A RESEARCH ON CHINESE CONSTRUCTION ENGINEERING INCORPORATING BUILDING INFORMATION MODELLING, LEAN CONSTRUCTION, AND QUALITY CONTROL.

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ABSTRACT

Due to market demands for more competitive products and services and the government's push for better quality growth, China's construction industry is undergoing fast transformation. There are always problems that prevent the project from progressing, no matter how far we get. Insufficient resources, different standards, and insufficient accountability are a few of these challenges. Examining the impact of quality control on Chinese construction engineering, particularly as it relates to "Building Information Modelling (BIM) and Lean Construction" processes, is the primary objective of the present study. A research method known as quantitative research was employed in this study. With the use of SPSS version 25, we evaluated data obtained from 812 industry executives through purposive sampling. Factor analysis, descriptive statistics, and analysis of variance were some of the statistical tools utilised by investigators to verify hypotheses and construct validity. With an F-value of 969.106 and a p-value of.000, the ANOVA results demonstrated a significant association between quality control approaches and superior outcomes in Chinese construction engineering. To increase a project's productivity, affordability, security, and customer satisfaction, the results demonstrate the significance of quality control systems. Quality control must be incorporated into the project lifecycle and supported by BIM, and lean construction approaches, according to research, to handle industrial difficulties and guarantee environmentally friendly growth. Construction firms should prioritise staff training, standardise their quality control processes, and make use of digital resources to their advantage to adhere to global standards.

Keywords: Chinese Construction Engineering; Building Information Modelling (BIM); Lean Construction; Quality Control.

INTRODUCTION

The growing amount of market saturation in the economy has made competition tougher in many fields, such as construction. To be competitive, building companies need to keep improving how they manage and operate, make sure that construction is of high quality, boost production efficiency, cut down on resource waste, and lower production

costs. Comprehensive quality control is the most important part of engineering project quality administration since it is the main goal and the thing that ties everything together. This is because it has a direct effect on the security of individuals and their belongings (Evans & Farrell, 2023). Given the progress of "The Times" and China's plans for the construction industry's future, it is more important than ever to improve quality management standards. First, the quality of the project is ensured by many divisions in engineering and construction, including design, supervision, and construction; nevertheless, these divisions are often driven by selfish interests and make immoral decisions. They set loose quality standards in their quest for short-term gains at the expense of the project's long-term use of its value and safety (Lekan et al., 2022). The second problem is that even if the appropriate standards are made, the implementation process is fraught with difficulties, and standards are often applied carelessly. Lean construction is based on the principles of managing and controlling the entire building process. Tight cost management is essential in lean construction. One technique is to limit expenses at every stage of the process by improving budgeting and costing (Aburumman et al., 2024). Lean Construction's quality management includes a system to monitor and control work processes, a system to track and identify problems and assign blame, and a programme to make sure all employees are aware of the importance of quality management. Finding a happy medium between time, money, and quality is one of the main objectives of construction project management.

BACKGROUND OF THE STUDY

These days, it seems like every Chinese construction company is trying to improve their quality management system for engineering projects. For a systematic project to be considered a whole, all its numerous phases—from planning and research to demonstration and design to building and completion and maintenance—must be closely related. However, in practice, the quality management system that the construction unit employs throughout the project's many phases is independent of and not dependent on any other system. Formal quality management will be implemented, addressing phases that are often overlooked regarding project quality (Li et al., 2020). Hence, quality control must be implemented throughout the entire engineering project. Because site operators and management aren't quality sensitive, an engineering construction process disaster is brewing. Because of this poor-quality concept, there have been very few attempts to improve engineering quality and efficiency, and it has damaged every aspect of engineering construction. Modern technologies, such as the cloud and big data, are swiftly making their way into a wide variety of industries (Xing et al., 2021). There are still many obstacles to overcome in the transition from conventional management to digitalisation, even while empowering technology has enabled the construction sector to accomplish intelligent upgrading. Many building construction enterprises in China still utilise the conventional management style, which is a feature of the current trend in the sector's development (Cisterna et al., 2022). Finally, many

Chinese building construction firms that use the old management style run into a lot of problems and difficulties as the project progresses, so there's a pressing need to improve the use of technology and reinvent the mode of management. The lack of sophisticated technology such as big data, cloud computing, and others is largely to blame.

