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Analysis of Concrete Structure Construction Technology in Civil Engineering Construction

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ABSTRACT
The construction technology of concrete structures plays a vital role in civil engineering. This paper mainly analyzes the construction technology of concrete structures in civil engineering construction, focusing on the key construction points of the formwork support system, including the installation and removal of formwork as well as the design and erection of the support structure. It also elaborates on the concrete pouring and vibrating techniques, such as methods like layered pouring and segmented pouring, along with different vibrating methods and parameters. Moreover, it introduces the concrete curing techniques, such as water spraying curing, covering curing, and spraying curing agents. Through in-depth analysis of these technologies, it aims to provide references for improving the construction quality of concrete structures in civil engineering.

KEYWORDS
Civil engineering; Concrete structure; Formwork support system; Pouring and vibrating; Curing technique

In modern civil engineering construction, concrete structures are widely used in various construction projects due to their advantages in good mechanical properties, durability, and economy. The quality of concrete structure construction technology is directly related to the quality, safety, and service life of the entire project. Therefore, this paper will conduct a detailed discussion on the key technical links in the construction of concrete structures, hoping to provide beneficial guidance for relevant engineering practices.

1 Key Construction Points of Formwork Support System

1.1 Installation and Removal of Formwork

Formwork installation is a crucial link in concrete structure construction, which directly affects subsequent construction and structural quality(Liu, X. Y. 2024). . Before installation, it is necessary to carefully check the material, specification, and model of the formwork according to the design drawings to ensure that they match the project requirements. For multi-story or high-rise buildings, standardized formwork should be preferentially selected to improve efficiency and maintain consistent dimensions. When the formwork arrives at the site, its flatness and integrity should be inspected, and deformed or damaged formwork is prohibited from being used.

The installation of formwork should start from the bottom and proceed upward gradually. Taking a frame structure as an example, the column formwork should be installed first, and its verticality should be ensured, with the deviation generally not exceeding 5 mm. It can be measured by a plumb line or total station. Meanwhile, the formwork should be fixed by positioning steel bars or embedded bolts to prevent displacement. When splicing, the gap should preferably not exceed 1.5 mm and can be sealed with a sealing strip.

The beam formwork is installed after the column formwork. The prefabricated formwork is designed according to the span and cross-section of the beam. When laying the beam bottom formwork, the elevation should be ensured to be accurate, with the error controlled within ±5 mm. When the span is greater than 4 m, cambering is required, and the camber height is generally 1% - 3% of the span. The beam side formwork should ensure verticality and be reinforced by supports and tie bolts, and the spacing should be reasonably set to ensure stability.

Before installing the floor formwork, a scaffold needs to be erected, and the calculated spacing of the upright poles usually does not exceed 1.2 m × 1.2 m. The formwork should be laid flat and spliced tightly, using either hard splicing or soft splicing. After the installation is completed, a comprehensive inspection of the connections, dimensions, and flatness of the formwork should be carried out, and problems should be rectified in a timely manner.

Formwork removal is an important concluding link and should be carried out at an appropriate time to ensure the integrity of the concrete structure. The removal time depends on the concrete strength and structural type. For example, non-load-bearing formwork can be removed after the strength reaches 1.2 MPa; for load-bearing formwork, it needs to be based on the test results of the test block strength. For components with different spans, there are different regulations regarding the removal time.

The removal sequence is opposite to the installation, following the principle of "removing after supporting first". When removing the column formwork, first remove the diagonal braces and tie bolts, and then gently pry the formwork. When removing the beam formwork, first remove the side formwork, and then remove the bottom formwork from the mid-span to both ends. The floor formwork is removed symmetrically from the mid-span to all around, and attention should be paid to monitoring the deformation. If there is any abnormality, the removal should be stopped immediately. After removal, the formwork should be cleaned in a timely manner, residues and dirt should be removed, deformed and damaged formwork should be repaired or replaced, release agent should be applied, and then the formwork should be classified and stacked for future use.

