Nanotechnology Perceptions
ISSN 1660-6795
www.nano-ntp.com

Implementation of QMS For Construction Project Using Advance Software

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Starting from inception, the construction industry is one of the most crucial industries in any nations development and growth. Over the recent past, the construction sector is on the boom with India being a significant player among other countries. To address the deficiencies in quality and non-standardization of the industry, Indian construction sector has undergone major upgradation by adapting ISO 9001:2015 quality Policies in the projects. Many organizations are also using ERP system for optimizing their business processes. Use of these advanced systems has proven to have many benefits. However, research on combining both these systems is very limited. The objective of this study is to explore the status of QMS being implemented in construction projects using ERP, its advantages, challenges and the remedial measures of challenges. Data was collected through online survey from the participants chosen by their specific characteristics, qualities and expertise. The data was analyzed for its reliability, correlation and ranking. The analysis revealed that the use of ERP for QMS implementation is low despite familiarity of both the systems in the industry. The combination of ERP and QMS has many advantages in efficiency, productivity, communication, collaboration, risk management, etc. Despite having the advantages, it is susceptible to challenges in complexity, usability, high cost, system reliability, etc. These challenges could be addressed by adopting the strategies like phased implementation, tasks automation, using cloud-based systems and providing training to the employees, etc. The findings suggest that while the implementation of QMS using ERP in a construction project has some challenges, its long-term benefits highly overrule.

Keywords: QMS (Quality Management System), ERP (Enterprise Resources Planning), ISO 9001;2015 (International Organization for Standardization).

1. Introduction

The global construction industry stands as a vital contributor to Gross Domestic Product (GDP) and a key driver of economic growth for nations. Over the decade from 2011 to 2020, the construction sector's share of global GDP increased from 11% to a projected 13.2%, with India emerging as a significant player among other growth-contributing countries. Despite its economic importance, the construction industry has faced criticism for perceived deficiencies in quality, non-standardization, and environmental impacts associated with construction

activities.

In response to these challenges, the Indian construction sector has undergone significant transformations, influenced by the Indian government's emphasis on implementing ISO (International Organization for Standardization) quality policies and the push for ISO 9001 Quality Management System (QMS) certification has led to an increasing number of contractors seeking accreditation. However, challenges arise due to limited experience in ISO quality implementation within the Indian context, exacerbated by issues stemming from ongoing economic globalization processes.

Simultaneously, information technology, particularly Enterprise Resource Planning (ERP) systems, has become indispensable for optimizing business processes in the construction industry. ERP systems, designed to enhance efficiency across various business processes, are especially pertinent for infrastructure construction companies. Despite the unique needs of these companies, a lack of tailored ERP systems complicates the assessment and selection processes.

As the construction industry faces heightened global competition, ERP implementation has become increasingly prevalent. ERP systems offer operational, managerial, strategic, IT infrastructure, and organizational benefits, providing a comprehensive view of all business functions and a centralized database for recording, processing, monitoring, and reporting transactions. However, challenges such as high costs, software incompatibility, technical and human resource issues, and a lack of clear objectives hinder seamless ERP implementation.

2. Objectives

The primary aim of this research is to study the potential of using an ERP system to implement QMS in a construction project. Thus, the objectives of the study are as follows:

1. To determine the status of the quality management systems being implemented in construction projects using ERP.

2. To find out the advantages of using ERP system for implementing the QMS as per 9001:2015.

3. To investigate the challenges in implementing QMS using ERP system and suggest remedial measures.

3. Literature Review

Andrejs Tambovcevs [1] observed that the ERP systems are critical for organizational change, connecting various areas of an enterprise and offering benefits like inventory reduction, improved customer insights, and integrated data sharing. The study categorizes reported difficulties into economic, technical, organizational, and social issues. The study suggests that the most significant difficulties experienced by the organizations are social problems connected with the knowledge, education, and attitudes of all stakeholders, high costs connected with ERP system implementation and organizational problems connected with planning activities of ERP system implementation.

