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Big Data Optimization Analysis and Calculation of First Pass Rate of Special-shaped Curved Curtain Wall Keel Installation

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Abstract: *The installation of special-shaped curved keel should not only be reliably connected with the main structure, but also meet the requirements of panel installation in the later stage of the curtain wall. Different professions have different construction precision, and there are inevitable errors in the construction process. Therefore, strict control of the first-pass rate of installation of special-shaped curved curtain keel is the key of curtain wall construction. In this paper, by making full use of BIM technology to optimize analysis and model program installation and construction, the first-pass rate of installation of special-shaped curved curtain wall keel is greatly increased from 76% to 92%. The successful application of this process provides reference for similar projects.*

Keywords: *Special-shaped curved curtain wall, BIM, Keel installation, Optimization analysis*

1. Introduction

As an important part of modern architecture, the glass curtain wall [1] of special-shaped buildings has many advantages, such as heat preservation, light weight and good decorative performance [2],which can be seen in many large public buildings in China.Reasonable application of glass curtain wall[3]-[7] can achieve very good results, which is an organic combination of architectural technology and architectural art.However, compared with ordinary flat curtain wall, the construction of special-shaped glass curtain wall is more difficult, and has higher requirements on the construction technology and construction quality control, and the construction process needs to pay attention to the technology and technology, with a certain degree of difficulty.In this paper, combined with the actual working conditions, the construction technology of improving the first pass rate of installation of the special-shaped curved curtain wall keel is described in detail.

2. Project Overview

This project is a key project of Chongqing Qijiang District, attracting high social attention and great influence. Area A of Qijiang Middle School “Fig. 1” relocation project is located in the eastern New Town of Qijiang District. The total construction area of the project is 138,700 m^2, with 132,900 m^2 above ground and 5,800 m^2 underground..Among them, the overall building of the art Center is round, small at the bottom and large at the top, hollow in the middle, the main body is reinforced concrete frame structure, exterior wall decoration is glass, aluminum curtain wall, curtain wall keel is shaped like a curved shape, the number of 1,151. Currently facing the following technical difficulties:

(1) The curtain wall keel of the art center is curved, which is difficult to construct and has high technical requirements. Conventional construction methods are difficult to meet the requirements of installation accuracy.

(2) The installation of special-shaped curved keel should not only be reliably connected with the main body of the structure, but also meet the requirements of panel installation in the later stage of the curtain wall. Different professions have different construction precision, and there are inevitable errors in the construction process. Therefore, it is the key of curtain wall construction to strictly control the qualified rate of installation of special-shaped curved curtain keel.

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(3) Check the components of MQ1, MQ2 and MQ3 curtain walls that have been completed, and find that the qualified rate of keel installation is only 68.00%, as shown in the following table 1:

Figure 1: Art Center of Qijiang Middle School

Table 1: Art Center mq1, mq2, mq3 component qualification rate survey

Serial number	Inspection contents	Spot check points (pieces)	Qualified points (pieces)	Pass rate (%)
1	Drilling, clearing	152	146	96.05%
2	Buried plate anchorage	38	37	97.37%
3	Welding of connectors	38	36	94.73%
4	keel installation	50	34	68.00%
5	Glass panel installation	50	46	92.00%
6	Fluorocarbon aluminum plate installation	30	28	93.33%
7	Glue sealing	40	35	87.50%
8	Sensory quality	10	9	90.00%

Based on the above situation, the main technical problem is to ensure the qualified rate of keel installation without affecting the construction period and cost, which has become the key of curtain wall engineering construction.

3. Optimization Analysis

3.1. Investigation and analysis

Table 2: The qualified rate of keel installation corresponding to the four main factors

Serial number	Inspection area	Inspection contents	Inspection Method	Spot check points (pieces)	Unqualified points (pieces)	Qualified points (pieces)	Pass rate (%)
1	Special-shaped curved curtain wall keel	Vertical verticality	Total station measurement	50	4	46	92%
2		Transverse levelness	Level measurement	50	2	48	96%
3		Lateral curvature	Collimator and tape measure	50	37	13	26%
4		Bolt connection	Wrench	50	5	45	90%
Total				200	48	152	76%

Through sampling investigation of specific construction of installation details of special-shaped curved wall keel, a total of 50 special-shaped curved wall keels completed by MQ1, MQ2 and MQ3 have been inspected, Comprehensive analysis shows that the main factors affecting the qualified rate of keel installation are the following four indicators: lateral bending, horizontal levelness, lateral bending and bolt connection, and the average qualified rate is 76%. The influence of the four main factors on the qualified rate of keel installation is shown in the table 2:

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According to the above list of survey problems, the frequency of the first pass rate of installation of the abnormal curved curtain wall keel is counted, among which the frequency of the lateral bending problem is as high as 77.08%, the second is the bolt connection, the frequency of unqualified is 10.42%, followed by the vertical verticality of unqualified frequency is 8.33%. Finally, the frequency of failure in horizontal levelness was 4.17%.