1.2 Design and Erection of Support Structure

The design of the support structure needs to comprehensively consider the engineering structure form, load distribution, and construction process. In the construction of vertical structures of high-rise buildings, such as core tubes and shear walls, steel pipe scaffolding with high strength and large stiffness or hydraulic climbing formwork is suitable. For example, in a 50-story super high-rise building, the core tube adopts a hydraulic climbing formwork support system. As the pouring height increases, it provides stable lateral support, reduces material input, and improves efficiency.

In the construction of large-span concrete structures, such as the roofs of exhibition halls and gymnasiums, truss-type, grid-type, or spatial combined supports are commonly used. These structures effectively transfer the self-weight of concrete and construction loads through reasonable rod layout and joint connections. For instance, the roof of a large exhibition hall adopts a grid-type support structure made of Q345 steel. Through finite element analysis, the design is optimized to ensure the bearing capacity and reduce the self-weight.

The selection of support materials is of great importance, and they need to have good bearing capacity and stability. Steel pipe scaffolding is widely used due to its versatility and stability. The commonly used specifications are $\varphi 48 \times 3.0$ mm or $\varphi 48 \times 3.5$ mm, and the upright poles and crossbars are connected by fasteners. Portal scaffolding is convenient to install and suitable for open sites, while bowl-lock scaffolding is suitable for heavy loads and large formwork supports.

When erecting the support structure, the design scheme and construction specifications should be strictly followed, and the spacing, verticality of the upright poles, and foundation treatment should be controlled. The spacing of the upright poles is determined according to the calculation and should be evenly distributed, with the deviation controlled within 1/500, which is monitored by a theodolite. A solid base plate should be set at the bottom of the upright pole, and soft foundations should be reinforced to ensure the bearing capacity.

Crossbars and diagonal braces are crucial for enhancing the structural stability. The step distance of the crossbars is reasonably set according to the spacing of the upright poles and the load situation, generally not exceeding 1.8 m. Diagonal braces should be set at key positions as required by the design, forming a triangular structure with the upright poles and crossbars to effectively resist lateral loads and prevent overturning. In a multi-layer support system, the upper and lower layer upright poles should be kept in the same vertical axis position to ensure the effective transfer of vertical loads and ensure the safety and stability of the support structure during the concrete construction process.

2 Pouring and Vibrating Techniques of Concrete

2.1 Pouring Methods and Processes

Concrete pouring is a key process in structure construction, and the reasonable selection of pouring methods and processes directly affects the structure quality. In engineering, an appropriate pouring method should be carefully selected based on factors such as the structure type, size, reinforcement situation, and construction conditions.

Layered pouring is a commonly used pouring method, especially suitable for mass concrete structures. Since the hydration heat of cement in mass concrete is difficult to dissipate quickly during the pouring process, it is easy to cause internal temperature stress, which may lead to cracks. Layered pouring can effectively alleviate this problem. The pouring thickness of each layer is comprehensively determined based on factors such as concrete supply, pouring speed, and the action depth of the vibrator, usually not exceeding 1.25 times the length of the vibrator, and at most not exceeding 50 cm. For example, in a large water conservancy dam, the dam body can be layered along the height, with each layer thickness controlled at 30 - 40 cm, and poured layer by layer from the bottom to the top. After each layer is poured, the next layer is poured when it is close to the initial setting, so that the hydration heat released by the lower layer of concrete can be dissipated outward, reducing the internal temperature gradient and the risk of cracks.

