

ORIGINAL RESEARCH ARTICLE

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# Research on Whole-Process Construction Management of Municipal Engineering and Construction Engineering

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**Abstract:** Municipal engineering and construction engineering are two core components of urban development, whose construction management levels directly impact project quality and investment efficiency. Based on the theory of whole-process management, this study systematically analyzes the fundamental differences between these two types of projects in terms of project characteristics and management challenges, and constructs an integrated management framework covering four stages: decision-making, design, construction, and completion. The results show that municipal engineering has the characteristics of linear distribution and underground concealment, and is vulnerable to external environmental interference. Construction projects are characterized by three-dimensional operations and the intersection of multiple disciplines, with high requirements for structural safety. Establishing a differentiated and phased management system is of great significance for improving the quality of engineering projects.

**Keywords:** Municipal Engineering; Construction Engineering; Whole-Process Management; Construction Management

## Introduction

Accelerated urbanization continues to expand the scale of municipal infrastructure and building construction. However, current construction management commonly suffers from fragmented phases, information silos, and inefficient resource allocation. Municipal engineering projects often face delays due to pipeline conflicts and traffic rerouting, while building construction struggles with poor coordination between structural work and interior

finishing. Whole-process construction management emphasizes integrated control from project initiation to completion acceptance, requiring synergistic achievement of quality, schedule, cost, and safety objectives. Thorough analysis of both engineering management characteristics and the development of targeted management frameworks hold significant theoretical and practical importance for standardizing construction practices, mitigating risks, and enhancing overall construction quality.



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## 1. Overview of Whole Process Management in Municipal Engineering and Construction Engineering

### 1.1 Definition of Whole-Process Construction Management

Whole-process construction management is a systematic concept that spans the entire project lifecycle, breaking through the limitations of traditional phased management to achieve seamless integration and dynamic control from decision-making and design to construction, completion acceptance, and handover. This model employs an integrated approach to coordinate the five key elements—quality, schedule, cost, safety, and environment—requiring all stakeholders to collaborate on a unified platform. It encompasses both the vertical time dimension (early-stage planning guiding construction, with process data feeding back into operations and maintenance) and the horizontal element dimension (continuous improvement through PDCA cycles). In municipal and construction engineering, managers must possess a forward-looking perspective, proactively anticipate risks, dynamically adjust resource allocation, and ultimately maximize the comprehensive benefits of the project.

### 1.2 Characteristics of Municipal Engineering

Municipal engineering encompasses infrastructure such as roads, bridges, and pipeline networks, exhibiting distinct spatial forms and technical characteristics: it demonstrates prominent linear distribution traits, with narrow, elongated work surfaces and segmented construction, necessitating organizational continuity; a high proportion of underground concealed works, such as pipeline laying and foundation treatment, are covered upon completion, making process inspection and visual documentation critical; complex external environmental interferences require coordination of traffic flow, pipeline protection, and residential needs, often making traffic diversion and pipeline relocation key bottlenecks in project timelines; direct impact by climatic conditions necessitates control of subgrade moisture content during rainy seasons and specialized concrete maintenance in winter. Additionally, municipal projects are typically handed over to government entities for acceptance, with stringent requirements for the standardization of archival

documentation <sup>[1]</sup>.

### 1.3 Construction Management Requirements for Building Engineering Projects

Construction projects primarily take the form of residential and commercial complexes, with construction management characterized by multidimensionality and multidisciplinary integration: Spatially, they encompass multiple divisions such as foundations, main structures, finishes, and electromechanical systems, where the coordination of interwoven processes and work areas is the core of management; Technically, the main structure requires strict control over rebar tying, formwork installation, and concrete pouring quality, while the finishing phase focuses on detail junctions and material color consistency, with high-precision requirements for turnkey delivery standards; Organizationally, it involves coordination between the general contractor and dozens of subcontractors, where interface delineation, process handover, and finished product protection mechanisms directly impact overall quality. The end users of construction projects are owners or property management entities, with unit acceptance inspections and functional tests (such as water spray tests) being critical for quality assurance.

## 2. Analysis of Differences in Construction Management Between Municipal Engineering and Construction Engineering

### 2.1 Project Characteristics Comparison

Municipal engineering and building engineering exhibit fundamental differences in product form, spatial layout, and service objects. From the perspective of spatial morphology, municipal engineering demonstrates a pronounced linear distribution pattern. Construction activities extend along road alignments or pipeline routes, and the working face dynamically migrates as construction progresses. Consequently, the storage of materials and the arrangement of machinery require frequent adjustment. In contrast, building engineering is characterized by a point-based concentrated layout. The working area is relatively fixed, and once vertical and horizontal transportation systems are established, they can operate in a stable manner. From the perspective of structural form, municipal engineering mainly involves earthwork filling, pipeline installation, and pavement paving. Although the structural force conditions are relatively simple, the scale of the projects is

enormous. Building engineering, however, involves multiple complex structural systems such as frames, shear walls, and tube structures, requiring precise calculations for structural analysis and node detailing. From the perspective of service functions, municipal engineering supports essential urban public functions, including transportation, water supply and drainage, and energy transmission. Quality defects in such projects can directly affect the normal operation of the city. Building engineering, by contrast, provides spaces for residential, office, and commercial use, where indoor environmental quality and user comfort become important evaluation indicators. From the perspective of acceptance standards, municipal engineering focuses primarily on functional tests, such as water-tightness tests, compaction degree inspections, and deflection value measurements. Building engineering places equal emphasis on visual quality and functional performance, including household acceptance inspections, water storage tests, and pipe ball tests.

