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CONSTRUCTION TECHNOLOGY AND APPLICATION OF HEAVY-DUTY IMITATION STONE WOOD GRAIN CLEAR WATER CLADDING PANELS

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Abstract: With the diversification of architectural design, heavy-duty stone-look wood-grain exposed concrete cladding panels have been widely used in modern architecture due to their excellent aesthetics and structural performance. However, traditional cladding installation methods suffer from problems such as stress concentration at connection nodes, high installation accuracy requirements, high construction difficulty, and difficult post-construction maintenance when dealing with heavy-duty cladding panels. To address these issues, this paper proposes a rapid installation, fine-tuning, one-time molding construction method for heavy-duty stone-look wood-grain exposed concrete cladding panels. The technical principles, process flow, and application effects of this method in the second phase of the Grand Canal Museum in Beijing and Hangzhou are described in this journal. The results show that this method significantly improves the installation efficiency of the cladding panels, enhances structural stability, and effectively avoids tearing damage, demonstrating good application prospects and promotional value.
Keywords: Stone-look wood grain; Exposed concrete; Rapid installation, Fine-tuning; One-time molding

1 INTRODUCTION

With the development of the times, the appearance of architectural projects is becoming increasingly diversified. To meet aesthetic and functional needs, different types of curtain walls are used in buildings, among which heavy-duty imitation stone wood grain fair-faced panels have become an important choice. Building curtain walls are usually composed of panels and their supporting structures behind them, forming an integral whole with the main structure through connecting structures. Therefore, the design of the connecting structure is particularly crucial for the safe connection of the curtain wall to the main structure [1-3]. Existing connecting structures are mostly suitable for lightweight panels, but have many shortcomings for heavy-duty concrete panels. For example, conventional connecting structures may lead to stress concentration at the connection nodes, resulting in tearing and damage to the panels; in addition, ordinary connection nodes are not adjustable, easily generating stress during installation, which adversely affects the use of the panels[4-5]. Furthermore, they require high installation precision, are difficult to install, and are challenging to maintain, disassemble, and replace later [6-8]. Therefore, it is urgent to develop an installation method suitable for heavy-duty imitation stone wood grain fair-faced panels to achieve fast, efficient, and high-quality installation, ensuring the structural safety, aesthetics, and service life of the curtain wall.

2 PROJECT OVERVIEW

The second phase of the China Grand Canal Museum is located on plot GS1003-12 in the Canal New City Unit of Hangzhou City, Zhejiang Province. It is bordered by the planned Lishui Road to the east, the Yaotan Yanghe River greenbelt to the south, the Grand Canal greenbelt to the west, and the Hanggang River greenbelt to the north. The exterior facade of the mountain-shaped tower in the building's atrium utilizes reinforced precast concrete panels, with a total area of 32,000 m², using 8,225 panels, each 30 mm thick, installed at a height of 73.5 m. The panels feature a wood-grain biomimetic effect, mimicking the geometric shapes and unique textures of nature. The largest single panel has an area of 30.612 m² and weighs 3.2 t. Through the selection of wood-grain base molds and surface treatment of component molding, aesthetically pleasing panel units were created. During the installation phase, installation equipment combinations were rationally selected based on the panel locations to ensure installation efficiency (Figure 1).

Figure 1 Rendering of the second phase of the China Grand Canal Museum

3 TECHNICAL PRINCIPLES

The heavy-duty imitation stone wood grain fair-faced siding proposed in this paper adopts an integrated design with a back-attached keel. The back-attached keel, as the internal framework of the heavy-duty siding, is cast together with the siding in one piece, significantly enhancing the structural stability of the siding. The back-attached keel consists of horizontal and vertical keels, with suspension ear plates on the keels for efficient on-site suspension and installation, avoiding the risk of concrete tearing due to stress concentration. After confirming the load-bearing performance of the main structure and the arrangement of hanging points, the pre-embedded fixing supports are formed in one piece with the facade of the main structure. After the main structure has cured, plates are added to each pre-embedded part location, corbels are welded, and a waterproof and thermal insulation layer is applied. The factory-prefabricated heavy-duty imitation stone wood grain fair-faced siding (with back-attached keel) is installed after secondary positioning, using the suspension ear plates on the back-attached keel and the positioning corbels, and precise leveling is achieved using a three-dimensional adjustment device. The installation sequence is L/U-shaped panel, column side panel, beam bottom panel, and beam side panel.

This method greatly enhances the structural stability of heavy-duty, large-area imitation stone concrete panels through the integrated design of the built-in back keel; the suspension ear plates on the keel effectively prevent concrete tearing caused by stress concentration in the panels; the pre-embedded and welded corbel support points on the main structure facade significantly improve the installation efficiency of the panels, and the three-dimensional adjustment device enables precise leveling of the panels.