Segmented pouring is often used for strip-shaped structures or when there are construction joints in the structure. For example, in the construction of ultra-long bridge box girders and the pouring of large water transmission pipelines, due to the excessive length of the structure, it is difficult to ensure the continuous supply and construction quality of concrete for one-time pouring. Therefore, segmented pouring is more appropriate. When segmenting, factors such as the mechanical characteristics of the structure, the setting of deformation joints, and construction convenience should be fully considered to reasonably determine the segment length. Generally speaking, each segment length is preferably controlled at 20 - 30 m, and a construction joint is set between adjacent segments. The position of the construction joint should be selected at a part of the structure where the force is small and it is convenient for construction, such as within one-third of the mid-span of the beam and in the secondary stress direction of the slab. Before pouring the concrete of the next segment, the construction joint should be properly treated. The concrete surface at the construction joint should be roughened, loose stones and floating slurry should be removed, it should be rinsed clean with water, and then a layer of cement mortar with the same mix ratio as the concrete should be laid to ensure a tight bond between the new and old concrete.

2.2 Vibrating Methods

Vibrating is a key link in concrete pouring, aiming to fill the internal voids and expel air through external force to improve the compactness, strength, and appearance quality of concrete. Different vibrating methods are suitable for different structures and working conditions, and precise control of vibrating parameters is crucial(Li, Z. Y. 2024). .

The inserted vibrator is a commonly used vibrating tool, suitable for beams, columns, walls, and thick slabs. When using it, the principle of "fast insertion and slow extraction" should be followed. Insert it quickly to avoid air entrainment, and extract it slowly to prevent leaving voids. The insertion points should be evenly arranged, and the moving distance should not exceed 1.5 times the radius of the vibrator rod (about 30 - 40 cm). When vibrating the upper layer, it is necessary to insert 5 - 10 cm into the lower layer to enhance the bonding. The vibrating time is generally controlled at 20 - 30 s until the concrete no longer sinks and no more bubbles appear.

For thin and large-area structures, such as floors, the surface vibrator is more applicable. It transmits vibration through contact with the concrete surface, and the moving speed should be controlled at 1 - 1.5 m per minute to ensure coverage of the edge of the compacted part. The effective action depth is 200 mm in unreinforced and flat slabs, and 120 mm in double-reinforced slabs. Each vibrating time should be at least 15 s to ensure compactness.

In large prefabricated components or projects with high requirements for appearance, the attached vibrator can be used. It is fixed on the outside of the formwork and transmits vibration through the formwork. When vibrating, the layout should be reasonably adjusted according to the size and shape of the component, with the spacing generally being 1 - 2 m, and the vibrating time being 30 - 60 s to ensure a flat surface, bleeding of mortar, and no bubbles.

3 Curing Techniques of Concrete

Concrete curing methods and curing periods are crucial to the quality of concrete structures(Xia, Y. X. 2023). Water spraying curing is the most common method. After concrete pouring, water should be sprayed in a timely manner to keep the surface moist and promote the hydration reaction of cement. The water spraying curing time for ordinary Portland cement concrete is generally not less than 7 days, while that for pozzolanic and fly ash Portland cement concrete is at least 14 days.

Covering curing reduces water evaporation by covering materials such as straw curtains, gunny sacks, or plastic films, and it is especially effective in high-temperature and dry environments. These materials can effectively maintain the humidity of the concrete surface.

Spraying curing agents is a modern and efficient curing method. A protective film is formed by spraying on the concrete surface to reduce water evaporation and prevent the erosion of external impurities at the same time. The selection of appropriate curing agents needs to be based on specific project requirements and environmental conditions.

In actual projects, curing methods are usually combined. For example, for mass concrete, a combination of water spraying and covering can be used first to reduce the internal temperature, and then spraying curing agents can be carried out to ensure long-term quality stability.

4 Conclusion

In summary, the construction technology of concrete structures is of great significance in civil engineering. The links of the formwork support system, pouring and vibrating, and curing are closely interlinked. During formwork construction, strict operation according to requirements is necessary to ensure stability and molding quality. In the pouring and vibrating process, the correct method should be selected to ensure compactness and strength. The curing work cannot be ignored, and the reasonable selection of a combination of curing methods can improve the performance and durability of concrete. In civil engineering construction, only by attaching importance to and controlling the quality of each link in the construction of concrete structures can the safety, stability, and durability of the concrete structure and even the entire project be ensured.

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