Khalid Al Marri [2] presented the case study comparing the alternatives of ERP systems i.e SAP, Oracle and Microsoft Dynamics. Analyzing the case study, author observed that the ERP offers a remedy to the challenges identified as deficiencies in project tracking, resource management, and decision-making within project-based entities in the construction industry. Successfully implementing an ERP system, coupled with enhancing the knowledge management framework within these organizations, empowers them to reap numerous advantages by enhancing their products, reducing expenses, and acquiring real-time information essential for an agile decision-making process.

Abhijit N. Bhirud, Bhushan M. Revatkar [3] investigated the case study related to ERP implementation by firms operating in the infrastructure construction industry and concluded that the systematic implantation of ERP system proves to be more beneficial to infrastructure construction enterprises in various divisions. i.e integration of all business processes, fully computerized generation of reports to assist in decision making, and attainment of competitive advantage. The fragmented nature of infrastructure construction, coupled with the limited advantages provided by ERP systems, contributes to infrastructure firms securing additional projects. Challenges encountered by infrastructure construction companies in ERP implementation encompass inadequate employee training and a short period for software testing.

Thathsarani Hewavitharana, et al. [4] studied 210 financial reports from 29 construction companies from developed and developing countries. The study revealed that after the implementation of ERP, 90 % of the medium and largescale construction companies in developed and developing countries showed an increase in profit and growth rate. 92% of the companies in developed countries have increased the growth rate by implementation of ERP. 68% of companies in developing countries have increased the growth rate by implementation of ERP. However, only 3 % of the total companies have managed to succeed without ERP.

Shadi AboAbdo, et al. [5] did questionnaire survey on 25 users of ERP in construction projects in KSA. By conducting literature review and questionnaire survey authors identified total 26 most critical success factors impacting the implementation of ERP in construction project. The statistical results shows that the top management involvement and awareness, training and support of users, and implementation team composition are the most significant factors of ERP implementation success.

Tiong Kung et al. [6] explored the role of quality management systems (QMS), specifically ISO 9000 and total quality management, and their application in the construction industry. Their approach involved a comprehensive review of existing literature on QMS within the construction sector. The primary objective of this literature review was to assess whether these systems had the potential to contribute new insights for enhancing quality management practices and outcomes in construction projects. The research findings underscored a notable gap in quality management research within the construction industry, particularly in discussions pertaining to the application of both technical and non-technical approaches, as well as human behavioral issues.

Prashant D. Deshmukh, et al. [7] investigated the impact of training, project management, hardware and software, skills of the workforce, and top management support on quality benefits in ERP implementation among 95 SMEs in India. Multiple regression analysis has

uncovered that training, top management support, project management, and hardware and software significantly influenced quality benefits. The study confirmed the positive influence of these factors through rigorous checks on fundamental assumptions and validities. Standardized values indicated that training had the highest impact, followed by hardware and software, and then project management, while the skill of the workforce showed negligible influence. The findings suggest that SMEs in India with ERP systems are gaining quality benefits, making them more competitive in the knowledge-based economy. The research emphasizes the importance of considering specific factors, such as training and top management support, for successful ERP implementation in SMEs.

Pravin Mane and Jalindar Patil [8] conducted a survey using questionnaires distributed to 150 participants involved in a construction project. The aim was to assess their experiences and positions. Upon careful examination and analysis of the collected responses, it was revealed that the predominant quality tool employed at the construction site was the checklist. This was followed by the utilization of tools such as fishbone diagrams, flow charts, Pareto analysis, histograms, check sheets, control charts, scatter diagrams, and statistical analysis. In terms of quality control measures implemented on the construction site, the study found that the primary focus was on the quality of workmanship. This was closely followed by activities such as conducting site review meetings with staff, establishing procedures to control quality, ensuring proper sampling and testing, adhering to a regular schedule, following prescribed curing and deshuttering schedules, understanding duties and responsibilities, maintaining a quality control laboratory at the site, adhering to the sequence of construction, and coordinating with the project's purchase department. The survey also highlighted the significance placed on customer satisfaction, with client satisfaction, stakeholder satisfaction.

