9000: 2000, a new edition of the ISO 9000 set which emphasized

Quality Control Systems by directing efforts to quality accomplishment, with a stronger emphasis on manufacturing method instead of product or service quality. ISO 9000 series emphasizes setting quality standards for different aspects of the project to execute the project successfully and cost-effectively. It provides a clear and concise written method to execute various tasks. Emphasis is given to client relations, communication, reducing defects, and production costs. However, ISO 9000 quality standards are far below TQM. ISO 9000 certification does not guarantee a product of high quality. There are several norms in ISO 9000 which makes it far below when compared to TQM certification. These include excessive bureaucracy and a lack of adaptability and control of products and services.

2.3 CRITIQUE

Although TQM implementation has many successful examples, there are some which failed to be successful. This section will review the literature of scholars who have found barriers to the implementation of TQM.

Beryl A. Radin and Joseph N. Coffee (2019) in their article have mentioned the barriers and failures of TQM implementation. They have identified that impatience, reluctance from stakeholders and managers, and obsession that their product is already of good quality were some of the reasons for failure. A J Likitha, et al (2018) pointed out that providing training and education to the employees is usually not included in the values of an organisation's mission. Also, providing continuous training and education to employees on-site is expensive and not beneficial for small organisations. They also found out that the process of implementing TQM within an organisation causes sudden changes in the organisation. These changes sometimes may harm the existence of the company. TQM implementation causes extra pressure and strain on the employees to maintain quality.

Uche Nwabueze (2016) clarifies that sometimes it may be difficult or impossible to overcome the barriers of TQM. The barriers like lack of awareness, lack of training and education, the strain on employees for maintaining quality, change of culture in the organisation, no proper execution of the plan, improper communication, lack of top management commitment, and fear of losing jobs among employees are difficult to overcome but can be if organisations commit to it and understand that it is not a phase. TQM is permanent and requires constant improvement. Organisations have to let go of old ways and overcome resistance through a commitment to become a TQM company.

3 METHODOLOGY

This research focuses on finding out the extent to which adoption of BIM helps in implementing TQM in the project and within the organisation and will look into the advantages of establishing a TQM framework inside an enterprise and assess whether BIM dimensions assist to boost quality services and client satisfaction. Since the emphasis of this research is on the benefits of TQM implementation in the organisation from several viewpoints, the author had to concentrate on contractors, customers, and end users.

To achieve the author's objectives, two data collection methods were used:

i) Literature Review

Articles published in journals or uploaded to various forums are easily accessible to the author and these articles were used to get an understanding of TQM and BIM concepts and then further research was conducted. These articles are usually peer-reviewed and have high standards and credibility.

ii) Questionnaire survey

This method is considered to be the cheapest mode to collect quantitative data. Also, the response rate in this type of survey is more than compared to other data

collection methods, the amount of effort required by the researcher is comparatively less and the cost of distributing the questionnaires and then collecting the responses is practically zero [11]. A questionnaire was sent via email to employees, managers, stakeholders and clients. As a result, this study utilised a realistic philosophy to gather information from employees, stakeholders, managers, and end users via questionnaires.

The research approach is determined by the study goal and targets. As a result, for the successful completion of this study, the deductive research approach was adopted. There are three main reasons for using a deductive research approach.

i) TQM literature provides for the development of theories that may subsequently be validated. Ghauri and Gronhaug (2005) claim that this method is deductive.
ii) The outcomes of this study are being generalised to reflect the full demographic. Because deduction tries to generalise conclusions from samples to the whole, the deductive research approach is the best option. On the other hand, the inductive approach intends to develop hypotheses.
iii) Even though there are certain pitfalls which might include no response to the survey and other risks, the deduction research approach can be a lower risk strategy as compared to the inductive research approach. In the inductive research approach, there is a concern of not being able to obtain relevant information trends and hence hypothesis will not develop.

Because of these three prominent reasons, this study is conducted by adopting a deductive research approach.

3.1 PURPOSE OF RESEARCH

The purpose of the research is determined by the study's goals and objectives [8]. This study will concentrate on comprehending the situation from the viewpoint of the participants to aid in the study of the phenomenon. The purpose of the research can be divided into two categories:

i) Exploratory research

The goal of exploratory research is to acquire fundamental data that allows one to comprehend the phenomenon and generate hypotheses [9]. This is typically utilised by an author who has limited comprehension of the issue or phenomenon to deal with the focus of the research. Furthermore, it is distinguished by versatility since whenever the scholar becomes aware of a new notion, he/she may divert the investigation to a different path.

ii) Conclusive research

The goal of conclusive research is to assess and evaluate particular hypotheses as well as explore the links among varying factors after the clarity of research issues or facts of the study has improved [10].

This study has adopted both approaches. Starting with conclusive research and then using exploratory research approach in order to achieve the objectives of the project.

