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Research on Construction Quality Control of House Building Projects

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Abstract: *With the continuous development of the construction industry, the role of social and economic promotion is more and more obvious, while the level of construction technology and quality requirements are also higher and higher. Housing construction project as a habitat for human survival, its quality is directly related to people's daily life, and even the country and the people's life and property safety. Construction phase quality control is a key link in the quality of construction, while quality control is the project management in cost control, schedule control and other management of the top priority, quality control and management of the situation will not only affect the successful completion of the project and the project cost, but also may bring serious safety hazards. Therefore, it is necessary to strengthen the quality control and management of the construction phase, using effective quality control methods and management systems to ensure that the quality of the project to meet the relevant requirements. Based on this, this paper in the construction process of quality control in the construction of basic methods and theories, combined with the actual project on quality control and management of in-depth study.*

Keywords: *building construction; construction quality; control content; control methods*

1. Introduction

1.1 Background and significance of the study

The quality of construction projects is crucial for ensuring the safety of people's lives and property. Ensuring impeccable project quality is a fundamental mission for all construction practitioners. As building types become more diverse and construction technology evolves rapidly, construction quality has increasingly captured public attention[1], and the standards have become more stringent. The quality of construction engineering is now pivotal to realizing contemporary and future architectural design concepts.

China's reform and opening up have significantly fueled the country's economic growth, which has, in turn, accelerated the development of its construction industry. However, China's relatively late start in construction technology research and the complexity of its construction environment have led to numerous quality issues. The introduction of the State Council's "Construction Project Quality Management Regulations" in 2000 has highlighted construction project quality as a critical focus. Ensuring construction quality hinges on effective regulatory requirements, methods, and engineering management throughout the entire lifecycle of construction projects. Thus, studying quality control methods and content in the construction process of housing and building projects holds substantial guiding significance and application value[2].

1.2 Significance of the study

Infrastructure development is crucial for societal progress, and this is particularly true for the construction industry. The growth of the construction sector not only stimulates regional economic development but also creates more space for human activities. The quality control of housing construction is vital for ensuring the safety of lives and property, impacting both daily human activities and national security. Thus, it is essential to prioritize construction quality and improve quality control and management methods.

Currently, domestic quality control measures primarily focus on the construction phase, which directly influences the overall building quality and is critical for effective quality control. This paper emphasizes quality control during the construction phase. Historically, varying levels of competence among construction practitioners and a lack of focus on quality control in enterprise management have

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led to weak quality consciousness and practices[3].

Additionally, the evolving nature of construction projects, including the diversification of building types and the complexity of construction processes, has highlighted numerous issues within construction management. Common problems include an inadequate quality management system, insufficient and poorly qualified personnel, non-standardized construction practices, improper implementation of technical documentation, lack of quality acceptance and problem analysis, and inadequate construction materials. These issues significantly reduce construction efficiency, increase the risk of accidents, disrupt project operations, and damage corporate reputation.

Therefore, improving the quality control methods and content during the construction process is crucial. This paper examines the main aspects and methods of quality control in housing construction projects, using project examples to demonstrate the practical significance of effective quality control. The findings aim to provide a strong practical foundation for other engineering applications and theoretical research.

1.3 The main problems of quality management and control of construction projects in China

Although the country has enacted various laws and regulations to improve quality standards, issues persist in the actual engineering construction process, leading to management problems. The key challenges in China's project engineering construction quality management and control can be summarized as follows:

1) Incomplete Quality Evaluation System: The evaluation system for engineering quality is not fully developed. Effective quality control requires detailed analysis and evaluation to understand methods and efficiency. However, many projects suffer from inadequate data analysis, insufficiently rigorous testing processes, and data errors[4]. These issues undermine the effectiveness of the engineering quality evaluation system.

2) Lack of a Robust Quality Management System: Many construction units and enterprises prioritize profit maximization over quality, leading to significant gaps in the quality management process. Responsibilities for quality management are often poorly implemented, and relevant personnel may not fully prioritize quality. Examples include incomplete monitoring records for foundation pit projects, missing signatures on quality acceptance records, non-compliance with construction sequence, and inadequate concrete curing conditions[5-7]. These lapses can result in severe quality issues.

3) Insufficient Technical Literacy Among Practitioners: Many practitioners, particularly in remote areas, lack sufficient technical expertise. The civil engineering industry often faces shortages of qualified professionals, with instances of unqualified individuals guiding construction. Low technological proficiency, inadequate knowledge of norms and atlases, and a lack of practical experience adversely affect construction quality and safety.

Addressing these issues is crucial for improving the quality control and management of engineering construction projects..