## 2.2 Management Challenges and Pain Points

In municipal engineering management practice, the intricate network of underground pipelines poses the primary challenge. Due to missing historical data or insufficient detection accuracy, cases where unidentified pipelines encountered during construction lead to work interruptions or even safety incidents are common. Traffic diversion organization is equally complex, requiring repeated communication and coordination with traffic management authorities to close work zones while maintaining basic urban mobility functions. The effectiveness of diversion plans directly impacts public sentiment. Earthwork balancing and transportation management also present difficulties, as urban construction waste transport controls become stricter, with route approvals and disposal site arrangements often consuming significant effort. Challenges in construction engineering management primarily focus on multi-disciplinary coordination. During the late stages of main structure construction, over ten specialized teams—including mechanical-electrical installation, decoration, fire protection, and HVAC—simultaneously commence work, frequently leading to workspace conflicts, reversed construction sequences, and damage to finished products. Deep excavation construction requires extremely high risk control standards, with protection of adjacent existing buildings, groundwater control, and support structure

monitoring forming the core of safety management <sup>[2]</sup>. Additionally, the vast variety of material specifications—from steel and cement to decorative stone and sanitary ware—creates extended quality control chains. Minor oversights in sample sealing or entry inspection can lead to large-scale rework.

## 3. Construction of the Whole-Process Construction Management Framework

### 3.1 Phased Management Strategy

The entire construction management process should be divided into four organically linked stages according to project evolution principles. In the decision-making and design phase, the management focus lies in preliminary feasibility analysis of construction. For municipal engineering, priority should be given to checking collision detection in comprehensive pipeline layout drawings, while building engineering requires evaluation of deep foundation pit schemes' compatibility with surrounding environments. Deliverables at this stage should include construction drawing review comments and a draft overall construction organization design. During the bidding and contract phase, the core tasks involve clarifying technical standards and interface divisions. Bill of quantities preparation must accurately reflect soil classification in municipal works and finishing specifications in building projects, with special measure costs separately listed to prevent future disputes. In the construction implementation phase, municipal engineering should establish workflow plans based on road sections or shaft segments, strictly controlling subgrade compaction and pipeline joint quality; building engineering requires standardized floor cycle planning, implementing model demonstration and actual measurement systems, with process feasibility verified through construction step prototypes. For the completion acceptance and handover phase, municipal works focus on organizing functional tests and as-built survey mapping to ensure traceability of buried pipeline coordinates; building engineering rigorously implements unit-by-unit acceptance, inspecting spatial dimensions and functional compliance for each unit, while establishing property takeover inspection archives.

### 3.2 Collaborative Management Mechanism Design

Establish a multi-level management framework led by

the construction unit, supervised by the supervision unit, coordinated by the general contractor, and supported by subcontractors. Municipal engineering projects must specifically include pipeline ownership units and traffic management departments as external collaborators, while construction projects should strengthen on-site services from design units and early involvement of property management units. Build an engineering data center based on a cloud platform to aggregate whole-process data such as geological survey reports, design drawings, construction logs, and inspection reports. Municipal engineering should emphasize accurate labeling of actual locations and burial depths of underground pipelines, while construction projects should meticulously document visual records of concealed work acceptance and material traceability information. Design change management should establish a rapid response mechanism. In municipal engineering, when unidentified underground pipelines are encountered, the design, construction, and supervision parties should conduct on-site consultations to determine appropriate treatment measures. In building engineering, when adjustments to decorative effects occur, the potential impact on the terminal positions of mechanical and electrical systems should be evaluated simultaneously<sup>[3]</sup>. The coordinated allocation of labor, materials, and construction machinery is also essential. Municipal engineering emphasizes the operational efficiency of earthwork machinery and paving equipment, whereas building engineering focuses on balancing the coverage range of tower cranes and the transport capacity of construction elevators.

## 4. Key Management Technologies and Methods

### 4.1 Digital Technology Application

Building Information Modeling (BIM) technology plays a central role throughout the entire process. In municipal engineering, BIM is utilized for integrated pipeline design, enabling collision detection and layout optimization in virtual space, reducing on-site adjustments by over 60% during later stages. In construction engineering, BIM facilitates detailed design and construction simulation, allowing workers to intuitively understand complex structural nodes through 3D visual technical disclosures. Geographic

Information System (GIS) technology provides spatial decision-making support for linear construction in municipal projects by integrating multi-source data such as topography, existing pipelines, and traffic flow, thereby optimizing temporary access road planning and traffic management schemes. Internet of Things (IoT) technology enables intelligent sensing at construction sites, with sensors deployed in deep foundation pits of municipal projects and high-formwork areas of building projects to monitor deformation data in real time and trigger automatic warnings. Anti-collision systems for tower cranes and personnel positioning systems significantly enhance safety management. Drone aerial photography technology is employed for progress monitoring, generating orthophoto images and oblique photogrammetry models weekly to visually demonstrate on-site progress and inform resource allocation decisions.

