Research on Supervision Strategies and Quality Risk Control in Green Building Construction

Wenlong Wu

Anhui Yuhua Construction Project Management Co., Ltd., Wuhu, Anhui, 241000, China

Keywords: Green Building; Construction Supervision; Quality Risk Control; Full-Process Management; Information-Based Supervision; Sustainable Development

Abstract: In recent years green concepts were vigorously promoted in the construction industry, and control of quality during construction phase gradually become critical at guarantee the compliance of projects with their green design targets (Lam et al., 2007) Integration means a unification process, construction supervision is a function to feel out whether or not Construction supervition has significant Contribution on which it reflects engineers performance, so as to controlling engineering quality, energy saving and environmental performance will be brought back to integrated whole. Based on the characteristics of green building construction, this paper also searches and analyzes the main quality risks that may be encountered in the construction process, and puts forward countermeasures from multi-dimensions (from full-process supervision to key points). It also wants to carry out a quality risk early-warning system and information-based management platform for cooperation with respect to the construction phase of green buildings, so as to improve the level of risk response capacity and construction quality. Thereby, optimizing construction supervision strategies and improving quality risk control systems will not only effectively curb the continuity of construction quality hazards; but also promote a comprehensive realization of green building goals to provide reference for sustainable development of the construction industry.

1. Introduction

Green building is one of the important directions in which China has transformed and upgraded its construction industry, because with energy conservation emission reduction and sustainable development strategies continually deepening practical implementation recently [1]. In a nutshell, green building is [doing less with more] in the design and construction phase by using fewer resources and generating less pollution while achieving greater energy efficiency and successfully protecting the ecology over the life cycle. This method acknowledges that construction phase is one of the most impactful determinants for reaching green building targets which consequently means that risk management and quality control are vital in this stage [2].

Multiplicity of stakeholders, complexity of processes, use of innovative / new materials and high technical requirements [3]. Poor management of the building, and deficiencies in green construction may result compliance failure risks which directly lead to deterioration in performance and quality hazards, unsafe conditions, material waste or economic loss. With the advent of green building, construction supervision as a professional field, how to properly implement the supervisory and control functions during the project process is critical; so how to set up a scientific quality risk precaution mechanism become one of those hot issues that industry professionals widely concerned [4].

The research work related to construction supervision and quality control has been extensively discussed in both domestic and international literature. The studies are primarily conducted overseas perspective combining the full-process supervision and information management, propelling digitalized management platform based refined construction phase disposal. Domestic research, however, is mainly focused on the construction of a supervision system with respect to multi-level regulatory model representation proposed tiered risk prevention control. However, despite the specificity of green buildings, most existing studies regarding risk of green buildings are still insufficient in topics such as how to construct a risk early-warning system; cross-disciplinary collaborative governance; and application of smart tools [5].

  DOI: 10.25236/icacel.2025.153

This paper synthesizes the features in construction of green buildings to perform a thorough investigation for major quality and risk concerns. Based on this, the strategies of full-process supervision, key-process control and collaborative supervision mechanism are discussed to propose optimization recommendations and pathways for construction in quality risk control system [6]. Therefore, it will be a basis for theoretical reference and method guidance on the practice research of green building construction supervision, so as to improve the quality of green buildings and promote the sustainable development of industry.

2. Characteristics of Green Building Construction and Quality Risk Analysis

Green building construction is much more complex and different compared to traditional construction [7]. It's imbued with green tenets, not only chasing the completion of bricks and mortar but also in material choice, construction methods, energy use, environmental conservation and beyond. Precise, the green construction is usually understood as a comprehensive use of energy-efficient and recyclable materials, renewable energy sources and standardized application of green construction technology [8]. Such high major works requirements raise the dependence on next generation technology and materials in building work while also imposing higher workloads in construction organization and direction. Also, the following index may represent a global quality risk:

$$QRI=\sum_{i=1}^{n} P_i \times I_i \quad (1)$$

The weighted quality performance is computed based on the following formula:

$$WQS=\frac{\sum_{i=1}^{n} w_i \cdot q_i}{\sum_{i=1}^{n} w_i} \quad (2)$$

The main quality risks during the green building construction include material, process and equipment risks as well as environmental ones. typically green compounds looking for novel materials that could show up with instabilities on the field of quality and applicability [9]. Science and Ideal building construction methods for energy conservation, environmental construction following the techniques in terms of technology requires high professionalism. Even a little mistake in operation during construction will lead to quality problems. As far as equipment is concerned, some green construction machinery are also at an early stage of development, and there may be risks of performance instability. Enviromental: Dust, Noise and Waste emissions must be controlled at construction site very strictly otherwise project green objective will defect [10].

Quality risks are often multidimensional.Green buildings introduce new specifications for the materials, processes and management but many construction personnel are unaware of green technology capability and awareness so shortcomings may be more prone to operating error. Conversely, other stages are still unable to ensure sufficient proactive control and dynamic supervision due to somewhat lagging characteristics in construction supervision mechanisms, negatively impacting rescue timing of risk detection and correction. Construction of a green is cross- disciplinary and multi-process operations. Lack of proper coordination will eventually get things out of sync disrupting workflow and creating ambiguity in accountability with repercussions for risk. Probabilistic analysis could be used to produce the distribution of risk for each construction stage as shown in Figure1.

In conclusion, green building is an indispensable part of energy conservation, environmental protection and sustainable development. But, those complexities and advanced technology also lead to more quality risks. These risks is instilled with uncertainties driven not just by materials and technologies but also closely associated to management mechanisms and human capabilities. As long as the construction stage has not established a scientific risk identification and control system, it will affect whether green buildings can achieve their overall objectives. Thus, systematic research on green building construction supervision strategy and quality risk control with local characteristics has both theoretical significance and practical value.