Neyestani, Behnam [9] did the literature review and unearthed that the Implementing Quality Management Systems (QMS) is an effective strategy, employing a process-oriented approach based on the PDCA methodology to successfully achieve project objectives and optimize performance of the companies in the construction industry. Notably, the study, based on responses from 37 managers, highlights the substantial impact of QMS on customer satisfaction, emphasizing its prioritization of customer requirements and satisfaction within organizational processes. However, despite the potential benefits across quality, cost reduction, time efficiency, and enhanced customer satisfaction achievable through the comprehensive implementation of all QMS standards, the study reveals a prevailing focus among managers on ISO 9001 certification alone, neglecting other QMS standards.

Sergey Lukichev, Marina Romanovich [10] studied the Russian construction companies and observed that the foreign certification bodies has given more importance to get certified from them to gain foreign trust. The study shows that the quality management system needs to be developed in the country as per the ISO 9001:2015 requirements to enhance the competitiveness in global market. This will directly increase the demand for the ISO certification. The study also stressed that there are many articles on the topic of obtaining quality management system certificates, but there is no single methodological guide for its implementation. To create methodological guidelines, it is essential to categorize certifiers, certification systems, and the organizations implementing the Quality Management System (QMS). This categorization should consider the unique economic conditions prevailing in the Russian Federation.

Md. Asrul Nasid Masro, et al. [11] reviewed the success factors and determined the key success factors of the large infrastructure project. The fig 2.6. Shows the factors affecting the success of large infrastructure projects. To achieve success in the large infrastructure project all the participants need to achieve the aim and objectives of the project.

Behnam Neyestani [12] in different research conducted a questionnaire survey over 67 managers employed in construction projects for the ISO 9001:2008 certified large-scale companies in Philippines. The study shows that the the main factors of projects success are customers satisfaction and (Cost, Time, Quality) aka iron triangle. ISO 9001 is a powerful quality management technique that can help projects to achieve their objectives satisfactorily and positively resulting in projects success, customer satisfaction, and higher construction quality at strong level. However, study also unfolds that the construction companies focus on "short-term" goals for getting just a certificate and becoming qualified for tendering in huge projects of private or government sector.

T.M Naveen Kumar, P. Naveen Kumar [12] conducted questionnaire surveys and collected and analyzed the data of responses. The authors through their study concluded that the Indian construction industry faces challenges in ensuring the quality of its products amid rising demands for higher standards. To compete regionally and internationally, the industry is urged to adopt quality management systems (QMSs) based on ISO 9001, which aim to define processes leading to end-product quality and enhance overall performance. In Indian domestic market most of the companies obtain ISO 9001 certification as a matter to fulfilling tender administration requirements for domestic infrastructure projects. However, despite ISO 9001 certification, the study emphasizes that possession alone does not guarantee a well-operated QMS, revealing a need for a more integrated approach to address challenges such as higher initial costs and a lack of understanding of the QMS concept within organizations.

Fazal Ali Shaikh, Samiullah Sohu [13] identified 34 basic aspects from the literature review and according to it they prepared questionnaires and distributed to 51 recognized construction companies out of which response remained only 59%. The results of analysis showed that the advantages of ISO implementation are satisfaction of employees, winning ratio of new construction projects are increased, decrease in waste of material, increased efficiency of the company and contacts in the global market respectively. The study also showed the elements influencing the incorporation of ISO standards within the construction industry include addressing current challenges and eliminating avoidable credentials, meeting quality requirements through the quality system, examining materials prior to use, conducting regular inspections of construction work, and ensuring consistent quality inspections by the team.

Ghaleb Y. Abbasi, Qais Al-Nagrash [14] distributed questionnaire to 125 registered first-class construction companies in Jordan. Analysis of returned 64 % of responses was concluded in three parts i.e motivation, obstacle, and benefits of ISO 9001:2015 implementation as a QMS. The motivation were pressures from competitors and improvement in quality image of company. The obstacles were the cost reduction, improved design process and management to the site resident staff and resistance from top management and sub-contractors due to low level of understanding of applying all the requirements of ISO 9001:2015. The benefits of implementing QMS were improvement in documentation, customer satisfaction and reduction of time.