Optimal path

According to the above analysis, it can be concluded that the main problem affecting the installation of the keel of the special-shaped curved curtain wall is the lateral bending degree, whose cumulative frequency has reached 77.08%. *If the one-time pass rate of the lateral bending degree is improved from the current 26%* and controlled at more than 90%, Then the qualified rate of special-shaped curved curtain wall keel installation can be increased to (90%+90%+92%+96%) ÷4=92%, so the qualified rate of special-shaped curved curtain wall keel installation will be increased from 76% to 92%, which has been greatly improved.

Through the investigation and analysis of the reasons that may affect the lateral bending deviation of curtain wall keel on site, a large number of technical data and related specifications of curtain wall keel construction were consulted, and the reasons for the installation quality problems of lateral bending were analyzed from six aspects of "man, machine, material, method, environment and measurement" respectively. Finally, it is confirmed that there are two main reasons affecting the lateral bending degree of abnormal curved keel:(1) BIM technology[8]-[10] should be insufficient; (2) No unified correction is made after the overall installation. In order to achieve the above qualified rate to increase to 92% of the target value, it is necessary to optimize BIM technology modeling and analysis, specific countermeasures are as follows:

(1) Target

Use BIM technology to guide the construction, modular cutting and installation, to ensure that the pass rate reaches 90%;

(2) Countermeasures

After comprehensive retesting of the completed structure's outer edge entity, modeling is carried out to combine theory with practice;

(3) Measures

Comprehensive retest of the completed structure entities; According to the retest data, BIM technology is used to re-model “Fig.2”; According to the model size material, model program installation construction.

Figure 2: Modeling of curtain wall of art Center

3.2. Inspection effect

Qijiang middle school project art center special curved curtain wall keel installation “Fig.3” results again extracted 50 inspection, unqualified points 12, a pass rate of 94%>92%, the goal was achieved.For the frequency of quality problems before and after project optimization, please refer to the statistical table 3 of qualified rate:

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Figure 3: Art Center Keel Installation

Table 3: Statistical analysis table of qualified rate of installation of front and rear special-shaped curved curtain wall keel

No.	Inspection contents	Inspection Method	Number of investigations (places)	Unqualified points	Qualified points	First pass rate (%)
1	Vertical verticality	Total station measurement	50	3	47	94%
2	Transverse levelness	Level measurement	50	2	48	96%
3	Lateral curvature	Collimator and tape measure	50	4	46	92%
4	Bolt connection	Wrench	50	3	47	94%
Total			200	12	188	94%

The frequency arrangement diagram of quality problems before and after the implementation of the countermeasures is as the following table 4 and table 5:

Table 4: Quality problem frequency statistics table (before)

No.	Inspection contents	Frequency (piont)	Cumulative frequency (piont)	Frequency (%)	Cumulative frequency (%)
1	Lateral curvature	37	37	77.08	77.08
2	Bolt connection	5	42	10.42	87.5
3	Vertical verticality	4	46	8.33	95.83
4	Transverse levelness	2	48	4.17	100
Total	48			100	

The frequency of quality problems before the implementation of countermeasures is shown in “Fig.4”

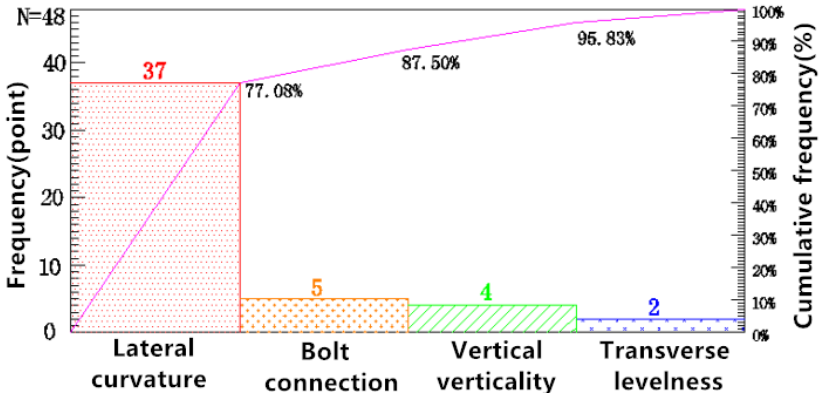

Figure 4: Frequency Arrangement Chart of Installation Accuracy of Special-shaped Curtain Wall Keel (before)

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Table 5: Quality problem frequency statistics table (after)

No.	Inspection contents	Frequency (piont)	Cumulative frequency (piont)	Frequency (%)	Cumulative frequency (%)
1	Lateral curvature	4	4	33.33	33.33
2	Bolt connection	3	7	25	58.33
3	Vertical verticality	3	10	25	83.33
4	Transverse levelness	2	12	16.67	100
Total	12			100	

The frequency of quality problems after the implementation of countermeasures is shown in “Fig. 5”

