Journal of World Architecture, 2026, Volume 10, Issue 1
https://ojs.bbwpublisher.com/index.php/JWA
Online ISSN: 2208-3499
Print ISSN: 2208-3480

Research on the Construction Technology Control Mode of Cement Concrete Engineering in Construction Projects

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Abstract: With the continuous development of the construction engineering industry and the renewal of related technologies, improvement of the construction quality and management efficiency of cement concrete engineering has become a focus of research. Against this background, this paper elaborates on the key role of construction technology control in cement concrete engineering from multiple dimensions, such as ensuring the physical quality of the project, optimizing construction process management, and guaranteeing the long-term durability of structures. It deeply analyzes the practical problems faced in concrete engineering construction, and then proposes a "standardized, dynamic, intelligent, and refined" construction technology control mode. This mode achieves full-chain and full-process control effects from raw material management, mix ratio design, mixing and transportation, pouring and vibration to curing monitoring, thereby improving project quality, saving costs, and achieving green construction standards, which is conducive to enhancing the technical management quality of the industry.

Keywords: Cement concrete; Construction technology; Control mode; Full-process management; Intelligent monitoring; Refined construction

Online publication: March 17, 2026

1. Introduction

In modern construction projects, cement concrete, as a basic structural material, its construction quality directly affects building safety, service durability, and functional characteristics. Against the background of the continuous expansion of modern building scale and the increasing complexity of building structures, project quality, construction efficiency, resource conservation, and environmental protection have become core control factors of construction projects, and the construction technology control of cement concrete engineering is the key among them. Therefore, exploring a scientific, systematic, efficient, and implementable construction technology control mode for cement concrete engineering has become an important path for the high-quality development of China's construction engineering industry.

2. Analysis of the role of construction technology control in cement concrete engineering of construction projects

2.1. Cornerstone role in laying the physical quality of the project

In terms of project results, technical control is an important factor to ensure the internal and appearance quality of concrete structures. For instance, the technical control mode can standardize the management of raw material quality, clarify the accuracy of mix ratio, and select the correct mixing process, thereby ensuring that the design strength of concrete meets architectural requirements and achieves the required uniformity [1]. Moreover, the technical control mode can reasonably regulate the working performance of concrete, ensuring that different processes are used for pouring and vibration at different positions to meet architectural design needs and avoid problems such as poor fluidity or segregation. Furthermore, refined technical control can also effectively reduce quality problems such as cracks, holes, and honeycombing on the internal and external surfaces of concrete, thereby improving its appearance quality and durability, and meeting subsequent decoration and long-term use requirements.

2.2. Hub role in optimizing construction process and resource allocation

From the perspective of project management and economic benefits, technical control can effectively connect various construction links to achieve the goal of optimizing resource allocation. On the one hand, the technical control mode needs to establish standardized operating procedures and inspection processes, thereby proposing clear process operation standards, handover requirements, responsibility boundaries and other specifications. This can not only avoid construction randomness but also improve the connection efficiency between processes, thereby shortening the construction period and reducing the rework rate. On the other hand, the technical control mode can also establish a dynamic mix ratio adjustment plan and an intelligent transportation scheduling system, thereby realizing the optimization of raw material utilization and saving costs as much as possible on the premise of ensuring quality and quantity [2]. In addition, high-quality technical control can optimize and improve the entire process of construction projects, thereby reducing safety risks and ensuring the professionalism, rationality, and scientificity of construction links.

2.3. Supporting role in ensuring the long-term performance and sustainability of structures

From the perspective of the whole life cycle of buildings and sustainable development, the construction of a technical control mode is also conducive to improving the durability and environmental friendliness of concrete structures. Technical control requires strict material selection and strict mix ratio control, which can significantly enhance the impermeability, freeze-thaw resistance, carbonation resistance, and corrosion resistance of concrete structures, achieving the purpose of extending service life [3]. Conversely, technical control also requires the scientificity and effectiveness of the curing link. Especially under the real-time monitoring system, the adequacy of the concrete hydration reaction can be ensured, thereby reducing the probability of early plastic shrinkage and temperature stress cracks. Additionally, modern technical control standards also encourage the addition of industrial waste such as fly ash and mineral powder as admixtures in concrete, which can also reduce the amount of cement used, thus conforming to the concepts of green buildings and energy conservation and emission reduction.