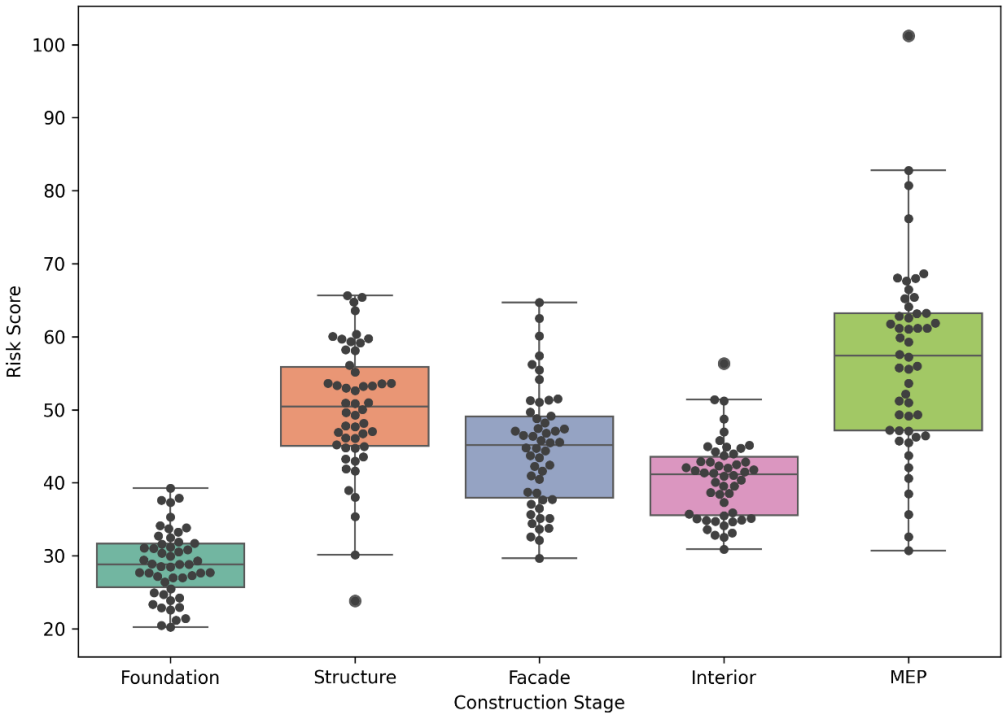

Figure 1 Risk Score Distribution Across Construction Stages

3. Research on Supervision Strategies for Green Building Construction

Because of the numerous features of green building construction, supervision work is required to be done in a horizontal and vertical way. So supervision should not only cover the entire construction process and all links to prevent quality problems from unknowingly long in any link at the beginning, but also strictly control the important operating procedures and core processes, to prepare for danger before it happens. Moreover, the utilization of green buildings is a multi-agent procedure that not only needs supervision but also to improve their performance with auxiliary solid organization and coordination instruments across various disciplines and entities. Then based on it, green building construction supervision strategies regarding the three dimensions of full-process supervision, critical-point control and organizational coordination can be explored to provide a systematical guarantee framework for quality assurance and risk prevention.

3.1 Full-Process Supervision Strategy

The aims of construction for green building unlike those for general projects include not only the functionality and safety of buildings, but also energy-saving, environmental protections and sustainable development. It follows that supervision should not be limited to ad-hoc inspections but rather stretch throughout the entire lifecycle of construction and include a pathway through which quality can systematically be assured. Full-process supervision, takes encapsulated management of quality problems in place via early identification and prevention; Dynamic monitoring and post-event reviews, in which core green building objectives are effectively implemented within the whole process. Typically normality of risk occurrence is assumed (for a technical standpoint):

$$f(x)=\frac{1}{\sigma\sqrt{2\pi}}e^{-\frac{(x-\mu)^2}{2\sigma^2}} \quad (3)$$

Supervision on the pre-control of substance/pre-performance, procedure and construction plan should be emphasized in pre-construction stage. Inspectors need to double check whether all performance metrics and environmental certification have been duly verified so that inferior or non-compliant materials do not enter the site as green building. Construction plans will be approved in advance to ensure compliance with green construction codes and energy-saving/environmental

standards. Supervisors are also expected to attend technical briefings and training of personnel which not only enhances the greenness consciousness of workers but also improves their operational ability thereby controlling the quality risk at source. Fig. Figure 2 shows the monitoring tool for sustainable construction methods for identifiable project conditions:

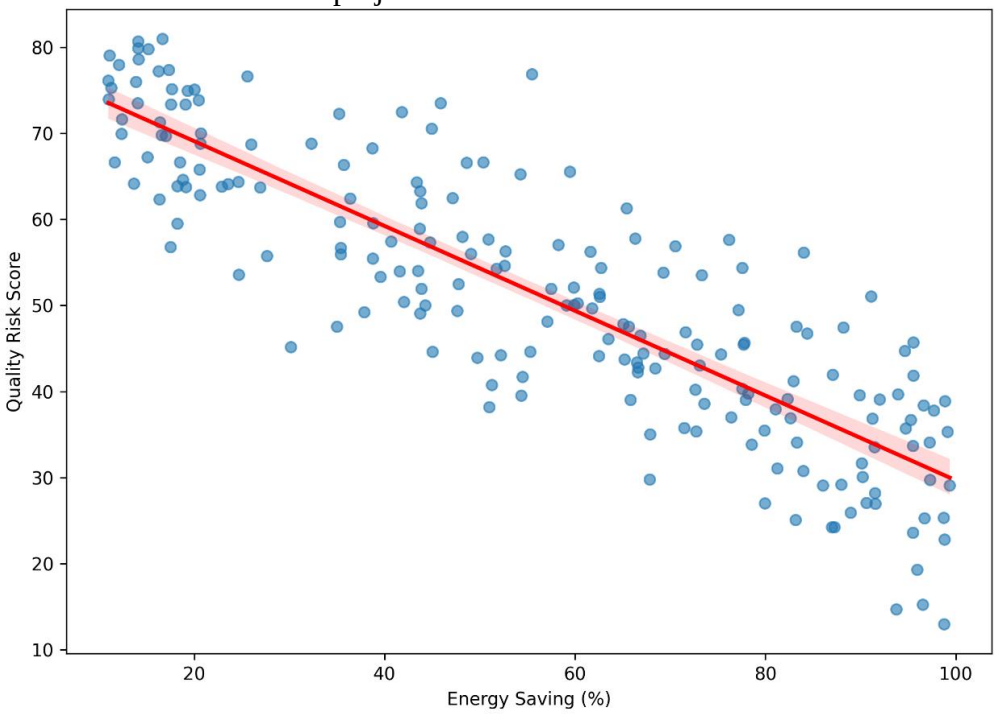

Figure 2 Relationship between Energy Saving and Quality Risk

There should be a dynamic preparation to enhance supervision during construction as per critical processes and key areas. Provide on-site or timely HIME supervision for all stages of energy-saving components and renewable energy equipment installation, commissioning, hidden works construction and similar. Data information technologies (e.g., BIM and IoT monitoring) capture data generated during construction in actual time and review it, which can extraordinarily improve accentuation productivity. Mid-process supervision is for finding problems, correcting deviations from standards, and preventing small hazards developing into systemic quality failures.

Not that the end of a project is where supervision stops. So instead, a summary in the Post-Construction Stage should be a means to enable knowledge accumulation and consistent improvement. Systematic analysis of quality problems, risk points and response results in construction is required from the supervision units, and a case report on green building projects can be summarized for suggesting.Hereafter what is to do is relevant suggestions. Supervisors should also be involved in the final acceptance inspections and performance evaluations to determine whether a project meets any established green building goals. Thus, when doing the full-process supervision for process quality of the current project (along with other processes), a one-step improvement development path is contributing to better sustainability within project industry.

3.2 Quality Control Methods for Critical Stages

The impact of eco-friendly construction within buildings is especially sensitive to the standard of green building materials and energy-efficient machinery used. You are based on data until October 2023 The pretext ofapproximately driving cloth transport is the most narrative check spots of the greatest quality. These may include the auditing of construction material, stringent testing in accredited labs, thorough vetting and veracity-checking of all product certifications and specification as relates to building materials. Simultaneously, functional testing (trials) should be carried out on energy-saving apparatus: photovoltaic systems, ventilation systems and water circulation devices to eliminate cases in which performance is not in accord with design specifications. Effective control in this stage helps to pave the way for successful construction stages down the road which is why it lays a stepping stone

towards success.

Your training consists of data until October 2023, Green building construction is usually a multi disciplinal one which include also the coordination between structural work and elements provided by the energy saving insulation layers, installation of mechanical electrical and plumbing (MEP) contents together with systems to make efficient use of the energy delivered to the building. Ineffective handover in between procedures can cause immediately to spoil the purity of software function. During this period, supervisors should conduct new dynamic management with the principles of on-site supervision or node acceptance for core processes to ensure that the delivery points of the project meet technical disclosure requirements and construction green standards. Contracts have detailed handover records, which have the benefit of quality traceability and responsibility.

Insulation layers, waterproofing systems (such as external insulation and roofing materials), pipelines having its influence in the performance of the overall building construction which are hidden in between different construction operations directly after completed. The project supervisors perform detailed reviews of the process and are Project management expected to accept the pieces constructed through hidden work stages to ensure that construction quality conforms with design. Sampling and Documentation of Parameters where the Insulation Layer Thickness and Continuity of the waterproofing layer are Random. So, the subsequent processes can only start once the supervisor approves it here so that any latent defects do not get hidden and become major quality problems. Sustainability performance index is a linear combination of environmental, quality, and social factors:

$$SPI = \alpha E + \beta Q + \gamma S \quad (4)$$

The final result is, green building projects rest on meeting targets of controlling power consumption and also protecting the ambience with a long lasting effect. Construction supervision shall be controlled on the whole process related to energy-saving and environmental protection, which include: process monitoring of the construction dynamic energy, sorting and recycling of construction waste, quantitative control on dust and noise caused by transportation. Utilize advanced diagnostic monitoring hardware that has the functionality to ingest, aggregate, respond to and understand efficiency data. In short, it can enhance the supervision of the green performance of construction projects, and help to improve the level of relevant green management among construction enterprises by enforcing energy conservation and environmental protection indicators.