1.4 Research ideas and content

This paper conducts an in-depth study on quality management and control during the construction process, integrating both qualitative and quantitative research approaches. The primary theories and methods of quality control and management in construction are thoroughly detailed, and based on existing research, several effective strategies for engineering quality control and management are proposed. The main contributions of this paper are as follows:

1) **Overview of Engineering Quality Control Theories**: The paper outlines the foundational theories of engineering quality control, summarizes the commonly used quality control and management methods, and analyzes the main factors influencing construction quality.

2) **Comprehensive Analysis of Construction Quality Control**: The paper elaborates on the entire process of construction quality control and management, specifying the key control indicators and management content.

3) **Incorporation of Quality Statistical Analysis**: The paper introduces quality statistical analysis methods throughout the construction quality control process. Detailed studies of quality fluctuations in

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engineering examples are provided to offer a strong basis and recommendations for quality control in subsequent unit or subdivision projects.[8]

2. The theory of construction quality control of housing construction project

2.1 Basic concepts

2.1.1 Meaning of building construction

A house construction project, often referred to as construction engineering, generally comprises two main components. The first part involves the new construction, alteration, or expansion of the physical structure of the house building. The second part encompasses the various technical tasks associated with the construction process, including surveying, planning, design, construction, and maintenance.

2.1.2 Construction quality implications

The main focus of construction quality is the construction project itself, which typically involves three key aspects: quality control during construction preparation, quality control during the construction process, and quality control during completion and acceptance. Construction quality is defined by the project's ability to meet the needs of the owner while complying with national laws and regulations, technical specifications and standards, design documents, and contract requirements. This quality is primarily reflected in six aspects of the construction project: applicability, safety, durability, reliability, economy, and environmental coordination.

1) **Applicability**: Under normal usage conditions, the structure of the building should function well to meet the user's (owner's) needs, without excessive deformation or cracking. Applicability means that the construction project can withstand various external influences such as high and low temperatures, acids, alkalis, and UV radiation, providing sufficient strength, rigidity, and stability. Additionally, the project's ancillary components, such as plumbing, heating, electricity, and sanitation, must meet requirements. The building's appearance, including its structural form, design, decoration, and color, should also align with aesthetic standards[9].

2) **Durability**: Durability refers to the building's ability to meet the requirements of normal use throughout a reasonable service life and to fulfill its intended functions. Based on the functional state of the main structure, durability is categorized into four standards:

Level 1: Applicable to high-rise and important buildings, with a design life of over 100 years.

Level 2: Suitable for general buildings, such as ordinary residential buildings, with a design life of 50 to 100 years.

Level 3: Applied to secondary buildings, with a design life of 25 to 50 years.

Level 4: For temporary buildings, with a design life of less than 5 years.

3) **Safety**: Safety ensures that the structure remains secure during construction and normal use, avoiding harm to people and the surrounding environment. The building structure should not fail under load and must maintain stability during events such as earthquakes, explosions, or other sudden accidents, preventing destructive collapse.

4) **Reliability**: Reliability is the ability of the building to consistently fulfill its intended functions during the specified period in the design.

5) **Economy**: This refers to the costs and expenses incurred throughout the building's life cycle, encompassing the survey, planning, design, and construction phases of the project.

6) **Environmental Coordination**: This aspect refers to the alignment of the building project with the principles of green and sustainable development, ensuring harmony with the local economic, social, and ecological environments. This consideration is increasingly prioritized by designers, constructors, owners, and other stakeholders.

These six aspects of quality characteristics are interconnected and collectively reflect the comprehensive attributes a construction project should possess. However, the specific standards for these quality characteristics can vary depending on the type of building, category, and professional construction engineering requirements. Safety, applicability, durability, and economy are the fundamental criteria for building design and construction, serving as the foundation for design standards. Therefore, in practice,

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the design and construction plan should be tailored to the specific characteristics of the building and its surrounding environment.

2.1.3 Quality control implications

Quality management encompasses several key elements: quality planning, control, assurance, and improvement, with control being the central focus. The primary purpose of quality control is to ensure that the project meets its specified requirements.

1) Role of Quality Control: Quality control is a crucial component of quality management, aimed at ensuring that products, systems, and processes meet specified standards. This involves satisfying the quality requirements of the property owners while also adhering to relevant laws, regulations, and other mandatory standards. Quality control is primarily implemented through operational techniques and activities[10].

2) Operational Techniques and Activities: These two aspects form the core of quality control, represented by professional technology and professional activities. From the design phase to the completion of construction, each step in the process is monitored to ensure it meets quality standards. The goal is to minimize the impact of unfavorable factors, maintain real-time quality monitoring, and control, detect problems promptly, and take preventive measures. This approach emphasizes prevention, inspection, and strict quality control.

