

Research on Housing Construction Project Management and Quality Control Based on Total Quality Management

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Abstract: Total Quality Management (TQM) is a management model centered on quality that requires the participation of all staff. Its concepts of covering the entire process, controlling all elements, and coordinating among all personnel are highly compatible with the actual needs of housing construction project management. Integrating this model into housing construction project management and quality control not only aligns with the transformation trend of the construction industry from scale expansion to in-depth quality enhancement but also compensates for the shortcomings of traditional management models through full-process control, providing strong support for the high-quality development of the industry. This study starts with the necessity of applying TQM in housing construction projects, analyzes the practical problems currently existing in the management and quality control of housing construction projects, and further explores specific application strategies of this model in key stages such as preliminary project preparation, construction process, and completion acceptance. The aim is to provide a feasible path for improving the overall quality of housing construction projects.

1. Introduction

Housing construction is an important foundation for national prosperity and people's livelihood, as the quality of housing construction reflects the overall development level of the construction industry, but also related to residential safety and social stability. In the past few years, China has made significant progress in terms of technological innovations and optimizing management in its construction sector. Conventional quality control practices within the implementation phase focus on inspections, lacking a holistic process management framework through which root causes can be addressed throughout the lifecycle from design to operation. Total Quality Management (TQM), on the other hand, is a comprehensive management approach that focuses on quality in all aspects of an organization and emphasizes total involvement, continuous improvement, and customer satisfaction. TQM integration in housing construction project management overcomes traditional constructs by providing a holistic quality system, clarifying roles and responsibilities, and streamlining processes for total quality control [1]. As such, there is substantial practical value in understanding how to implement it.

2. The Necessity of Applying Total Quality Management in Housing Construction Projects

2.1 An Inevitable Choice to Meet the Demands of High-Quality Development in the Construction Industry

At present, the construction industry in China is developing towards high-quality development from scale-oriented at all level. Housing construction engineering is a vital component of the development process in our industry. Traditional quality control models are mainly focused on the construction phase and do not meet the industry needs for lifecycle-wide quality management of a project from its initiation and design through to its construction, acceptance, and operation and maintenance stages. This is where Total Quality Management (TQM) fills the void, providing systematic control of the entire project lifecycle, raising overall engineering quality and

contributing to a strong foundation for championing high quality development in construction [2].

2.2 An Effective Approach to Addressing Current Quality Issues in Housing Construction Projects

At present, the construction quality of most housing projects is generally poor due to the lack of awareness quality and management skills throughout a project lifecycle and all-factor control which results in very common problems like wall leakage and structural vulnerability. This is exactly where Total Quality Management (TQM) comes in, focusing on "full participation and all-factor management" to tackle these issues head on. As an example, in material management a number of projects have end up performing the bare minimum and allowing for inferior materials to slip into the constructing phase. Using TQM, a total chain control mechanism can be set up for procurement inspection storage combined with QR code traceability systems. This means that poor-quality materials are excluded from construction sites, substantially mitigating quality risk at its root.

3. Problems in Current Housing Construction Project Management and Quality Control

3.1 Weak Quality Awareness

In housing construction projects, many participants put low emphasis on quality control by competing with each other; they sacrifice progress over quality and cost over safety. For instance, Some development organizations knowingly compress the time and resources dedicated to quality assurance processes in order to expedite project timelines or operate under a tighter budget. In a similar way, managers and frontline workers tend to stick with non-compliant ops or substandard materials because they have no idea about quality [3]. Even more so, it is challenging to form a coordinated effort for quality control due to the lack of effective communication and collaboration among stakeholders alone, making void the Total Quality Management (TQM) principle of full participations.

3.2 Gaps in Whole-Process Quality Control

Conventional quality control in housing construction emphasizes primarily on during-the-construction stage while neglecting the early-stage design and post construction operation and maintenance, leading to fragmented lifecycle management. There are design firms which, during the design stage, consider construction practicality level superficially and generate indeed executables drawings but would result with such mis-organized piping layers duly not repairable when in progress thereby becoming latent quality defects. Causal Problem #4: Lax acceptance inspections at handover between work stages Similar issues are also common problems with wall leakage and hollow pieces of floor tiles because of lax acceptance inspections. In the acceptance of completed work, many projects apply "soft" inspection criteria, allowing quality problems to be unnoticed [4]. There is no efficient quality follow-up mechanism during operation and maintenance, leading to problems reported by property owners not being rectified on time resulting in poor performance of the building; lower levels of customer satisfaction.