Vikas Sheoran and Divya Jyoti Thakur [15] conducted an exhaustive review of the literature on Quality Management Systems (QMS) and ISO 9001. Their investigation revealed that the general objectives of ISO 9001:2015 are designed to maintain a balance between standardization and adaptability, ensuring applicability to companies of all sizes and industries. The primary aims include establishing standardized practices while tailoring them to diverse business contexts and optimizing operational performance and compliance checks to enhance efficiency and reduce costs. The authors highlighted the numerous advantages associated with ISO registration and QMS implementation, including increased efficiency in management and job performance, improved communication, enhanced control over documentation, elevated levels of customer trust and satisfaction, a surge in the number of projects undertaken, and greater efficiency in on-site operations.

Andika Prasetya, et al. [16] systematically reviewed the literature/studies published in Indonesia within the last five years (2019-2023). The study revealed that before implementing ERP, companies often face challenges managing scattered data, non-automated business processes, and limitations in making quick decisions, difficulty in accessing customer information quickly, complicated inventory management & higher operational costs due to manual process taking up lot of time. The study revealed multiple benefits and challenges of adopting ERP systems. Benefits includes improvement in efficiency of operations, better resource management, and enhanced strategic decision making. Challenges include issues related to adapting to change, integration with existing systems and significant increase in costs and time.

Each of the system i.e. ISO 9001 and ERP is being used in construction projects as a management system. However, each is being used separately and has a limited scope. ISO 9001:2015 Quality Management Systems (QMS) is an effective strategy, employing a process-oriented approach based on the PDCA methodology to successfully achieve project objectives and optimize performance in the construction industry. However, the organizations only get ISO certified only to get eligible for tendering process of projects. Thus, to avoid this, the organization can use ERP to manage the project as per the requirements of ISO 9001:2015 throughout the life cycle of project. The ERP systems offer operational, managerial, strategic, IT infrastructure, and organizational benefits, providing a comprehensive view of all business functions and a centralized database for recording, processing, monitoring, and reporting transactions. Therefore, the need is felt to assess the advantages and challenges of combining the two systems.

4. Scope and Methodology

The scope of the study carried out in this dissertation to demonstrate the applicability of the proposed system will include the following:

- Study of latest revision of ISO 9001:2015 and application of an ERP software.
- Combining and analyzing the synergy of ISO 9001:2015 and ERP in construction projects.
- Study of applicability in the context of Indian industry.

Methodology of research outlines the steps taken to conduct the study. It includes the identification of target population, design of questionnaires, identification of sample size and data collection instruments. Additionally, it offers a detailed explanation of the analysis techniques to be used.

4.1 Target Population

The questionnaires are distributed to professionals in the construction industry across various types of organizations, including clients, contractors, and PMC's, and across different departments, like execution, planning, quality, etc. The focus is specifically on professionals working in large scale companies that have implemented ERP systems or hold ISO certifications.

4.2 Questionnaire Design and Sources of Data

Questionnaire consisted of four parts. The first part is the introductory part of the respondents. Second part is to know the status of the QMS being implemented using ERP. The third and fourth part is to know the advantages and challenges of using ERP for implementation of QMS 9001:2015 respectively. The scale of measurement is a five-point Likert Scale. 1= Strongly Disagree, 2= Disagree, 3= Neutral, 4= Agree 5=Strongly Agree.

4.3 Sample Size

The study was focused on a subset of the target population. The subset comprises of the selected respondents that are highly relevant to the research objectives. Participants are chosen on specific characteristics, qualities or expertise to get the representative sample from different groups within construction companies in India. This approach enhances the effectiveness of the sample. The sample size for the survey was determined using the formula provided below.

$n = (z*z)(p*q)N/(e*e(n-1)+(z*z)(p*q))$

where n= sample size,

z = 1.96 (standard normal deviation at a confidence level of 95%.

p = 90% (target population assumed to have characteristics)

q = 0.1 (1-p)

N = population size

e = 0.05 (confidence level / margin of error)

Considering population size of 250, the sample size is found out to be 90. Therefore, the responses are taken from 90 nos of respondents.

4.4 Data collection instrument.

The research employed a questionnaire survey made using Google Forms to gather data. The distribution of questionnaires was done via email, WhatsApp, or other relevant channels. Given the quantitative nature of the data required for this study, structured questionnaires were utilized to ensure consistent responses. The design of the questionnaires was done by

considering the study's objectives and insights from the literature review, and they were used to collect information from carefully chosen experts from client, consultant and contractors organizations involved in Indian construction projects. Aware of the busy schedules of respondents in the construction industry, the questionnaires were sent with the flexibility for them to respond at their convenience. After the questionnaires were distributed, follow-ups were made to confirm receipt and encourage participation. The respondents were given the time of two weeks to complete the questionnaire.