3. Practical problems faced in the construction of cement concrete engineering in construction projects

3.1. Fluctuations in raw material quality and extensive management

Raw materials such as cement, aggregates, and admixtures are fundamental to affecting the quality of concrete buildings, but practical construction projects face problems as follows:

(1) The sources of sand and gravel materials vary greatly, and their properties such as particle size distribution, mud content, and impurity content fluctuate significantly [4];

(2) The management of raw materials at the construction site is relatively extensive, and targeted protection for different materials has not been implemented.

3.2. Disconnection in construction process control and information silos

Concrete construction requires the cooperation of mixing stations, transportation parties, construction parties, etc., but disconnection problems are prone to occur in the construction process as outlined:

(1) The ready-mixed concrete mechanism pursues efficiency and cost reduction more, and fails to plan the mixing progress according to needs [5];

(2) There is a lack of regulation in the transportation link, which is prone to traffic jams and on-site congestion;

(3) There is a lack of data recording and monitoring in each link, making it difficult to trace and hold accountable for quality problems.

3.3. Dependence on human factors and lag in technology updates

The experience and sense of responsibility of operators are also important factors affecting the quality of concrete construction. However, in the traditional construction process, there is a lack of monitoring and testing for links such as whether vibration is dense and whether curing is timely and in place. Objective and quantitative evaluation standards have not been established, making quality control dependent on workers' skill levels and conscious awareness. On top of that, there is a misunderstanding of "valuing the main structure and neglecting curing", failing to recognize the important significance of curing work, and failing to introduce intelligent monitoring equipment and testing technologies [6].

4. Construction strategies of the construction technology control mode for cement concrete engineering in construction projects

4.1. Build a full-process standardized management system throughout the entire process

The construction of the construction technology control mode for cement concrete engineering should establish a full-process standardized management system throughout the entire process from three levels: system, execution, and personnel, thereby optimizing the top-level design.

At the system level, in accordance with national specifications and industry standards, a detailed Special Construction and Control Plan for Concrete Engineering should be compiled to clarify the concrete construction requirements for different types of buildings, including raw material entry inspection, material storage management, concrete mix ratio design, and relevant approval, transportation, production, curing, pouring, strength evaluation and other links, thus forming a full-process technical standard, operation specification, and quality acceptance system [7].

At the execution level, a traceable file management system should be established. Through unique identification and record filing, the key parameter information of each batch of materials and each batch of concrete should be clarified, including batch number, origin, mix ratio report, pouring location, transportation order, curing record, etc., thereby achieving a traceable effect [8].

At the personnel level, a standardized training system and assessment system should be established. It is necessary to strengthen the understanding of relevant norms and standards among management, technical, and operational personnel through pre-job training, regular training, and assessment training to ensure strict implementation. That said, a corresponding assessment system should be established to score and assess the execution of each employee. Employees who violate regulations or fail to meet assessment indicators should be improved through training and given corresponding penalties of varying degrees.

4.2. Implement dynamic mix ratio design and mixing process control based on data feedback

The concrete construction technology control mode should introduce dynamic control theory and change the traditional fixed mix ratio specifications of concrete.

In the design stage, based on laboratory research benchmarks, the specific conditions of the construction site should be considered, including parameter differences such as moisture content and mud content of sand and gravel raw materials on site, changes in ambient temperature and humidity, and construction process requirements, and then fine-tuned to a certain extent according to the situation. In this process, rapid detection equipment such as online moisture content meters can be used to determine data, and the concrete mix ratio can be fine-tuned accordingly [9].

In the production stage, an automated and accurate metering feeding system should be established to upgrade the auxiliary functions of the mixing station. In the process of adding and mixing various materials, especially for materials such as water and additional admixtures, the measurement error needs to be controlled within the minimum range to ensure compliance with specifications and standards [10]. In addition, a mixing monitoring system should be established to ensure that the mixing time and uniformity meet the standards, and the relevant mixing data should be uploaded to the cloud platform with the help of the Internet of Things (IoT) system, providing a convenient channel for supervisors to monitor and detect.