The piano, as a popular and all-ages musical instrument, is particularly important in the future development of art teaching in colleges and universities. The introduction of multimedia technology into piano teaching in colleges and universities is important means to meet the needs of art teaching in the current era. The piano, as a popular and all-ages musical instrument, is particularly important in the future development of art teaching in colleges and universities. The introduction of multimedia technology into piano teaching in colleges and universities is important means to meet the needs of art teaching in the current era.

PURPOSE OF THE RESEARCH

With a focus on the integration of Building Information Modelling (BIM) and Lean Construction techniques, this study aims to assess the effect of quality control on the efficiency and sustainability of Chinese building engineering. Resource waste, insufficient responsibility, competing standards, and rising project costs are some of the persistent issues facing the business, and this study aims to assess how well quality control systems cope with these challenges. The rising requirement for high-quality infrastructure is driven by China's rapid economic progress, which is why this is taking place. The goal of this research is to find out if quality control methods significantly affect project outcomes, including efficiency, customer satisfaction, and safety. Researchers will achieve this by making use of statistical tools and quantitative methods. By the end of the day, the study's goal is to help construction companies, politicians, and other interested parties create thorough quality control mechanisms that support sustainable development and technical progress. Finally, the main goal of the current research investigation is to analyse the effect of Lean construction on Chinese construction engineering.

LITERATURE REVIEW

A key component of any successful construction project is total quality management (TQM). It offers greater than simply maintaining a steady flow of supplies, tools, and personnel. According to Alnajjar et al. (2025), every step of the construction process must be meticulously and authentically managed. The goal here is to guarantee that the project is executed to the greatest standards of quality at every stage, from initial planning to final judgement. A prior analysis that used a case inquiry in China focused on the appropriateness, durability, exhibition costs, and economic outcomes of

architectural concrete. Its goals include lowering servicing expenses, increasing consistency in substance reliability, and diminishing power and uniqueness variety among tangible illustrations, all while speeding up manufacturing. Contemporary building machinery, socioeconomic innovative concepts, and arrangement all rely on construction material, which is highlighted by this. Lekan et al. (2022) uncovered all the intricacies and offered insight into the evaluation of ceramic construction grade in Heqing, which is in Pudong, a district of Shanghai. Constant vigilance over concrete quality is required to preserve durable and consistent structures in the Shanghai industrial conditions. This study not only calculated the resilience of major installations in salty water supplies and freezing thrawn situations, but it also highlighted the need of considering environmental elements in quality confirmation. Prior study has focused on both the methodical examination that enters evaluating Chinese construction engineering standards and the standardisation itself. According to Yuan et al. (2022), the study has been divided into 5 phases, each of which corresponds to a different facet of managing quality in the construction industry. Finally, an acceptable example is used to explain and determine the efficacy of the CQMS utilising a pilot simultaneous DC signal deployment in China. In addition to revealing the amount and variance of CQMS, the results show that this evaluation analysis might be used as an indication for CQMS in building engineering. Lean construction theory has been defined in another article (Li, 2024), which aims to address the many problems with China's current assignments quality governance by providing a detailed explanation of its theoretical significance, lean building engineering, and its performance in the building industry. The paper continues by outlining the present status of performance oversight in construction companies and providing optimisation recommendations centred on 6S plant control, inspection procedures, quality control systems, and suitable quality evaluation. The construction sector can benefit from this and reach new heights of development.

RESEARCH QUESTIONS

What is the impact of Lean construction on Chinese construction engineering?

RESEARCH METHODOLOGY

Research Design

The quantitative data was analysed by the researcher using SPSS version 25. A 95% confidence interval and odds ratio were used to determine the strength and direction of the statistical link. Because the p-value was smaller than 0.05, we may say that the result is statistically significant. To get to the meat of the data, descriptive statistics were employed. To determine the reliability and validity of the data, quantitative methods were applied to organised tools such as surveys.