4.5 Validity and Reliability of data.

4.5.1 Validity Test

A preliminary study was carried out to validate the research questionnaire. This process helped evaluate the wording, identify relative questions, and estimate the time needed to complete the survey. Pre-testing played a crucial role in verifying the correctness of the data collection tool. In this study, the distribution of questionnaires was done to the same demographic of working professionals. Feedback from respondents was considered when refining the final version of the questionnaire.

4.5.2 Reliability Test

The reliability test is conducted by subjecting the data to Cronbach's Alpha test. The test is conducted to find out the Cronbach's alpha coefficient of advantages and challenges.

Table 1 Cronbach's Alpha Value Coefficient Range

Cronbach's Alpha Range	Internal Consistency
$\alpha < 0.6$	Poor Reliability
$0.6 < \alpha < 0.7$	Acceptable Reliability
$0.7 < \alpha < 0.8$	Good Reliability
$0.8 < \alpha < 0.9$	Very Good Reliability
$\alpha > 0.9$	Excellent Reliability

Cronbach's alpha is a widely used reliability test that measures internal consistency, making it important for designing questionnaire surveys. This test plays a key role in evaluating the assessments within surveys, especially when using a Likert Scale, as in this study. It helps ensure the reliability and accuracy of data while minimizing random errors. Table 1 presents the range of Cronbach's Alpha value coefficients.

4.6 Pearson Correlation Coefficient

Pearson correlation coefficient is used to determine the relationship between two or more variables and its strength. Correlation coefficient R value is used from Pearson correlation analysis in MS Excel. The table 2 shows the strength of correlation as per the range of R value. The closer the r value to 1 or -1, the stronger the relationship in the linear correlation. p value is also determined during the same test and if it is less than 0.05, it means there is enough evidence to suggest that the correlation is significant and represents the population. However, if p value is more than 0.05 it indicates that the correlation (R) is not

Table 2 Range of R Value Correlation Coefficient

R Value	Linear Correlation
0.10 to 0.35 or -0.10 to -0.35	Low Correlations
0.36 to 0.67 or -0.36 to -0.67	Moderate Correlations
0.68 to 0.90 or -0.68 to -0.90	Strong Correlations

very significant, and it occurred just by chance.

4.7 Technique for order by similarity (TOPSIS)

TOPSIS analysis is conducted to determine the weight of variables and to rank them. It is used to rank the factors of advantages and challenges of using ERP for the implementation of QMS.

5. Result and Discussion

This section presents the results of the data analysis to draw conclusions and provide recommendations for the study. The analysis and explanation take consideration of the literature review and the questionnaire survey, with data analyzed using Microsoft Excel. The study specifically focuses on identifying the benefits and challenges of using ERP software for implementing QMS 9001:2015 in construction projects.

5.1 Response Analysis

All the survey questions are divided into four parts according to the study objectives as follows.

- Respondents Demographics.
- Status of implementation of QMS using ERP.
- Advantages of using ERP for implementation of QMS
- Challenges of using ERP for implementation of QMS and their remedial measures.

5.1.1 Demographic Information

Table 3 Frequency for working experience of the respondents

Sr. No	Working Experience	Frequency	Percentage (%)	Cumulative Percentage
1	1 – 5 Years	24	26.67	26.67
2	5 – 10 Years	32	35.55	62.22
3	10 – 15 Years	15	16.67	78.89
4	15 Years and above	19	21.11	100

Table 3 indicates that amongst total no of 90 respondents, the highest percentages of respondents have working experience “5 – 10 years”. Second highest percentage of respondents have working experience of “1 – 5 years” followed by “15 years and above” and “10 – 15 years” respectively.

5.1.2 Type of Organization

Table 4 Frequency for different types of organization.