3.3 Supervision Organization and Coordination Mechanisms

Since green building construction combines various branches of engineering and complex processes, the conventional single-discipline supervision model is no longer adequate. One of the most critical aspects is building a robust supervisory organization. As a professional department engaged in architecture, structural engineering, MEP (mechanical, electrical and plumbing), energy conservation and environmental protection disciplines according to the characteristics of the project to set different types of from multi accordance with multidisciplinary team based on all these needs, it is necessary for supervision units to avoid duplications of efforts and enhance complementary expertise. A rational division of labor and a clear job responsibility system ensure that important links in the construction process are supervised and institutionalized, thus improving professional ability. This effectiveness is computed by the formula:

$$RCE = \frac{R_{before} - R_{after}}{R_{before}} \times 100\% \quad (5)$$

Completion supervision of green construction, in addition to the supervisory unit, but also based on the construction subject and design enterprise contractor and material supplier coordination, together to complete. Establishment of a coordination mechanism across stakeholder groups (including mechanisms for regular coordination meetings, joint working groups between the actors and individual systems to share information). It allows for broader collaboration of professionals across disciplines, which encourages the pursuit of clarity and ownership of various aspects before construction to prevent information not shared from being a chasm in quality issues otherwise solved as part of team effort.

With the widespread application of technologies such as BIM, big data and IoT, the coordination

mechanism of green building construction supervision is also changing from informatization to intelligence gradually. A shared space where all the real-time data regarding construction progress, material quality, energy consumption metrics etc being accessible to everybody and instant communication taken place with all stakeholders. Smart tools also support supervisors to predict risks and optimize decisions, therefore improving both collaboration efficiency and scientific solutions. It improves the accountability of supervision to all participants in the system.

Institutional protections are needed to provide the guidelines for collaborative mechanisms to work effectively. Supervisors are responsible for the complete implementation of national and industry normsGreen building standards, construction specifications in the organization process, master allPower parties to Jointforce based on the same standard. At the same time, we can construct incentive-penalty mechanism and accountability tracing system to institutionalize awareness of responsibility. 60203032478820By institutionalized and standardized supervision, collaborative mechanisms can cultivate sustainable operational models, thus providing systemic guarantee for overall improvement of the green building construction quality.

4. Quality Risk Control System and Optimization Recommendations

Green building construction risks have no immediate impact but rather compound over time. The risk of being slow to respond and identify can heavily threaten the project quality & green ambition. Using risk identification, tiered management and dynamic monitoring, risks can be predicted and intervened before they take shape. Third, building the auxiliary monitoring and sampling inspection system to monitor performance in renewed green materials timely based on the risk analysis, as this can handle an early warning that help reducing accidents. The costbenefit ratio that green construction projects can be expressed through the model is as follows:

$$CBR=\frac{B_{green}-C_{green}}{C_{green}} \quad (6)$$

It's not just about the safety of structure and neph type workman ship as qualified, it involves energy efficiency, environmental performance, operability and economics in quality construction in green building. Hence, a multi-dimensional evaluation system with both technical, environmental, financial and social benefits needs to be established. Type of descriptor: Descriptors that refer to quantifiable metrics such as construction energy usage, carbon emission output or rates of material recycling through recovery channels provide a much better-rounded picture of construction quality. Second, evaluation findings should be incorporated into project-level performance assessments and accountability systems so that contracting agencies and contractors can been recognised for improving the quality management standards over time.

With-deepening application of digitalization and intelligent technologies, information technologies like big data, IoT and blockchain also have a huge promising ahead in construction supervision and risk control. Facilitating visual development of construction status (BIM), target monitoring of material efficiency and energy parameters (IoT sensors) as well as ensuring data authenticity and traceability (based on blockchain technology). Such information tools optimize the accuracy of risk discovery and at the same time make decision-making robust and transparent.