Sampling

Researchers in this study used a purposive sample strategy to find people who might have knowledge of or expertise with BIM, lean construction, or quality control in Chinese construction projects. A total of 785 people were selected for the study using the Rao-soft methodology. Researchers used this strategy to filter out survey takers who lacked the necessary expertise. 1000 surveys were sent out to selected individuals working in the construction sector, at various project locations, and for consultancy companies. The researcher got a total of 898 replies; however, 86 were removed because of incomplete or inaccurate information, leaving just 812 as a final sample size. Hence, 812 people make up the final sample.

Data and Measurement

The main tool for data gathering was a questionnaire survey that was created to get opinions from experts in the construction industry. In the first section, participants were asked to provide basic personal information. In the second section, they were asked to rate the level of collaboration across BIM, Lean, and quality control using a 5-point Likert scale. Additional information was provided to back up the primary results by using secondary data sourced from reliable sources, such as online databases and industry reports.

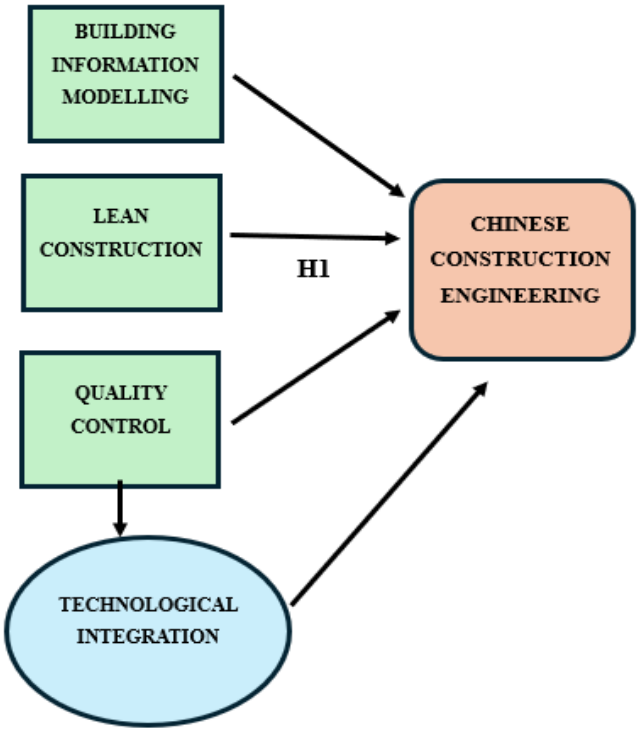
Statistical Software:

The statistical analysis was conducted using SPSS 25 and MS Excel.

Statistical Tools

To better understand the data, a comprehensive analysis was carried out. The researcher used analysis of variance (ANOVA) to check for group differences and factor analysis to confirm the construct's validity. To gain a better understanding of the patterns, correlations, and trends in the intentionally selected sample, descriptive and predictive statistics were employed.

CONCEPTUAL FRAMEWORK



RESULT

Factor Analysis: Finding latent variables in observable data is the goal of Factor Analysis (FA). When transparent visualised or diagnostic indicators are not accessible, regression coefficients are usually used to make assessments. Vulnerabilities, violations, and potentially observable links are what modelling is all about. Datasets obtained from multiple regression analyses are evaluated using the Kaiser-Meyer-Olkin (KMO) Test. It has been shown that the theoretical model and its parameters for the samples are good estimates. If duplicates are there, the data can show it. The information is made clearer by reducing the proportions. The researcher is given a value between 0 and 1 by KMO. It is considered an appropriate sample size when the KMO value falls between 0.8 and 1.

These are the permissible levels, according to Kaiser: Kaiser has established the following criteria for approval: An appalling 0.050 to 0.059, well below the usual range of 0.60 to 0.69. The typical range for middle grades is between 0.70 and 0.79. A quality point score between 0.80 and 0.89. The interval from 0.90 to 1.00 astounds them.

Examination of KMO and Bartlett's Sampling Adequacy (Table 1): According to the Kaiser-Meyer-Olkin scale: 0.874

The results of Bartlett's test of Sphericity are as follows: 3252.968; 190 is degrees of freedom (df); sig =.000 is the approximate chi-square value.

Table 1. KMO and Bartlett's Test.