Sr. No	Type of Organization	Frequency	Percentage (%)	Cumulative Percentage
1	Client	13	14.44	14.44
2	Consulting Engineer/PMC/GC	43	47.78	62.22

3	Contractor	32	35.56	97.78
4	Others	2	2.22	100

Table 4 states that the "Consulting Engineer/PMC/GC" has the highest no of respondents of 47.78 % (43 nos). Second highest is "Contractor" with 35.56 % (32 nos) and third and fourth are "Client" with 14.44 % (13 nos) and "Others" with 2.22% (2 nos) respectively.

5.1.3 Working Department

Table 5 Frequency for Different type of Working Department

Sr. No	Working Department	Frequency	Percentage (%)	Cumulative Percentage
1	Execution	43	47.78	47.78
2	Quality	28	31.11	78.89
3	Planning	5	5.56	84.44
4	Design	5	5.56	90.00
5	Other	9	10.00	100.00

Table 5 represents that the "Execution" department has highest nos. of respondents of 47.78% (43 nos). "Quality" department has 31.11% (28 nos) respondents while "Other" department such as survey, document control, BIM, etc. has a respondent size of 10% (9 nos). "Planning" and "Designing" has same no. of respondent 5.56% (5 nos)

5.1.4 Type of Construction Project.

Table 6 Frequency for different type of construction project involved

Sr. No	Type of Construction Project	Frequency	Percentage (%)	Cumulative Percentage
1	Infrastructure	72	80.00	80.00
2	Residential	15	16.67	96.67
3	Industrial	2	2.22	98.89
4	Others	1	1.11	100.00

Table 6 shows that highest no of respondents 80% (72 nos) work in infrastructure projects. Residentials projects contains second largest nos of respondents 16.67 % (15 nos). Third position occupied by Industrial with 2.22 % (2 nos) and there is only one respondent from other types of construction projects.

5.2 Status of the QMS being implemented in construction projects using ERP.

Table 7 Frequency of Status of QMS implementation using ERP

Sr. No	Status of QMS in construction Project using ERP	Frequency	Percentage (%)	Cumulative Percentage
1	Yes	34	37.78	37.78
2	No	56	62.22	100
3	Total	90	-	-

Table 7 shows around 37.78% (34 nos.) of the respondents have used ERP softwares for implementation of QMS in their projects and 62.22% (56 nos) of the respondents have not used it.

5.3 Reliability Test.

Reliability analysis is carried out to measure the consistency of ranking scale data or ordinal data which was used in questionnaires. Reliability analysis used the Cronbach's alpha to measure data in MS Excel. The results of the analysis showed that 12 items of advantages have passed the reliability test with acceptance value of 0.91 which indicates excellent reliability. 09 items of challenges have also passed the reliability test with acceptance value of 0.78 that indicates good reliability.

5.4 Pearson Correlation Coefficient

Table 8 Pearson Correlation

		Use of ERP for the implementation of QMS
Use of ERP for the implementation of QMS	Person Correlation	1
	P value	
	N	90
Working Experience	Person Correlation	0.106
	P value	0.320
	N	90
Type of construction project	Person Correlation	0.117
	P value	0.272
	N	90
Type of organization	Person Correlation	0.011
	P value	0.918
	N	90
Working Department	Person Correlation	0.043
	P value	0.687
	N	90

The information of the respondents such as working experience, type of construction project, type of organization, working department is tested with use of ERP for the implementation of QMS by the pearson's correlation to determine whether the respondent's information will affect the implementation of QMS by using ERP. According to table 8, the correlation between working experience of respondents and use of ERP for the implementation of QMS has no significant correlation between them with the pearson correlation value of 0.106 and p value of 0.32. It means the increase in working experience does not influence the adaptation of ERP to implement QMS.

Furthermore, there is no correlation between type of construction project and use of ERP for the implementation of QMS due to pearson correlation coefficient value of 0.117 and p value

of 0.272. This indicates that there is not a specific type of project that use ERP for QMS implementation.

The pearson coefficient value and p value for type of organization against the use of ERP for the implementation of QMS as 0.011 and 0.918 respectively shows there is not any relationship exists between them, which proves that the type of organization does not affect the use ERP for QMS implementation.

Based on table 8, Pearson correlation value between working department and the use of ERP for the implementation of QMS is 0.043 and p value more than 0.05. It can be understood that there is no correlation between them and the working department does not influence the use ERP for QMS implementation.