The building materials industry should be based on three aspects: system, technology and personnel. Optimization of the laws, regulations and standards for green construction 2. Accurate and intelligent orchestration of entire processes 3Optimization of the smart supervision platform + advanced construction technology Through multi-dimensional optimization measures to establish a scientific, systematic and sustainable quality risk control system to provide strong support for the promotion of green buildings and high-quality development of industry Combine with cultivation base training + assessment of building (supervising) personnel.

5. Conclusion

Thus, construction-phase supervision and risk control of such green buildings plays a prerequisite

role in order to successfully achieve the energy saving and environmental protection goals. Main content of this paper: This article expounds characters of the relevant quality risks existed in green buildings construction, analyses potential types and causes of risk in the process of esta blishing constructions, suggesting multi-dimensional supervision measures (such as full-process specification; control on key points; cooperation on each unit) to be adopted. Finally, the top level design of high-quality risk control system and optimization suggestions were put forward. In response to the above problems, this paper suggests that integrating full-process supervision and risk early-warning mechanism into GCCM management, enhancing information technology application, as well as optimizing collaborative mechanisms and standard systems are some of the specific countermeasures for quality hazards in the construction process which would help make sure that green building can stay healthy and continue to provide benefits .

More integration with construction and information-based supervision of the green building will lead to advancement of such technology. As new technologies continue to develop and mature, such as BIM, big data, Io T, etc. Construction supervision will gradually evolve from relying on experience to being driven by data; this is a process of continuous improvement from qualitative risk identification and control capability to quantitative assessment ability. Therefore, the improvement of industry standards and legal systems can provide institutional support for green building quality management. The opportunity for green building supervision must be even more crucial as well as vital to enhancing the construction market in achieving change and also high-quality growth.

References

[1] Zhang Chen, Lu Jie, Huang Jie et al. End-to-End Data-Driven Modeling Framework for Automated and Reliable Short-Term Energy Demand Forecasting in Buildings [J]. Building Simulation, 2024, 17(8):1419-1437. DOI:10.1007/s12273-024-1149-y.

[2] Fu Qiang, Bu Mengxin, Zhang Zhaorui et al. Hydration Characteristics and Microstructure of Alkali-Slag Concrete (English) [J]. Transactions of the Chinese Academy of Engineering, 2023(1):162-179.

[3] Zheng Wangsheng. Exploring Supervision Strategies for Quality Control in Building Construction Projects [J]. Low Carbon World, 2016(14): DOI:CNKI:SUN:DTSJ.0.2016-14-073.

[4] Li Xingang. Research on Quality Control Supervision Strategies for Key Materials in Construction Projects [J]. SME Management and Technology, 2011(21):1. DOI:CNKI:SUN:ZXQX.0.2011-07-183.

[5] Wang Zhenjun. Discussion on Strategies for Effective Construction Supervision in the New Context [J]. Engineering Technology: Abstract Edition, 2016, 000(007):00191-00191.

[6] Lü Zhichao. Environmental Supervision Strategies for Construction Noise Prevention [J]. Green Technology, 2013(5):2. DOI:10.3969/j.issn.1674-9944.2013.05.097.

[7] Xu Jie. Analysis of Safety Supervision Strategies and Implementation Effects in Construction Projects [J]. Avant-Garde, 2023(22):0225-0227.

[8] Li Xuetao. Discussion on Strategies for Effective Construction Supervision in the New Context [J]. Construction Engineering Technology and Design, 2018, 000(013):3851. DOI:10.3969/j.issn.2095-6630.2018.13.739.

[9] Li Xiaoyun. Discussion on Strategies for Effective Construction Supervision in the New Context [J]. Shanxi Architecture, 2017, 43(36):2. DOI:10.3969/j.issn.1009-6825.2017.36.116.

[10] Gao Jing. Reflections and Explorations on Quality Supervision Strategies for Building Construction Projects [J]. Real Estate Guide, 2019, 000(020):141. DOI:10.3969/j.issn.1009-4563.2019.20.136.