4 RESULTS

4.1 Self-administered Questionnaire Participant Attributes

This chapter explains the demographic attributes of 71 surveys administered to individuals who are linked to the construction sector, such as civil engineers, architects, construction managers, clients. There were two sets of same questionnaires which was emailed to professionals working in the construction sector in India and United Kingdom.

The finding of the queries is subdivided into four categories: Education, Profession, Number of years of experience and nature of projects worked on.

4.1.1 Education

23.7% of the respondents have completed their Doctor of Philosophy, 44.7% have completed their Masters, 15.8% have completed their Bachelors and the remaining 15.8% have completed their Diploma in a field related to construction sector. This is illustrated in form of pie chart in figure 1. From the chart shown, it can be concluded that most of the respondents have a degree of Masters or PhD.

4.1.2 Profession

31.6% of the respondents are civil engineers, 28.9% are construction managers, 13.2% are architects, 10.5% are construction firm owners and remaining 15.8% respondents are professors.

4.1.3 Experience

18.4% respondent have experience in the range of 10-20 years, 23.7% have experience in the range of 5-10 years, 23.7% people have experience in the range of 3-5 years and 34.2% respondents have experience of 0-3 years in the construction sector.

4.1.4 Type of projects

39.5% of the respondents have worked in private projects, 23.7% have worked in public projects and 36.8% have worked in both- public and private projects.

4.2 Analysis

The goal of this study was achieved by combining statistical methods to examine the data acquired. A total of 100 questionnaires were sent out to individuals working in the construction sector in UK and India. 50 questionnaires were sent to workforce in India and 50 questionnaires to workforce in UK. Out of these, there were 33 responses form UK and 38 responses from India. Since, the responses are in agreement and disagreement, Likert scale is used to do the analysis.

1. Response Rate

There was a total of 100 questionnaires sent out. 33 responses from UK respondents and 38 responses from India was received. Therefore, response rate is responses received/ questionnaires sent out.

Response rate= (33+38)/100 = 71%

Relative importance index for UK respondents

No.	Question	Mean	Proportional Mean	Relative importance index	Rank
1.	How much do you agree that you are aware of TQM elements and BIM dimensions?	3.73	74.54%	0.75	5
2.	How much do you agree that you are aware of TQM implementation in your organisation?	3.73	74.54%	0.75	5
3	How much do you agree that there is a lack of awareness regarding TQM and BIM integration?	3.30	66.06%	0.66	16
4.	How much do you agree that TQM implementation means satisfying external customers?	3.58	71.51%	0.72	11
5.	How much do you agree that TQM implementation is cost-effective?	3.61	72.12%	0.72	11
6.	How much do you agree that TQM implementation helps	3.76	75.15%	0.75	5

	meet deadlines?				
7.	How much do you agree that TQM implementation will be beneficial for your organisation?	3.70	73.93%	0.74	8
8.	How much do you agree that TQM implementation will lead to the elimination of defects?	3.88	77.57%	0.78	1
9.	How much do you agree that TQM implementation will give a competitive edge to an organisation when compared to other enterprises that have not adopted TQM?	3.58	71.51%	0.72	11
10.	How much do you agree that your organisation has a system in place for receiving customer feedback?	3.88	77.57%	0.78	1
11.	How much do you agree that top management is committed to quality in you are organisation?	3.52	70.30%	0.70	15
12.	How much do you agree that BIM can ease the adoption of the TQM approach?	3.79	75.75%	0.76	4
13.	How much do you agree that your organisation has a quality improvement plan in place?	3.91	78.18%	0.78	1
14.	How much do you agree with the need to switch current construction practices to TQM and BIM?	3.64	72.72%	0.73	10
15.	How much do you agree there should be education provided to site developers and stakeholders with regards to BIM techniques that will ease the adoption of the TQM approach?	3.58	71.51%	0.72	11
16.	How much do you agree that the usage of BIM tools during construction will play an important role in achieving TQM in construction?	3.70	73.93%	0.74	8

Relative importance index for Indian respondents

No.	Question	Mean	Proportional Mean	Relative importance index	Rank
1.	How much do you agree that you are aware of TQM elements and BIM dimensions?	3.79	75.78%	0.76	1
2.	How much do you agree that you are aware of TQM implementation in your organisation?	3.53	70.52%	0.71	7
3	How much do you agree that there is a lack of awareness regarding TQM and BIM integration?	3.61	72.10%	0.72	2
4.	How much do you agree that TQM implementation means satisfying external customers?	3.45	68.94%	0.69	9
5.	How much do you agree that TQM implementation is cost-effective?	3.58	71.57%	0.72	2
6.	How much do you agree that TQM implementation helps meet deadlines?	3.47	48.42%	0.48	16
7.	How much do you agree that TQM implementation will be beneficial for your organisation?	3.58	71.57%	0.72	2
8.	How much do you agree that TQM implementation will lead to the elimination of defects?	3.45	68.94%	0.69	9
9.	How much do you agree that TQM implementation will give a competitive edge to an organisation when compared to other enterprises that have not adopted TQM?	3.45	68.94%	0.69	9
10.	How much do you agree that your organisation has a system in place for receiving customer feedback?	3.39	67.89%	0.68	14
11.	How much do you agree that top management is committed to quality in you are organisation?	3.37	67.36%	0.67	15
12.	How much do you agree that BIM can ease the adoption of the TQM approach?	3.58	71.57%	0.72	2
13.	How much do you agree that your organisation has a	3.55	71.05%	0.71	7