3) Comprehensive Quality Control: Quality control spans the entire product development process. By managing each step, quality control ensures that the product consistently meets the required standards, ultimately satisfying the user's needs..

2.2 Construction quality control of housing construction projects

The quality of a housing construction project is intrinsically tied to the quality of the building's construction. Engineering quality is characterized by two main aspects: engineering characteristics and construction characteristics. Therefore, effective quality control in construction must fully account for these aspects and implement targeted, specific measures to ensure optimal quality.

2.2.1 Characteristics of building construction projects

1) **One-time Nature**: Housing construction projects are one-time endeavors formed under specific conditions, with the construction process being irreversible and non-returnable. If significant quality issues arise, it is generally impossible to revert to the original state, potentially leading to a final product that does not meet the specified quality requirements or, in extreme cases, to the project being abandoned. Given the substantial investment involved in housing construction, any quality problems during the project management process can lead to significant financial losses for investors, which may be irreparable.

2) **Fixity and Mobility**: The fixed geographic location of a housing construction project necessitates construction at a designated site. This fixity determines the geological and hydrological environments in which the project is located. While the project itself is fixed, the construction process exhibits mobility—both in the movement of production factors within a single project and between different projects. This combination of fixed project location and mobile production factors underscores the unique nature of housing construction projects in project management.

3) **Individuality**: Housing construction projects are influenced by factors such as geology, hydrology, climate, and socio-economic conditions, which necessitate individualized designs tailored to each specific project. Unlike mass-produced items, housing projects cannot be standardized, though lessons from one project may inform others. Additionally, construction projects are subject to varying conditions such as location, timing, construction methods, and regulatory requirements, further emphasizing their unique nature.

4) **Large Scale**: Housing construction projects are large-scale undertakings designed to provide living, working, and other functions. These projects require the use of significant amounts of engineering materials, various mechanical equipment, and a large workforce, often over multiple stages, occupying substantial physical space and being vulnerable to climatic conditions.

5) **Pre-arrangement**: Housing construction projects are carried out under specific, pre-arranged contract conditions, which differentiate them from other industrial products. Unlike goods that are produced and then sold, housing projects are typically contracted and reserved in advance. This

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requires that costs, timelines, and quality standards be established upfront through processes like tendering, bidding, and contracting.

2.2.2 Characteristics of the construction quality of house building projects

The construction quality of housing building projects is characterized by the following four aspects:

1) Multiple Influencing Factors: Construction quality is affected by numerous factors. The completion of a project requires the coordination of various machines, personnel, and materials, making elements such as materials, machinery, hydrology, technical measures, and management systems critical to the outcome. Therefore, quality control must comprehensively account for these factors to ensure the desired quality.

2) Fluctuations in Quality Levels: The quality level of construction projects can fluctuate due to the variability of construction conditions and materials. These fluctuations make quality control during the construction process more challenging, as unfavorable factors can easily cause inconsistencies in the quality of the project.

3) Hidden Quality Issues: The complex nature of construction processes, including work procedures and hidden works, means that many aspects affecting structural safety and functionality are not immediately visible. This hidden nature requires construction workers to be vigilant in detecting potential quality hazards promptly, in order to prevent quality problems, defects, and accidents.

4) Limitations of Final Inspection: Unlike general industrial products, the overall performance of housing construction projects cannot be fully verified through final inspections alone. The intrinsic quality of the project cannot be disassembled and reassembled for verification, and thus, the final inspection and acceptance of the project have inherent limitations. As a result, relying solely on final inspections for quality control is insufficient, and ongoing quality assurance throughout the construction process is necessary.

2.2.3 Basis for quality control of construction of house building projects

The basis for quality control in housing construction projects can be categorized into the following four groups:

1) Engineering Contract Documents: These documents include project contracts, entrusted supervision contracts, and other related agreements. They outline the rights and obligations of all parties involved, specify responsibilities, and address the handling of breaches of contract. These documents guide the normal construction process and are fundamental to ensuring all parties adhere to agreed-upon standards and procedures.

2) Design Documents: Quality control in construction follows the principle of "construction according to the design." This principle includes adhering to design drawings, technical notes, and other related documents. Design documents are crucial for quality control; thus, during the technical submission and drawing review process, the construction unit should engage in thorough communication with the supervision unit, design unit, and owner to fully understand design and quality requirements.

3) Government Laws and Regulations: Relevant laws and regulations issued by the state and competent authorities provide mandatory standards and norms for quality management. These documents set the required standards for construction quality and must be followed to ensure compliance with legal and regulatory requirements.