3.3 Inadequate All-Factor Management

However, the majority of frontline workers in housing construction are migrant laborers with little education or professional experience and very limited systemic quality training. They are less aware of construction specifications and quality standards, resulting in operational errors and quality defects. Also, they may not have any professional quality management skills, so it becomes difficult to properly apply the system. In the case of material management, lack of oversight during procurement means that certain suppliers are able to provide low-quality materials thus introducing latent risks into project quality [5]. In terms of Machinery and Equipment, older performance on some construction sites not only slows progress but even makes sacrifices on quality as result of equipment failures. In addition, the adherence to modern quality control measures in housing construction projects is made difficult by outdated construction methods and limited use of

advanced technologies

4. Application Strategies for Total Quality Management in Housing Construction Project Management and Quality Control

4.1 Strengthening Quality Awareness and Establishing a Participatory Quality System

In order to ensure promoting quality in housing projects, construction enterprises must design how testimonies of different stakeholder and personnel engaged on different roles in the process are provided. In terms of management staff from development entities, training programs should include TQM principles and quality control processes specific to the project. For example case study on wall cracking due to design defect, some enterprises give designers targeted training on design codes and quality risk prevention; through the analysis of typical cases, designers' awareness of risk can be enhanced. For example, one project provided hands-on training for workers in steel bar tying so they could master appropriate spacing and techniques; frontline workers in construction firms should be trained according to construction methods and operational standards. Training for supervisory personnel helps strengthen the responsibilities of supervision and inspection, including at preparation or approval stage, such as the study of key points for on-site supervision of hidden works to enhance their oversight capacity. This method improves quality awareness and professional competence of all project participants through stratified training [6].

The responsibility for quality must be personal all participants on projects in housing construction must work with respect to a lifelong accountability system, entailing division of duties and roles between specific persons. Development entity The project leader of the Development entity is responsible and has overall accountability for the quality of a specific project, including approving quality plans and high-level deviations. At the design firm, the lead designer is responsible for quality in design proposals that comply with regulations, codes and avoid safety hazards; e.g., pipeline conflicts were resolved because it was the lead designer who was held accountable to correct mistakes or omissions. The construction firm's project manager is the main on-site quality inspector, with overall authority over quality management during construction while frontline workers are responsible for the quality of their specific operational tasks. The supervision entity grants qualified supervision engineers in charge of quality assurance within specific disciplines, penalizing for failure to detect issues with the construction's quality. You also need to create incentives and penalties. One housing project had teams that complied with quality standards rewarded RMB 20,000 and those found to have cut corners fined RMB 10,000 and suspended from work while they rectified any shortcomings. Such measures efficiently encourage the active participation of all in quality management activities.

We need all related parties in housing construction projects, to work together and set up a multi-dimensional communication and coordination mechanism. The quality review meetings should be scheduled once a week and include representatives from development, design, construction, and supervision entities to discuss all the quality-related issues that arise during this period. Also, some information sharing platform to establish a collaborative management system based on Building Information Modeling (BIM) technology should be developed. Design firms can upload 3D Models and construction teams give real-time feedback on how the site conditions differ from what they show in their designs. Supervision bodies will check the progress of repairs online for example, one project used it to detect conflicts between pipelines and fix them before carrying out costly rework. Doing so, through such coordinated mechanisms, turns stakeholders into an unbreakable wall that exists to ensure quality control.

4.2 Implementing Whole-Process Quality Control Across the Project Lifecycle

As such, design firms must incorporate Total Quality Management (TQM) principles early on, and across the entire design phase of housing construction projects. It starts with extensive studies of the project, which means coordinating site expeditions to study geological situations and having interviews with developers to understand user needs. A residential project is an example, where the

design team increased window sizes and spaces between buildings after they were found to be popular in research for a greater natural light. It is necessary to implement a multi-party review mechanism for design schemes involving the development, construction and supervision units and geotechnical investigation units to conduct a joint review of design solutions with emphasis on structural safety and feasibility of construction. Additionally, endearing technology BIM utilization to carry out visual analyses of design programs using 3D modeling. For example, a BIM model used to study pipeline routing collision detection found conflicts with intersection locations, which allowed for proactive changes to routing and eliminated the latent quality risk at the source [7].