	quality improvement plan in place?				
14.	How much do you agree with the need to switch current construction practices to TQM and BIM?	3.47	69.47%	0.69	9
15.	How much do you agree there should be education provided to site developers and stakeholders with regards to BIM techniques that will ease the adoption of the TQM approach?	3.45	68.94%	0.69	9
16.	How much do you agree that the usage of BIM tools during construction will play an important role in achieving TQM in construction?	3.58	71.57%	0.72	2

2. Validity of Questionnaire

Questions are considered significant if the value of sigma(p) is less than 0.05. From the tables above, we can conclude that the questions are significant.

3. Relative Importance Index

The relative importance of quality elements is determined using the Relative Importance Index (RII). Relative importance is calculated to know the importance of different factors in the questionnaire.

$$\mathrm{RII} = \frac{(\sum w)}{w\_\mathrm{highest}\hat{}xn},$$

5 DISCUSSIONS

5.1.1 QUESTIONNAIRE FINDINGS

Participants in the surveys were provided with four segments, each separated into a series of questions to assess and determine if all enterprises need a TQM approach. As a result, this subsection is divided into four segments, as follows:

I) Respondents' understanding of TQM and BIM

Several companies have adopted a TQM approach, but individuals working in the organisation do not know why it was implemented, which, in turn, has an impact on performance and the effectiveness of the quality strategies. The author using a questionnaire has asked queries about their awareness of TQM elements and BIM dimensions, and the benefits of TQM and BIM implementation to assess the level of knowledge of the respondents of quality strategies in evaluating the knowledge of construction sector professionals and determine whether they acknowledge the TQM notion and its existence.

ii) Respondents' view on elements of TQM

One of the objectives of the research is to understand the current perception of the workforce towards quality. Therefore, to get further insights on this, the researcher has asked a few questions to the respondents based on cost, time, defects, and customer satisfaction. The responses indicate that majority of the workforce has confidence in the TQM framework and its advantages. However, a minority of the workforce is not confident about its advantages related to cost, time, elimination of defects, and customer satisfaction. The main reason for this might be a lack of training and education.

iii) TQM framework in organizations

There were four questions regarding this section in the questionnaire. These were asked to know more about top management's commitment toward TQM implementation, improvement plans in the organisation, a system for receiving customer feedback, and a competitive edge in the market. 69.7% of respondents from the UK agreed that the top

management in their organisation is committed to quality, at the same time, 12.1% of the respondent from the UK showed little confidence in leadership commitment towards quality. 42.7% of respondents from India agreed with Top management's commitment while 26.3% disagreed. 66.7% of the respondent from the UK and 60.6% of respondents from India agreed that their organization has an improvement plan in place for quality. These would help these organisations set higher standards of quality in future projects. 51.5% of respondents from the UK and 52.7% of respondents from India agreed that their organisation has a system in place to seek customer feedback. This feedback from clients plays a critical role in developing a relationship with the client which will in turn help the organisation secure future projects from the same client. However, still, almost half disagreed that their organisations do not have a system to seek customer feedback. From the responses to the questionnaire, it was evident that 72.7% of respondents from the UK and 55.3% of respondents from India believe that TQM implementation within an organisation gives them a competitive edge in the market when compared to organisations that have not adopted the TQM framework.

iv) BIM and TQM integration

Participants were asked to share their views in terms of the Likert scale on whether BIM eases the process of adoption of the TQM framework, whether BIM tools help achieve TQM standards, and whether there is a need to switch the traditional practices of construction to TQM and BIM framework.57.5% respondents from the UK and 52.6 respondents from India agree that the BIM dimensions ease the process of adoption of TQM framework within an organisation. 54.5% of respondents from the UK and 55.3% of respondents from India believe that BIM tools like Revit, Navisworks, etc. help achieve the set quality standards. 72.8% of respondents from the UK and 60.6% of respondents from India believe that there is a need to switch traditional construction techniques with BIM and TQM practices. This shows that the majority of the workforce both in the UK and India believe that TQM and BIM are the futures of the construction sector.