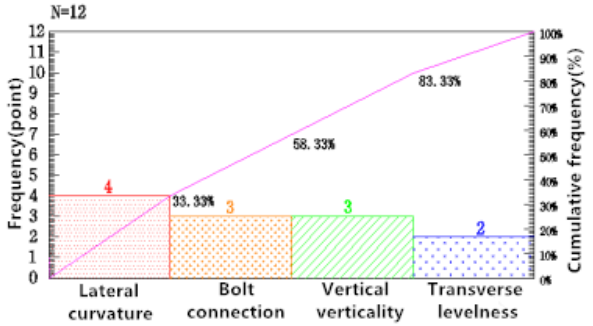

Figure 5: Frequency Arrangement Chart of Installation Accuracy of Special-shaped Curtain Wall Keel (after)

It can be seen from the arrangement chart that the “Lateral curvature”, which affects the first pass rate of curved keel installation, has been fundamentally solved after the implementation of the countermeasures, and has achieved good results as shown in “Fig.6”.

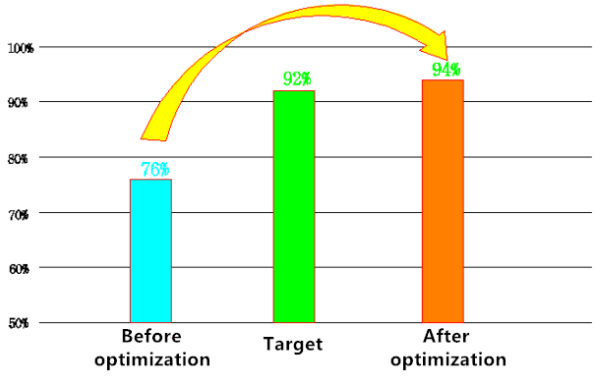

Figure 6: Effect histogram

Figure 7: Pictures of arts Center achievements

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The Qijiang count high school program is a key project the Qijiang count area, high social awareness, to achieve the desired effect, this project makes full use of BIM modeling technology optimization analysis, management, and strictly control the process according to the model size blanking installation, reduce after fine-tuning correction work completed, the final hand over satisfaction questionnaire, art center drawing as shown in “Fig.7”.

4. Conclusions

Through BIM technology optimization analysis and on-site fine management, the qualified rate of the installation of special-shaped curved curtain wall keel is effectively improved, and certain economic benefits are improved.

(1) The keel cutting is changed from on-site testing to factory customization based on BIM model size, and the rework rate is increased from 5% to 2%. It can be seen that the full application of BIM technology can improve the economic benefits of production;

(2) Through BIM optimization analysis, the one-time pass rate of installation of special-shaped curved curtain wall keel is increased from 76% to 92%, which has been greatly improved;

(3) Compared with CAD, BIM technology is more convenient and accurate in the installation engineering of special-shaped structures. In the current installation project, BIM technology is increasingly widely used.

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References

[1] Gerasimova E., Galyamichev A., Schwind G., Schneider J. Deflection of a cladding panel of fully tempered glass in curtain wall system [J]. Magazine of Civil Engineering, 2021, None (104).
[2] Cao Yajun, Che Zhiyan, Liu Cipei. Application of 3D Laser Scanner to Special-Shaped Curved Curtain Wall Construction [J]. Engineering and Applied Sciences, 2020, 5(6)
[3] Yuan Yuan, Zhou Yifei, Wang Lixin, Wu Zhirui, Liu Wenbai, Chen Jubing. Coupled deformation behavior analysis for the glass panel in unitized hidden-frame supported glass curtain wall system [J]. Engineering Structures, 2021, 244
[4] Rokoni A A, Hasan A B M T. A computational study on the development of secondary flow through S-shaped curved channel[C]// BSME International Conference on Thermal Engineering. 2015.
[5] Gargallo Mercedes, Cordero Belarmino, GarciaSantos Alfonso. Material Selection and Characterization for a Novel Frame-Integrated Curtain Wall [J]. Materials, 2021, 14(8).
[6] Zijun Xia, Zheng Zeng. Research on assembly installation technology of special-shaped decorative grille curtain wall [J]. IOP Conference Series: Earth and Environmental Science, 2021, 760(1).
[7] Xiong Wei, Gong Wang, Liu Chang, Ma Yong. Application of Prefabricated Curtain Wall Sectors in Special-shaped Stadium Projects [J]. Engineering and Applied Sciences, 2020, 5(6).
[8] Venera Garyaeva. BIM modeling for sustainable design and energy efficient construction [J]. E3S Web of Conferences, 2021, 263.
[9] Venera Garyaeva. Application of BIM modeling for the organization of collective work on a construction project [J]. MATEC Web of Conferences, 2018, 251.
[10] Jin X , Guo S , Guo J , et al. Preliminary Method for Reducing Contact Force between Catheter Tip and Vessel Wall in Endovascular Surgery[C]// IEEE International Conference on Mechatronics and Automation. IEEE, 2021.