In terms of the actual construction period of housing construction, the whole-process quality control has to be strictly implemented by construction firms. Set detailed quality standards and acceptance procedures for process-based quality management, implemented with the "self-inspection, mutual inspection and special inspection" system; In the case of masonry wall construction for example, workers first perform self-inspection regarding mortar joint thickness, followed by mutual inspection on verticality between two teams and finally special inspections on flatness by quality inspectors before moving to the subsequent construction phase. As required overlapping supervision on-site and for concealed works, supervision entities shall designate personnel to supervise full time. During the foundation construction of one project, supervisors conducted 24-hour on-site supervision, video-recording steel bar tying and concrete pouring processes, keeping relevant records for quality traceability during acceptance inspections. Construction companies should prepare a complete management system of materials and equipment involved in the whole life cycle. Examples include choosing qualified suppliers during procurement, performing standard sampling inspections (e.g. heat resistance and tensile strength of waterproof membranes), and storage categorized to prevent material degradation affecting quality (e.g. cement in both weatherproof warehouses).

In the acceptance and completion phase, a development entity can establish an acceptance team with representatives from development, design, construction supervision, geological investigation units to conduct whole inspection of the project entity and documents. As an example, inspection teams for the acceptance of a residential community have done tests such as strength of concrete, wall flatness and so on, while checking construction records and material inspection reports. Whenever they discovered doors and windows sealed improperly, they ordered the construction firm to fix them before allowing repairs to be checked again.

During the operation and maintenance stage, the development entity or property management service provider is reasonably required to formulate a quality follow-up mechanism by regularly visiting owners for collecting feedback on quality issues. The quarterly post-occupancy evaluations conducted by one project found and quickly repaired issues like wall leakages and pipe clogging. In parallel to this, the relevant units should carry out a statistical analysis of quality defects: For example, one project discovered that insufficient waterproofing was the main reason for bathroom leaks; therefore, it made process optimization in subsequent projects and continued to improve quality.

4.3 Optimizing All-Factor Management to Enhance Quality Control Standards

When it comes to workforce management, construction firms should focus on effective oversight of frontline workers by investing in skills training and safety education while implementing a certification-based employment system. In one project, scaffolders were required to undergo specialist training and pass examinations before being certified as operational, significantly limiting safety and quality incidents resulting from inadequately used scaffolding. Besides, construction enterprises carry out professional quality management personnel recruitment to form professional teams that can constantly promote advanced scientific management methods and improve the efficiency of overall quality control [8].

By utilizing the potential of Internet of Things (IoT) in establishing a systematic material quality traceability system, construction firms can ease volatile trends around the procurement-inspection-utilization cycle with end-to-end tracking. For example, in a case of

housing construction was used QR codes on steel bars, concrete and other materials containing the information about manufacturer, specifications and even inspection reports. When project managers scanned these codes with mobile devices, they instantly found out everything there was to know about the material data—from origin to strength—enabling extremely rapid traceability (A batch of steel bars that failed inspection were quickly tracked down in the system to their few application sites where immediate replacement was required). At the same time, construction enterprises should also pay more attention to supplier management, strengthen the supplier evaluation system, and score suppliers in terms of quality, delivery date and service performance. Unqualified suppliers are eliminated to ensure regular material quality standards.

For machinery and equipment management, construction companies need an equipment inventory with a periodic maintenance system in place. One project kept meticulous ledgers of usage hours and maintenance records for tower cranes, concrete pumps, and other equipment, performing monthly inspections (e.g. measuring wire rope wear on tower cranes), scheduled component changes as they degraded to ensure operational safety. In terms of construction method management, construction enterprises should propound scientific and technological process methods. This project implemented prefabricated building technology that utilizes offsite fabrication, leading to the construction of individual factory-produced components and on-site assembly in order to reduce errors associated with site operations and yield superior quality. Moreover, the usage of Building Information Modeling (BIM) to simulate construction worked another project used BIM models to simulate sequencing when pouring concrete and set up an optimized area so that no cold joints would happen during setting, just to maintain structural integrity.

5. Conclusion

TQM principles—full participation, whole-process control, all-factor management, and continuous improvement—align very well with the requirements of housing construction project management. You are applied to solve the problems of weak quality awareness and fragmented lifecycle control that exist now. TQM improves the quality of engineering, building safety and high-quality industry development through participatory quality system and full-lifecycle management supported by all-factor governance.

The evolution of Total Quality Management (TQM) via technological integration and conceptual advancement is a necessity as the building business moves toward digitalization and green transformation in order to overcome new challenges. This fundamental model will be crucial in protecting public security, promoting industry development and improving the quality of housing construction in China.

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