5.2 BENEFITS OF TQM IMPLEMENTATION:

Considering the viewpoint of the UK workforce in construction, TQM might be useful in terms of increasing revenue, improving workforce happiness, reducing consumer grievances, motivating staff, and reducing operating flaws. Furthermore, organisations that please their customers with high-quality standards have a better chance of doing business with them again and receive referrals that might help them gain new work opportunities. TQM enables enterprises to enhance competitiveness by increasing profitability, extending customer base, boosting credibility, and above all remaining in business and giving more employment to the local community.

5.3 CHALLENGES IN THE ADOPTION OF THE TQM FRAMEWORK

Due to the current financial condition in the construction sector, findings reveal that perhaps the main difficulty would be market competition. This affects the supplier's ability to supply services and the contractors with whom they desire to collaborate may be limited. As a result, developers must sacrifice sourcing, resource choices, and layout potentially resulting in quality issues, meanwhile, construction companies must continue performing in the market and maintain financial viability.

In a traditional project, a lot of importance was allotted to the price of tenders and not quality. So, a challenge emerges for individuals to adopt a new work culture. Top management's commitment to quality plays a vital role in TQM implementation. It is critical to take suggestions from the employees and include their feedback in decision-making. Many companies do not implement TQM to its full extent because they believe

that their product and services are already of high quality. Companies need to proactively invest their time and effort in TQM implementation for keeping their competitive edge in the market.

6 CONCLUSIONS

This research was carried out in an attempt to induce quality as the 9th dimension of BIM. For this purpose, research was conducted to get insights into the benefits of TQM implementation within an organisation and understand the perspective on quality management of different stakeholders, clients, managers, and engineers associated with the construction field. This section will conclude with the findings of various activities carried out for achieving the objectives of the project.

- From the findings of the research and questionnaire survey, it can be concluded that TQM implementation within an organisation helps gain a competitive edge over other organisations in the market that do not follow the TQM framework. However, respondents also agreed that there is a need for more awareness among the professionals, proper training and education need to be provided to the staff and top management needs to commit themselves to set higher standards of quality.
- From the responses to the questionnaire survey, it was found that still, several professionals in the construction field believe that TQM implementation will not or does not help in reducing costs, meeting deadlines, reducing or eliminating errors, and satisfying the demands of the client.
- After understanding the dimensions of BIM and elements of TQM, we can conclude that BIM dimensions help to achieve the TQM framework. An example of this can be seen by considering the Communication element. BIM is based on the concept of ‘one source of truth. This helps to achieve the open lines of communication required for the TQM framework. It also makes the communication process faster and more efficient.
- Considering the response to the questionnaire and literature review, it can be concluded that the adoption of the TQM framework helps make the execution of the project more cost-effective, reduce and eliminate errors, helps the employees in meeting deadlines, and cope with clients’ demands. This also helps the organisation in doing future work with the same clients and get new opportunities through referrals from satisfied clients. There were several challenges and obstacles discussed in brief in way of implementing the TQM framework. Some of them were top management commitment, lack of training and education to employees, lack of awareness, and present financial condition of the market. However, some of these challenges can be dealt with by using BIM tools. One of the examples of this is that lack of communication can be dealt with using the BIM concept of “one source of truth”.

7 RECOMMENDATIONS

1. Top management needs to commit toward quality for the successful implementation of the TQM framework in their organisation. Top management should provide open lines of communication to employees and seek their feedback for decision-making and proposing solutions.
2. Human resource needs to put in extra effort to train and educate their employees about the advantages and purpose of implementing the TQM framework. Employees should be motivated to come forward if they are facing challenges in adopting new work culture.

3. Businesses need to be humbler to new technologies and ideas and get rid of the obsession that there is no more room for improvement. Businesses should work to find new ways of improving the standard of their products and services.
4. Contractors should seek and value feedback from clients. Contractors need to have a healthy relationship with their prior clients for future opportunities.
5. Government and policymakers should introduce policies and norms which help in setting higher standards of quality in every aspect of the project.
6. More funds and research should be dedicated to finding new and innovative ways to improve quality in a cost-effective and time-saving manner.

7.1 RECOMMENDATION FOR FURTHER RESEARCH

1. Further research can be conducted in developing new software to measure the level of TQM implementation at various stages and departments of the project. This would help in ranking and detecting errors quicker and more efficiently.
2. More research can be conducted to find out the critical success factors to be taken care of while implementing of TQM framework.
3. Research can be done to highlight the benefits of TQM on an individual level to shareholders, managers, contractors, engineers, architects, and clients. This would help raise awareness across every department concerned with the successful execution of the project.
4. Research on how external factors such as political influence, policies, pandemics, and climatic conditions affect the process of implementation of the TQM framework.
5. Research on how BIM and TQM denominators can be integrated to make a single phenomenon would ease the whole process of adopting the TQM and BIM framework to a great extent.

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