4 PROCESS FLOW

4.1 Detailed Design of Precast Heavy-Duty Imitation Stone and Wood Grain Fair-Faced Panels

After fully considering the stress performance of the main structure, the fair-faced concrete mix proportion was determined to be suitable for the external environment and structural stress system by optimizing the mix proportion and improving the mixing process. A heavy-duty imitation stone and wood grain fair-faced panel model was established, and the stress performance of the panel under planar loads was numerically analyzed to rationally determine the backing keel and hanging point positions (Figure 2).

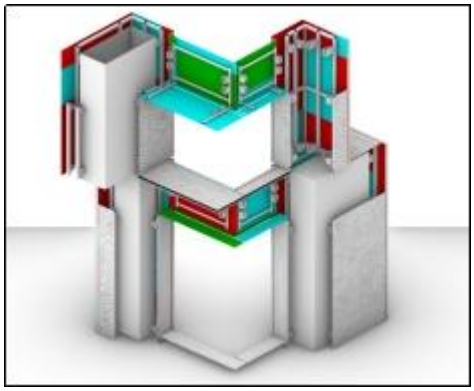

Figure 2 Detailed Design of Heavy-Duty Imitation Stone Wood Grain Exposed Concrete Curtain Wall

4.2 Precast Heavy-Duty Imitation Stone Wood Grain Clear Water Cladding Panels Processing and Preparation

Based on the detailed layout of the main structure facade cladding curtain wall, the unit cladding panel sizes and specifications were rationally divided, and factory formwork casting was carried out. Pine wood was selected as the plywood raw material. Vertical grain plywood was produced using a 1.2m steel brush machine, and horizontal grain plywood was produced using a straight-line cutting and splicing method. Standard 1.2×2.4m plywood panels were combined according to the actual area of the cladding panels, and the cladding panel molds were made by tightly splicing them together. A backing keel was fixed in the mold, and positioning cladding panels were installed on the keel. During casting, detailed node treatment was continuously monitored to ensure that the area around the keel was filled tightly. After curing, a unique slurry-wiping process was used for post-treatment of the panel surface to enhance the texture contrast (Figure 3-5).

Figure 3 Wood Grain Plywood Production

Figure 4 Heavy-duty Hanging Panel Casting

Figure 5 Precast Stone-Like Siding Plastering

4.3 Positioning and Installation of Embedded Parts

Based on the detailed layout of the facade panel curtain wall of the main structure, determine the installation position of the corbels and pre-embed fixed supports. Weld the embedded parts to the steel bars of the main structure columns and beams, and cast them together with the main structure in one go, ensuring that the deviation of the embedded parts is controllable (Figure 6-7).

Figure 6 Installation of Embedded Parts

Figure 7 Welding of Bracket Connector

4.4 Bracket Welding

After the main structure reaches its design strength, determine the position of the transition piece according to the layout lines and perform bracket welding. If there is any misalignment of the embedded parts, make additional embedded plates according to the design requirements and ensure the transition piece is properly rust-proofed and corrosion-resistant.

4.5 Heavy-Duty Imitation Stone Wood Grain Plain Cladding Panel Lifting and Installation

After secondary positioning, mark the control lines for the cladding panels and use auxiliary equipment to lift and install the heavy-duty imitation stone wood grain plain cladding panels. After lifting the cladding panels to the designated position, overlap them with the bracket transition piece using the cladding panels' built-in ear plates. The installation sequence for the cladding panels is L/U-shaped panels, column side panels, beam bottom panels, and beam side panels. For vertical cladding panels, use a truck crane to lift the cladding panels to 0.5 meters from the target position, and then use a manual hoist for close-range installation; for horizontal cladding panels, use a truck crane to transport the cladding panels to the floor, then use a multi-angle suction cup vehicle to suction and transport the cladding panels, and then manually adjust the back ear plates of the cladding panels to connect with the bracket transition piece (Figure 8-9).

Figure 8 Hanging Plate Hoisting

Figure 9 Hanging Plate Leveling and Fixing

4.6 Leveling and Fixing of Heavy-Duty Imitation Stone Wood Grain Concrete Hanging Panels

Considering the large weight and size of the imitation stone concrete hanging panels, it is impossible to guarantee one-time splicing during installation. A three-dimensional adjustment device is used to precisely level the panels. After the flatness meets the design requirements, the hanging panel connecting components are tightened with bolts to ensure the overall stability of the heavy-duty imitation stone wood grain concrete hanging panels.

5 APPLICATION AND EFFECTS

The heavy-duty imitation stone concrete hanging panels, with their backing keel and suspension ear plates, are integrally formed. Compared with previous hanging panel installation methods, this eliminates the need for on-site keel installation and other procedures, greatly saving installation time and significantly improving installation efficiency. A comparison shows that using the imitation wood grain concrete hanging panel installation method can effectively save 45 yuan per unit area, resulting in an estimated economic benefit of approximately 1.44 million yuan (Table 1).

