Research on assembly installation technology of special-shaped decorative grille curtain wall

Xia Zijun¹ and Zeng Zheng²*

¹Wuchang University of Technology, Wuhan, Hubei, 430223, China
²China Construction Science and Industry Corporation Ltd., Ltd., Shenzhen, Guangdong, 518040, China

*Corresponding author’s e-mail: zengzheng2017@cscce.com

Abstract. The Zhumadian International Convention and Exhibition Center project is designed to create a "wind blowing wheat wave" architectural effect. The large cantilevered structure of the inner and outer ring adopts hyperboloid special-shaped aluminum alloy decorative grille curtain wall design, and the whole is in the shape of a streamer. The construction period is tight, the installation volume of the special-shaped grille curtain wall is large, the positioning is difficult, and the forming effect is not easy to control. After exploration and research, a special-shaped aluminum alloy decorative grille curtain wall assembly installation technology method has been formed. It innovatively solves a series of problems encountered in construction, and has achieved good economic and social benefits. It can provide a reference for similar projects and promote the application of aluminum alloy decorative grille curtain walls in construction projects.

1 Introduction

Zhumadian International Convention and Exhibition Center project is located on the west side of the intersection of Kaiyuan Avenue and Chengxi Avenue, Yicheng District, Zhumadian City. It covers a total area of about 230,000 square meters and a total construction area of 156,000 square meters. It includes four large exhibition halls, three middle exhibition halls, banquet halls, Theaters, etc. It is currently the largest public buildings in Zhumadian, and will become the country's largest agricultural product display and trading center after completion. The engineering design starts from the “seed” spatial form, adopting the main structure of steel frame + steel truss, the vertical seam aluminum-magnesium-manganese metal roof, and the combined facade of glass curtain wall and pale gold aluminum alloy decorative tube curtain wall, forming folds. The rich texture of the shape implies a good harvest of wheat waves.

2 Project Overview

The outer ring of Zhumadian International Convention and Exhibition Center project and the outside of the atrium cantilever truss adopts aluminum alloy decorative grille curtain wall. The overall shape is a circular ring shape with space-distorted ribbons. The shape is unique. The total area of the grille curtain wall is about 50,000 square meters, and there are 45,000 pieces of different sizes. There are more than 10,000 keel installation positioning points in total for the decorative grille round pipes. The project volume is large and the measurement, positioning and installation are difficult.

The section of the decorative grille curtain wall is in the shape of a broken line, and the supporting structure is a main cantilever steel truss. The outer cantilever length of the truss is 6-25m, and the spacing...
is 9-18m. The truss spacing is large and the overall shape is "eagle beak". The typical design section is shown in Figure 1. It is difficult to fix the grid curtain wall on the main structure. There are many decorative grilles, the shape is a hyperbolic surface, and the forming effect is high. If the traditional full-floor scaffolding is used, the site occupies a large area and there are many grille installation positioning points. The measures are expensive and the construction efficiency is extremely low, which cannot meet the requirements of the tight construction period [1].

3 BIM technology deepening design

3.1 Prefabricated unit division
The project uses BIM technology to complete the remodeling of the surface of the special-shaped aluminum alloy decorative grille curtain wall, optimize the surface of the curtain wall modeling, and finally determine the three curves formed by the angle change point of the grille curtain wall profile and the upper and lower boundary points as the basic modeling control line of the curtain wall; The grid installation angle is used to control the grid, and the single curtain wall surface is divided into four parts to form a small grid plate with a specification of about 5.2m×3m. The coordinates of the grid point are determined to guide the ground processing and assembly; each four small plates are combined into a large plate, Forming an assembled hoisting unit.
3.2 Deepening design of grille decoration frame structure

Through refined modeling and finite element software calculation and analysis, the structure and node deepening design of the unit grid decorative frame is completed. The grille decorative frame includes a main keel, a cross beam, an adjustment support, a hanging code, and an oblique brace. The main keel, a cross beam and an adjustment support are welded to form a platform frame, and the decoration frame is welded and fixed with the main structure through the oblique brace.

The main principle is as follows: Before construction, adjust the size of the support and the diagonal brace of the decorative frame to control the overall shape of the decorative grille; the decorative grille is connected to the beam through the hanging code to ensure that it can still be installed after installation. The angle of the decorative grille can be fine-tuned through the hanging code. After the fine-tuning is completed, the hanging code can be locked by the self-tapping nail. Hanging code and grille, hanging code and decorative frame beams are connected by stainless steel bolts; 3mm thick aluminum plates are added to both ends of the decorative grille, and they are fixed with countersunk self-tapping screws; the lower ends of all decorative grilles are closed at the lower edge of the aluminum plate. The drain hole prevents rainwater from accumulating for a long time and causing problems such as corrosion of components.