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.874
Bartlett's Test of Sphericity	Approx. Chi-Square	3252.968
	df	190
	Sig.	.000

In most of the cases, this makes it more helpful to administer requirements for sampling purposes. To determine if the correlation matrices were statistically significant, the researchers used Bartlett's Test of Sphericity. A sufficient sample is indicated by a Kaiser-Meyer-Olkin value of 0.874. The results of Bartlett's Sphericity test yield a p-value of 0.00. The correlation matrix does not constitute a unique matrix, as indicated by the positive outcome of Bartlett's Sphericity test.

INDEPENDENT VARIABLE

Lean Construction: In lean construction, the principles of lean production—which have been successful in manufacturing—are transferred to the construction industry. This means that lean management thinking is applied systematically throughout the entire building construction process to ensure that customers' needs are met to the fullest. Lean construction has several benefits, including cutting costs and time in half while still meeting project criteria with high quality and within the allotted budget. Consequently, putting Lean Construction into reality in the construction industry is essential (Garcés & Peña, 2023). According to China's Lean Construction Engineering Centre, Lean Construction is a method that aims to reduce and eliminate waste throughout the whole life cycle of construction products while simultaneously fully meeting customer requirements possible. It incorporates "production management theory, construction management theory" and a unique characteristic of construction production. Scalable construction is made possible by Lean Construction. To guarantee individualisation, this does not imply basic repetitive production but rather efficient large-scale building through maximising construction administration and organising resources. The fundamental principles of lean construction are the comprehensive management and stringent control of the building process (Singh & Kumar, 2020). For lean construction projects to be successful, companies must implement stringent cost management strategies. One way is to control spending at each stage of the project by means of improved estimation and costing. Another is to use value engineering tools early on to optimise the system of design rationally while preventing unnecessary expenditure. Lean

construction is defined as an approach for managing projects that emphasises creating a clear and acceptable timetable.

DEPENDENT VARIABLE

Chinese construction engineering: Modern society's rapid progress is mirrored by the trend of quickly increasing data. Classical cost control methods also need to be used more strictly due to the growing complexity of contemporary construction projects. Digitalisation is the way of the future in China's building industry. A major pillar of China's economy is the construction sector. By adapting and modernising, the construction industry may increase profits and strengthen its core competencies. Lack of standardisation, slow technological advancement, and new development drivers are just a few of the many issues plaguing the construction industry (Wang et al., 2023). Chinese President Xi Jinping's "14th Five-Year Plan" prioritises digitalisation in its industrial strategy. Following the model of the real and digital economies' strong integration is the plan's stated goal. Due to the complexity and ever-changing nature of construction project environments, digital transformation must be approached as an ongoing, sustainable process. The construction industry is facing numerous obstacles that are hindering its digital transition, including a lack of essential technologies, low financial ability, and an inadequate data volume. The Chinese Construction Industry Administration Network reports that electronic expenditure in the real estate industry is a meagre 0.10 per cent of the total output value. According to Zhang et al. (2023), this is significantly lower than the average global rate of 0.30 per cent. There is a permanent shift in the construction sector right now towards BIM technological advancement, which has been utilised to enhance project management in China. Big data and other technological advancements have also led to better project expense control over time. Therefore, using big data in the administration of project costs is becoming increasingly commonplace thanks to BIM software. This increases the project's value while decreasing the costs of project management.

Relationship between Lean Construction and Chinese construction engineering: There is a strong and substantial connection among Chinese building technology and the distinct Lean construction approach. As a result of the industry's pressing need to reduce pollution and resource consumption, Lean Construction is having a noticeable and ongoing influence on Chinese manufacturing. Advantages such as better effectiveness, decreased expenses and wasted resources, and enhanced execution of projects have been observed with early adoption, particularly in the realm of publicly funded infrastructures (Yuan et al., 2022). But organisational problems include a lack of long-term philosophy, an ineffective lean environment, scattered project execution, and inadequate trust among stakeholders make widespread implementation difficult. Regardless of these obstacles, the adoption of lean concepts and the growing use of BIM are driving industry change and making a difference in China's construction sector in

terms of sustainability and efficiency. Lean methods in China are being amplified by combining them with digitalised technology including the "Enterprise Resource Planning (ERP)" systems (Li et al., 2020). This is helping to improve collaboration across disciplines and real-time data flow. There has been promising evidence that combining lean concepts with prefabrication processes can improve safety and quality while cutting down on construction time and material waste. Little is known about lean construction in China, and what little is known is primarily focused on governmental construction programmes. Since it is essential to China's economic progress, the construction sector is a major source of resource usage and carbon emissions. To achieve this goal, the government has implemented numerous measures aimed at actively supporting EPC projects throughout 2016.