Table 1 Economic Benefit Comparison Table

plan project	Construction process of separating keel and heavy-duty cladding curtain wall	Construction process of heavy-duty integrated hanging panel with back keel
Embedded parts installation	-	-
Keel installation	Electric welder's work efficiency: 30m²/day Electric welder's daily wage: 450 yuan/day Electric welder's unit price: 15 yuan/m² Installation worker efficiency: 30m²/day Daily installation worker rate: 300 yuan/day Installation worker unit rate: 10 yuan/m² Suspended platform unit price: 20 yuan/m²	-
Heavy-duty mounting plate installation	-	-
Comparative analysis: Compared with the previous siding installation method, the heavy-duty imitation stone wood grain clear water siding (with its own back keel) eliminates the on-site keel installation process, resulting in an economic benefit of approximately 45 yuan/m².		

The field application results of the heavy-duty imitation stone wood grain exposed concrete siding installation method in this study show that the installation process is efficient and stable, with strong overall structural integrity, effectively avoiding structural damage problems such as concrete tearing. Despite the significant achievements, some problems still exist during installation, mainly concerning the protection of the finished siding and the susceptibility to damage during transportation and installation. Therefore, further in-depth research is needed on the protection of the finished siding during installation to ensure its quality, reduce repair and rework costs for damaged siding, and lay the foundation for the further promotion of this method (Figure 10-11).

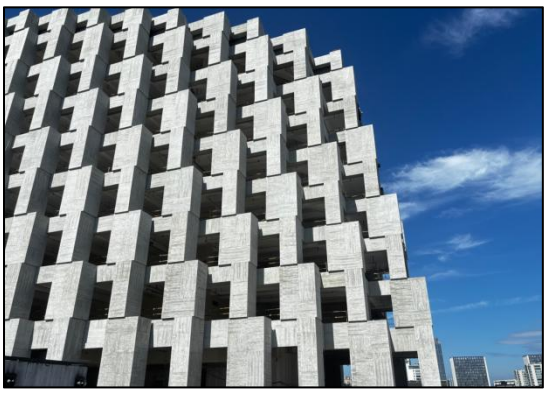

Figure 10 Front View of the Panel

Figure 11 Detailed Finish of the Panel

6 CONCLUSION

This paper proposes an innovative method for installing heavy-duty imitation stone wood grain siding, solving problems such as stress concentration, high installation accuracy requirements, and high construction difficulty associated with traditional methods when handling heavy sidings. Through an integrated back-attached keel design and an efficient installation process, the method significantly improves the installation efficiency and structural stability of the siding, and has been successfully applied in the second phase of the Grand Canal Museum project in Beijing and Hangzhou. Research shows that this method not only improves the installation quality and construction efficiency of the sidings but also offers good maintenance convenience and aesthetic appeal. However, further research is needed on the protection of the finished product during the installation of heavy-duty sidings to improve the entire installation system and promote the widespread application of this method.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

REFERENCES

[1] Chen Chen, Li Shuangquan, Xie Mowen, et al. A review of research on safety inspection methods for existing building curtain walls. Applied Laser, 2024, 44(06): 158-167.
[2] Xiong Zhenzhen, Wang Jianjun, Li Dongbin, et al. Current status and development trend of prefabricated lightweight exterior wall panel technology. Wall Material Innovation and Building Energy Conservation, 2019(11): 4-12.
[3] Li Yueliang. Research on preparation process of 3D printing casting template for imitation wood grain concrete. Building Technology Development, 2022, 49(13): 111-114.
[4] Jinping Chen, Jinchen Shao, Jing He, et al. Orthogonal Test for Mix Proportion of Fair-faced Concrete and its Quality Control. Fly Ash Comprehensive Utilization, 2020, 34(05): 72-76.
[5] Mintao Zhu, Qiang Zhou, Anbiao Zhu, et al. Research and Application of Production Technology on Specular Fair-faced Concrete Components. China Concrete Andcement Products, 2021, 01: 44-47.
[6] Honglei Chang, Penggang Wang, Zuquan Jin, et al. Durability and aesthetics of architectural concrete under chloride attack or carbonation. Materials, 2020, 13(4): 839.
[7] Kunpeng Gu, Fu Yu, Shoujie Ye, et al. Effect of admixture on appearance of high durable fair-faced concrete. Port & Waterway Engineering, 2018, 10: 63-67.
[8] Tingmin Mou, Qingjun Ding, Xiulin Huang, et al. Effects of slurry viscosity on appearance quality of fair - faced concrete. Concrete, 2015, 02: 104-106.