4.3. Build an intelligent transportation scheduling system integrating IoT and GIS

In the concrete transportation link, problems such as slump loss, segregation, and excessively long on-site waiting time are usually faced. For this reason, an intelligent scheduling system needs to be established to optimize the connection and efficiency of the transportation link as follows:

(1) Implement vehicle monitoring: Mixing transport vehicles can be equipped with Beidou positioning, RFID identification, and on-board sensors to real-time monitor the rotation status of the transport vehicle tank, analyze data such as concrete temperature, so as to achieve real-time tracking of vehicle position, status, time and other information, and adjust the vehicle transportation scheduling plan in a timely manner according to the actual situation [11];

(2) Establish an optimized scheduling system: Vehicle monitoring data should be integrated, and an intelligent scheduling model for transport vehicles should be established in combination with GIS maps, real-time traffic information, and construction site pouring progress [12]. The optimal transportation route and

departure interval should be planned through intelligent algorithms, thereby realizing the transformation from "vehicles waiting for materials" to "materials waiting for vehicles" and ensuring the continuity and timeliness of concrete supply;

(3) Establish an information collaboration mechanism: Communication platforms should be established at the mixing station, construction site, and scheduling center to achieve real-time communication between the three parties, thereby ensuring the dynamic transmission of production and transportation plan information and effectively responding to on-site emergencies.

4.4. Implement refined pouring process control based on structural characteristics and process parameters

The pouring link is a key process for concrete to form a physical structure and an important link directly affecting the characteristics and attributes of the building structure. Therefore, refined operations are needed for optimization and improvement as outlined:

(1) Pre-construction planning: Before pouring, plans should be formulated in advance for the pouring sequence, layered thickness, feeding point layout, vibration plan, and emergency preparation. The formulation of the plan should also refer to factors such as the structural type, steel bar density, and formwork form of concrete pouring , such as the size of the pouring volume, whether there is a towering shape, and whether it is thin-walled [13];

(2) Process monitoring: Strict on-site slump inspection of the pouring link should be carried out, and subsequent processes can only be implemented after passing the inspection to ensure that the performance of the concrete entering the form meets the established requirements. Specifically, the vibration process is required to be standardized and standard. The type of vibrator, moving spacing, insertion depth, and duration should be clarified in advance. During the execution link, over-vibration or missing vibration should be avoided [14]. For mass concrete, a real-time temperature monitoring system and a circulating water cooling system need to be established to ensure moderate temperature through temperature control measures, thereby preventing cracks caused by harmful temperatures.

4.5. Promote a full-cycle curing monitoring system covering early and late stages

Curing is the last link in concrete engineering construction and a key process to ensure its strength and durability quality. Therefore, a full-cycle curing monitoring system covering early and late stages needs to be established as follows:

(1) Establish a customized plan: Different curing plans should be formulated based on differences in factors such as the composition characteristics of concrete, structural parts, seasonal climate, and temperature, humidity, and wind speed conditions, including measures such as covering and moisturizing, water spraying, curing agent spraying, and steam curing [15]. At the same time, the start and end time, frequency, and indicators of curing should be clarified;

(2) Ensure process monitoring: A sensor system should be arranged at key structural parts of the curing area to real-time monitor the environmental characteristics and temperature and humidity data inside and on the surface of concrete, and upload them to the management platform. When temperature and humidity data are abnormal, the system will automatically issue an early warning to remind relevant staff to take measures for timely intervention;

(3) Establish an electronic recording mechanism: For the monitoring data and curing actions during the curing period, relevant information should be generated into electronic curing logs, including curing personnel, curing items, curing conditions, curing results, etc., to provide data support for subsequent completion.

5. Conclusion

In summary, the construction quality of cement concrete engineering is affected by many factors. Therefore, it is necessary to build a systematic control system throughout the entire process of planning, production, transportation, pouring, and curing to ensure project quality. Based on the framework of full-process standardized management, this paper uses dynamic design and intelligent scheduling as means, and refined construction and full-cycle monitoring as guarantees, thereby establishing a forward-looking, adjustable, and traceable three-dimensional control network, and further promoting the intelligent transformation and sustainable development of the construction industry.

Disclosure statement

The author declares no conflict of interest.

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