5.5 Ranking of Advantages and Challenges

TOPSIS analysis method is used to rank the different factors of advantages and challenges of using ERP for implementation of QMS. The below table 9 shows the ranking of the factors of advantages of using the ERP for implementation of QMS.

Table 9 Ranking of Advantages factors

Rank	Factor	Preference
1	ERP allows more accurate forecasting and risk management related to quality issues	0.588
2	ERP makes internal audits, external audits and management reviews easier by providing a structured and accessible repository of all QMS-related documents.	0.551
3	ERP systems automate many of the repetitive tasks involved in QMS implementation.	0.536
4	ERP can improve the efficiency of document management and control in QMS.	0.533
5	ERP would facilitate easier access to historical quality data for continuous improvement purposes.	0.429
6	ERP systems would reduce the chances of non-conformance through better monitoring and reporting.	0.413
7	ERP systems can enhance customer satisfaction by ensuring product/service quality standards are consistently met.	0.411
8	ERP would provide better control over supplier quality management and evaluation.	0.371
9	Implementing QMS through ERP would lead to better compliance with ISO 9001:2015.	0.371
10	ERP integration would enhance the consistency of quality procedures across different departments.	0.298
11	ERP integration with QMS would result in faster decision-making due to centralized data.	0.280
12	ERP would facilitate better alignment of project goals with quality management objectives.	0.235

Table 10 Ranking of Challenges factors

Rank	Factor	Preference
1	Implementing ERP for QMS may introduce vulnerabilities that could compromise data security and integrity.	0.887
2	The need for extensive training on ERP systems for QMS purposes could slow down implementation.	0.682

3	Ensuring that all team members and external partners (e.g., subcontractors) consistently use ERP for QMS-related tasks may be difficult.	0.638
4	The time required to fully implement ERP for QMS purposes may be longer than initially planned, causing delays.	0.353
5	Implementing QMS through ERP would require substantial customization of the system.	0.318
6	ERP systems might lack the flexibility needed to address unique quality challenges in construction projects.	0.202
7	Adapting an ERP system to meet the specific requirements of ISO 9001:2015 could be complex.	0.196
8	The initial cost of using ERP for QMS implementation would be prohibitively high.	0.140
9	A lack of skilled personnel to operate the ERP system may hinder its effectiveness in QMS implementation.	0.130

The above table 10 shows the ranking of the factors of challenges of using the ERP for implementation of QMS.

5.6 Addressing the challenges.

To cater the vulnerabilities which may compromise data security and integrity, the organizations must control the accessibility of the system by its employee using strong passwords, permissions and two-factor authentication. To keep the system secure and prevent unauthorized access, the organization should encrypt data and run regular security checks. Regular training should be conducted to create awareness amongst the employees about the phishing and possible breaches and prepare them to respond effectively. Organization should maintain regular backups of the data and store them securely. Organization shall define clear policies for data classification, its retention and disposal.

The organization can address issue of slow implementation process due to extensive training needs, by providing the training in phases and aligning the training programs based on each users roles and responsibilities. Organization should consider providing facilities like e learning and hands on training to make training easier and more engaging. The experienced staff should mentor the new users to provide required support. Also, the help desk should be formed to help address the issues of the users post training.

To ensure all the team members and external partners consistently use ERP for QMS related tasks, the organization should involve them from start of the implementation process to make them understand that they are the part of the system. Organization should provide role specific training and highlight the advantages of using ERP for QMS related tasks. Clear rules and policies should be made to ensure use of ERP for QMS tasks. The system should be user friendly so that everyone could use it efficiently.

To manage the delays, the organization should start implementing the ERP in stages by focusing on critical QMS features first. During transition period the organization should run the ERP system alongside existing QMS processes to maintain continuity. To resolve the issues and track progress the experience staff and dedicated team should be engaged.

To address the substantial customization of the ERP system, the organization should identify the most critical changes required to meet ISO 9001:2015 standards. Organization should use built-in features and add-on modules wherever possible. To ensure the process is efficient and

effective the organization should only customize the system from only experienced vendors or experts.

To handle the dynamic nature of the construction industry, the organization should choose systems that allows configuration and provide templates to match project specific needs. Organization should involve quality managers and projects teams during the implementation process to ensure the system meets the requirements of the team. Based on the feedback of the team the ERP system should be updated regularly to keep it aligned with evolving project requirements.