4) Specialized Technical Regulations and Documents: These documents pertain to quality inspection and control within specific technical areas of the industry. They include various standards, norms, and regulations at different levels—international, national, industry, and enterprise. Technical standards offer guidelines for the quality of engineering projects, materials, machinery, and equipment, ensuring smooth project progress and maintaining operational order. Technical regulations or specifications, which implement these standards, establish codes of conduct that significantly impact product quality. These provisions are characterized by their relevance, directive nature, and timeliness.

Together, these four types of quality control bases work in conjunction to ensure comprehensive and effective quality management throughout the construction process. Each type addresses different aspects of quality control, contributing to the overall improvement and assurance of project quality.

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2.3 Influencing factors of construction quality control of house building projects

In the construction process, quality control and management encompass five main aspects, commonly referred to as "4M1E": Man, Machine, Material, Method, and Environment. Here's an overview of each aspect:

Human Control: This aspect involves managing the personnel directly engaged in construction activities, including organization, command, and operation. People are the driving force behind quality control, and their proactive involvement is essential to avoid mistakes. Key measures include:

Implementing professional qualification management to enhance personal management levels.

Enforcing licensing policies for various professional roles to ensure the quality of construction.

Introducing a reward and punishment system to motivate project personnel and maximize their potential. These measures collectively improve human control and contribute to maintaining construction quality.

Material Control: Material control pertains to the management of production equipment, construction materials, and semi-finished components. As the material basis of the project, material control is crucial for ensuring quality. Key aspects include:

Collecting and analyzing material information to select optimal suppliers.

Organizing material supply efficiently to support continuous construction.

Strictly accepting materials to ensure they meet quality standards.

Reviewing construction equipment and machinery for compatibility, variety, and performance to meet project requirements.

Mechanical Equipment Control: This involves managing construction equipment and machinery, such as elevators and cranes. Effective control of mechanical equipment includes:

Ensuring the quality and performance of equipment to enhance construction efficiency and quality.

Conducting regular inspections and adjustments to ensure accurate and standardized operation.

Selecting appropriate machinery and equipment to support construction progress and quality.

Construction Methods Control: This focuses on the selection and implementation of construction methods, including construction programs, organization design, and operational procedures. Key considerations include:

Evaluating construction programs for technical feasibility, economic rationality, resource conservation, simplicity, and operational feasibility.

Analyzing methods from various aspects—economic, technical, management, and environmental—to ensure quality control and cost-effectiveness.

Ensuring that the chosen methods positively impact construction quality and progress.

Environmental Factors Control: This aspect addresses the influence of the project's environment on construction quality. It includes:

The engineering environment (e.g., topography, hydrogeology, meteorological conditions).

The management environment (e.g., quality assurance activities, quality management systems).

The labor environment (e.g., labor tools, work surfaces).

Environmental factors such as temperature, humidity, and wind speed can affect construction quality. Effective control involves scientific and comprehensive analysis of these factors to manage their impact on the project.

Overall, quality control in construction requires a holistic approach, considering the interaction between people, materials, machinery, methods, and the environment. By addressing each aspect and optimizing their interactions, construction quality can be significantly improved.

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3. Conclusion

This paper provides a comprehensive analysis of the current state of domestic and international research on quality control in housing construction projects. It begins with an introduction to the basic theories of quality control, establishing a foundational understanding. The paper then examines various factors influencing construction quality from multiple perspectives to offer a scientifically grounded basis for quality control. Based on this research, the following conclusions are drawn:

Scientific and Effective Quality Control Systems: A well-structured engineering quality control system is crucial for standardizing construction projects. Such systems can effectively enhance the overall quality of engineering projects by ensuring adherence to established standards and procedures.

Tailored Quality Control Systems: For different types of construction projects, it is essential to develop quality control systems that address both the unique characteristics of individual projects and commonalities between them. This approach helps in creating effective, project-specific quality control measures.

Strict Quality Control Throughout Construction: Effective quality control requires stringent oversight during both the pre-construction and in-construction phases. Implementing appropriate reward and punishment mechanisms can motivate adherence to quality standards and improve overall performance.

Advanced Statistical Analysis: Utilizing advanced statistical data analysis and evaluation methods can provide a more scientific and effective means of assessing construction issues. This approach enables the development of targeted strategies and makes quality control more quantitative and precise.

The establishment of a scientific quality control system is essential for continually improving engineering quality and meeting customer expectations. A well-functioning quality control system not only enhances the reputation of the enterprise but also supports the development of a robust quality management framework. Furthermore, quality control management aligns with sustainable development strategies and reflects the principles of a harmonious society.

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