### 4.2 Cost Control Methods

Whole-process cost control must be implemented throughout the project lifecycle. During the preliminary phase, emphasis should be placed on conducting economic comparisons of design schemes. For municipal engineering, earthwork balancing plans should be optimized to reduce transportation distances. In construction projects, cost differences and construction efficiency among different structural systems need to be compared. During the bidding phase, the bill of quantities pricing model should be adopted, with accurate and complete descriptions of project characteristics. Municipal projects should specify soil categories and transportation distances, while construction projects must clearly define brands and specifications of decorative materials to minimize later change orders. During the construction phase, dynamic cost monitoring should be implemented by establishing a material price information database. Bulk material procurement should undergo competitive bidding comparisons. Municipal engineering should focus on price fluctuations of key materials like steel, cement, and asphalt, while construction projects must strictly control the loss rates of owner-supplied materials such as decorative stone and tiles. A tiered approval system should be established for change order management, where all changes must undergo technical and economic comparisons and obtain confirmation of schedule impacts and cost

adjustments before implementation. In the completion phase, settlement documentation should be promptly organized. Municipal projects should thoroughly verify records of concealed works and site change orders, while construction projects need detailed statistics on discrepancies between actual material usage and design quantities to ensure the authenticity and completeness of settlement data.

### 4.3 Schedule Optimization Model

Progress management requires the application of scientific methods to achieve dynamic optimization. The critical path method serves as a fundamental tool for schedule planning. In municipal engineering, critical tasks such as earth excavation, pipeline installation, and pavement structural layer construction must be identified, while construction projects need to define milestone nodes including pile foundation construction, main structure topping out, and building envelope closure. As construction progresses, earned value analysis is employed for performance evaluation, accurately assessing schedule and cost variances by comparing the budgeted cost of work scheduled with the actual cost of work performed. Given the linear construction characteristics of municipal projects, the flow construction principle is introduced to optimize process sequencing. Long-distance road projects are divided into multiple construction segments, enabling orderly overlapping of earthwork, pipeline, base course, and surface course activities to reduce the overall duration. For building construction, simulation technology optimizes standard floor cycles by analyzing time requirements for rebar binding, formwork installation, and concrete pouring, thereby rationally allocating labor resources and work hours to compress standard floor cycles to optimal levels. When facing schedule delays, crash cost analysis evaluates the relationship between acceleration costs and time savings. Activities with the lowest cost slope are prioritized for compression to ensure coordinated achievement of both schedule and cost objectives<sup>[4]</sup>.

### 4.4 Quality Assurance System

The quality assurance system constitutes the cornerstone of whole-process management. A three-level quality management network—comprising the enterprise, project, and work team—should be established to clarify quality responsibilities for each

position. In municipal engineering projects, specialized quality inspection engineers for roads, bridges, and water supply and drainage are assigned, whereas building engineering projects deploy dedicated quality management personnel for civil works, installation, and decoration. Based on national standards, enterprises should formulate internal standards and project operation guidelines that exceed national requirements while incorporating project-specific characteristics. In municipal engineering, this includes refining the sampling frequency for subgrade compaction tests and the acceptance standards for pipeline joints. In building engineering, measurable indicators such as plastering flatness and the squareness of internal and external corners should be clearly specified through on-site measurement standards. Strict implementation of material entry inspection, process handover inspection, and concealed work acceptance systems is essential. Municipal engineering focuses on controlling the quality of raw materials and the results of functional tests, while building engineering strengthens on-site supervision of key processes, including concealed reinforcement works and waterproofing construction. The implementation of a quality analysis meeting system is also recommended. Quality issues should be periodically summarized and categorized, and analytical tools such as Pareto charts and cause-and-effect diagrams should be applied to identify root causes. Corrective and preventive measures should then be formulated and their effectiveness continuously tracked and verified. Through a comprehensive and multi-level quality assurance system, management can shift from result-based inspection to process-oriented control, thereby ensuring that project quality meets high standards at the first attempt.

## Conclusion

Municipal engineering and construction engineering are critical components of urban development, with construction management levels directly impacting urban functionality and residents' quality of life. This paper systematically examines the whole-process management of both types of projects, revealing their fundamental differences in spatial forms, technical characteristics, and management challenges. It constructs an integrated management framework covering four stages: decision-making and design,

bidding and procurement, construction implementation, and project completion acceptance. Key pathways such as digital application, collaborative mechanisms, and dynamic cost control are clarified. Managers must avoid simplistic application of models and instead extract common principles to enhance efficiency. In the future, smart construction will drive the evolution of management toward data-driven and intelligent decision-making approaches.

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