To investigate the link among quality control and Chinese construction engineering, the researcher formulated the following hypothesis considering the previous discussion:

"H_{01}: There is no significant relationship between Lean Construction and Chinese construction engineering."

"H_1: There is a significant relationship between Lean Construction and Chinese construction engineering."

Table 2. H1 ANOVA Test.

ANOVA					
Sum					
	Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
Between Groups	40647.169	263	4137.115	969.106	.000
Within Groups	512.890	548	4.269		
Total	41,160.059	811			

The findings of this study are quite substantial. There is statistical significance below the 0.05 alpha threshold, as indicated by the F value of 969.106 and a p-value of 0.000. The findings indicates that the *"H1: There is a significant relationship between Lean Construction and Chinese construction engineering"* has been accepted, and the null hypothesis has been rejected.

DISCUSSION

Based on the findings, it is obvious how Lean Construction produces a favourable and substantial effect on Chinese building technology. Lean Construction is significantly associated with higher effectiveness, decreased costs, and better overall project performance, according to the statistical results (F-value: 969.106, p-value: 0.000). This

confirms what other research has shown: that Lean principles provide a game-changing structure for the building industry in terms of lowering waste, increasing cooperation, and attaining resilience. The importance of Lean Construction as a bridge between old-school project management methods and revolutionary technological advancement like BIM represents one of the greatest consequential consequences of the results. Businesses in the building sector can improve their ability to make decisions, collaboration, and responsibility throughout the lifetime of a project by combining Lean approaches with technological resources. Problems with disjointed management, wasted resources, and varying quality standards have persisted in the business for a long time, but this collaboration helps fix them. The research also sheds illumination on the larger social and financial setting, where the building industry is being encouraged to digitalise and develop sustainably under China's "14th Five-Year Plan." Lean Construction helps achieve this goal by cutting down on waste, increasing efficiency, and shortening the time it takes to complete projects. Sensitivity to societal transformation, insufficient technical knowledge, and a lack of trust among stakeholders are some of the obstacles that still stand in the way of broader use. The complete benefit of Lean methods can only be realised by removing these obstacles. Henceforth, the study has proved that there is an important correlation among lean construction and Chinese construction engineering.

CONCLUSION

The purpose of this study was to investigate how Lean Construction relates to Chinese architecture technology, specifically looking at how it uses digital technologies and BIM. Lean Construction significantly improves building functionality, affordability, reliability, and environmental responsibility, according to the quantitative investigation, which was validated by a probability value of 0.000 and an F-value of 969.106. By minimising wastefulness, maximising asset utilisation, and assuring more responsibility throughout the undertaking's lifespan, these findings support the idea that Lean approaches, when used systematically, might revolutionise the built environment sector. In addition to producing improved achievements, the results suggest how lean building is in accordance with China's nationwide objective for modernisation and exceptional growth, as stated within the "14th Five-Year Plan." Lean methods, BIM, and numerous modern innovations work together to offer an effective structure for dealing with problems including disjointed administration, inefficient use of resources, and increasing cost of projects. The Chinese construction business nowadays has Lean Construction as its foundation for creative thinking and competitiveness. Numerous suggestions may be offered regarding the future. To start, businesses in sectors such as construction would do well to put money into instruction and development initiatives for their employees so that they can better implement Lean concepts. Furthermore, with the backing of legislation, a standardised approach to Lean techniques across the sector might promote uniform use in every endeavour. Third, to get the most out of Lean, it's

important to prioritise the integration of digital technologies like cloud-based computing, ERP software, and immediate that monitor data in real time. Finally, cross-national comparative studies should be a part of future study so that China may measure its performance against the world's finest. In ending, Lean Construction provides a game-changing strategy for the Chinese building sector, paving its route for prospective viability, increased productivity, and consistent development in a world of fierce competition.

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