The grille decorative frame section and detailed nodes are shown in the figure below.
The main materials of each component are as follows. All materials must meet the mechanical standards required by the deepening of the design. The quality of the incoming materials is qualified and meets "Aluminum Alloy Building Profiles" [2], "Building Curtain Walls" [3], "Steel Structure Engineering Construction Code" [4] Other norms and standards. After the mechanics check is qualified, the BIM software can be used to export the material list, processing drawings and precise positioning data of the grid curtain wall of each unit section to guide on-site processing and installation positioning.

| No. | Component              | Material Requirements | Specification |
|-----|------------------------|-----------------------|---------------|
| 1   | Main keel              | Square steel          | □120×80×6mm   |
| 2   | Cross beam             | Square steel          | □120×80×6mm   |
| 3   | Adjustment support     | Square steel          | □120×80×6mm   |
| 4   | Oblique brace          | Channel steel         | 18#           |
| 5   | Stainless steel bolt   | /                     | M6×25/M8×160  |
| 6   | Aluminum plate sealing plate | /                     | 3mm aluminum plate |

4 Construction process and operation points

4.1 Overall construction process
Construction preparation (familiar with the design drawings of the special-shaped aluminum alloy grille curtain wall and the original main structure) → deepen the design according to the characteristics of the grille curtain wall structure → unit plate division and positioning coordinate extraction → grille decoration frame structure design → material preparation and unit plate floor assembly → Plate hoisting → fine adjustment of grille angle → painting protection of welding parts.

4.2 Unit plate ground assembly process
Measure and pay off → assembled tire frame layout → decorative frame main keel layout → decorative frame beam and adjustment section temporary fixing group frame → decorative frame beam elevation adjustment and structural assembly fixing → welding seam polishing, painting, etc. → decorative grid hanging code installation →Decorative grille cutting and installation →Decorative grille angle adjustment and positioning.

4.3 Main points of assembly of prefabricated grille panels

4.3.1 According to the in-depth design of the grille curtain wall, extract 10 ground assembly coordinate control points for each assembled grille panel, mainly the intersection of the main keel and the beam of the decorative frame.

4.3.2 According to the processing and assembly drawings, lay the ground assembly tire frame. As shown in Figure 8 below.

4.3.3 According to the coordinate control point, start to assemble the main keel, beam and adjustment support of the unit plate grille decorative frame, and the welding connection between the components should meet the quality requirements of the "Steel Structure Welding Specification" [5]. As shown in Figure 9 below.

4.3.4 According to the grid spacing control method, place the grid positioning line on the decorative frame beam and install the hanging code and aluminum alloy decorative grid to adjust the shape of the decorative grid. As shown in Figure 10 below.
4.4 Installation of prefabricated grille panels

4.4.1 According to the hoisting weight of the single-piece assembled grille plate, select the appropriate model of car crane, and use the four-point hoisting method of the car crane to hoist the single-piece grille plate. Perform finite element simulation analysis before hoisting operation to determine the position of the hoisting point, and check the overall strength and stability of the plate during hoisting. As shown in Figure 11 below.

4.4.2 The installation of a single-piece assembled grille plate is carried out by using the combination of a car crane, a high-altitude vehicle and a chain hoist, and is fixed by welding with the main structure through diagonal bracing. The on-site installation is shown in Figure 12 below.

4.4.3 By adjusting the hanging angle, the decorative grille can be fine-tuned to achieve the final design effect.

4.5 Quality control points

4.5.1 Set up a special material acceptance team to conduct quality acceptance before materials enter the site, and strictly implement the prohibition of entry of unqualified products.

4.5.2 On-site lifting, welding, and climbing operations personnel shall strictly implement the certificate-holding system to ensure construction quality.

4.5.3 During the on-site construction process, the system of self-inspection, mutual inspection, and handover inspection is strictly implemented. When the previous process is unqualified, the next process is strictly prohibited to ensure the construction quality. The construction quality should meet the "Steel Structure Engineering Construction Quality Acceptance Standard"[6] and other specifications.

5. Conclusion
The Zhumadian International Convention and Exhibition Center project adopts a special-shaped aluminum alloy decorative grille curtain wall assembly installation method, which effectively solves the problems of many special-shaped decorative grille curtain wall units, low installation efficiency, and high molding effect requirements. The prefabricated installation unit combined into a large plate reduces
the amount of grille curtain wall decorative frame keel steel structure, reduces the number of hoisting, avoids the erection of scaffolding, saves time. It is conducive to professional interspersed construction such as outdoor engineering, effectively shortening the construction period and improving installation efficiency. At the same time, the installation method of ground assembly and assembly unit plate hoisting greatly improves the efficiency and construction quality of keel welding and grille installation. It effectively avoids the high-altitude installation and construction of large-scale steel structure keels and decorative grids, reduces operation risks, and can provide a reference for similar projects.

References
[1] Wu Yishuang, Jia Yanming, Lu Yuan. Analysis of the construction technology of the special-shaped hyperbolic ceiling grid of exhibition venues[J]. Building Materials and Decoration, 2019(33): 1-2.
[2] Ministry of Housing and Urban-Rural Development of the People's Republic of China. Aluminum alloy building profiles: GB/T 5237.1-2017. Beijing: China Construction Industry Press, 2217.
[3] Ministry of Housing and Urban-Rural Development of the People's Republic of China. Building curtain wall: GB/T21086-2007. Beijing: China Construction Industry Press, 2008.
[4] Ministry of Housing and Urban-Rural Development of the People's Republic of China. Steel structure engineering construction code: GB50755-2012. Beijing: China Construction Industry Press, 2012.
[5] Ministry of Housing and Urban-Rural Development of the People's Republic of China. Specification for Welding of Steel Structures: GB50661-2011. Beijing: China Construction Industry Press, 2012.
[6] Ministry of Housing and Urban-Rural Development of the People’s Republic of China. Steel structure engineering construction quality acceptance standard: GB 50205-2020. Beijing: China Construction Industry Press, 2020.