Organization can manage the complexity by choosing an ERP with built-in features of quality management. It can provide specific trainings to the users to make them aware how the system supports the requirements of ISO. The system should be regularly monitored and updated as per the requirement to stay compliant with ISO

Organization could lower the initial costs of using ERP for QMS by implementing the system in stages, focusing first on the critical features to spread the expenses over time. Organization could use cloud-based ERP system which has lower cost. The pre-configured ERP that supports the ISO 9001:2015 could be used to reduce the customization cost. Use of existing infrastructure wherever possible can minimize the new investment. Organization can train their employee according to their roles. External consultants could be hired to assist with initial setup and training. Automation of complex tasks through the ERP system can reduce the need for advanced technical skill.

6. Findings

6.1 Status of implementation of QMS using ERP

The results showed that the only 37.78% of the respondents were using ERP for the implementation of QMS in their respective projects and remaining 62.22% of the respondents were not using it. Around 19% of the respondents were not aware of the either QMS or ERP. Among the respondents who were aware of the ERP and QMS the most adopted ERP software is SAP (60%) followed by Microsoft Dynamics (13.33%) and Oracle (5.55%). Additionally, (13.33%) of the respondents used other ERP software not listed in the questionnaire.

6.2 Advantages of using ERP system for implementing the QMS

The respondents through their responses have proved the listed advantages are reliable and provided the ranking starting from; accurate forecasting and risk management; easier internal audits, external audits and management reviews; automation of the repetitive tasks; improved efficiency in document management and control; easier access to historical data; better monitoring and reporting resulting in reduces chances of non-conformance; better control over suppliers; better compliance with ISO 9001:2015; enhance the consistency of quality procedures across different departments; faster decision making due to centralized data and better alignment of project goals with quality management objectives. All the above advantages would result into the significant synergy between ERP and QMS if used combined.

6.3 Challenges in implementing QMS using ERP system.

During implementation of QMS using ERP organization can face multiple challenges. According to responses, the challenges in the descending order are; compromise in data security and integrity; extensive training could slow down the implementation process; ensuring the use of ERP for QMS by all tea members and external partners may be difficult; delays due to longer time required to fully implement ERP for QMS; substantial customization of the system; lack of flexibility to address unique challenges of construction projects; meeting specific requirements of ISO 9001:2015 could be complex; high initial cost; lesser effectiveness in QMS implementation due to lack of skilled personnel to operate ERP. These findings states that every respondent agreed that assessed factors were significant challenges in implementing QMS using ERP system.

7. Limitations and Research Gaps

This study was focused to determine the advantages and challenges involved in the implementation of QMS as per ISO 9001:2015 using ERP software in a construction project. The future scope of research could be as follows:

- To investigate how customizations can be done to ERP systems to integrate QMS with other ISO standards such as ISO 14001 Environmental Management or ISO 45001 Occupational Health and safety.
- To Compare the effectiveness of different ERP software in implementing QMS as per ISO 9001:2015 in construction projects.
- To investigate the use of ERP system for the implementation of QMS in specific construction industry/projects (Infrastructure, Residential, Industrial, etc) or specific type of organization (Contractor, PMC, Client, etc).

8. Conclusion

The uptake of ERP to implement QMS in construction projects was found to be low despite majority of the respondents being familiar with both ERP and QMS. SAP was the most adopted software among the respondents. The research established that the combining both the systems has multifold benefits in efficiency & productivity, communication & collaboration, compliance & risk management and data integration & reporting. However, the study also unfolds the facts that there exist some challenges associated with this combination of ERP and QMS. These challenges could be summarized as a larger domain of system complexity & usability, cost & resource allocation, Integration & adaptation, training & change management and system reliability & support. These challenges can be addressed by adopting the strategies like phased implementation, tasks automation, using cloud-based systems and providing training to the employees. To ensure smooth implementation of ERP organizations can focus on industry specific needs, adding specialized tools to the ERP and involving the stakeholders in the process. Overall, while the implementation of QMS by ERP in a construction project has some challenges, its long-term benefits can significantly enhance

project outcomes.

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