ISSN: 2414-1895 DOI: 10.6919/ICJE.202308_9(8).0014

Building Electromechanical Prefabrication Construction Technology and its Application in Tibet

Zhucai Liao

Xinyu Tengyuan Planning and Design Co., Ltd. Lhasa, Tibet, China

*353567056@qq.com

Abstract

In order to maximize the construction efficiency, ensure the construction quality, and maintain the on-site environment, through the constructed BIM model, combined with the digital component processing equipment, the digital and precise processing of prefabricated and pre-processed components can be realized, so as to ensure the engineering quality of the corresponding parts and greatly reduce the The impact of traditional on-site processing of components on the construction period, and at the same time, it can efficiently cooperate with the general contractor to achieve the overall progress and quality, environmental and health goals of the project. The prefabrication and assembly technology in this paper has been applied to varying degrees in many projects in Tibet, which has greatly improved the safety and efficiency of building electromechanical construction. The application is good and remarkable results have been achieved. The research shows that: the construction speed of building electromechanical prefabrication assembly construction technology is fast, and the construction period of the machine room, refuge floor and standard floor can be shortened by more than 30%; the construction technology of building electromechanical prefabrication assembly construction technology has a significant effect of material saving, and the material loss rate of the factory intelligent typesetting system is lower than that of on-site processing. The social benefits of building electromechanical prefabrication assembly construction technology are obvious, and the prefabrication factory processing production and on-site assembly using prefabrication assembly technology have won unanimous praise from owners and government personnel.

Keywords

Mechanical and Electrical Engineering; BIM Model; Prefabricated Components; Prefabricated Construction.

1. Introduction

In the process of rapid development in our country, the economy is developing rapidly and the society is constantly improving.Compared with the traditional electromechanical installation and construction technology, prefabricated assembly construction technology has more significant advantages. After the production is completed, it is transported to the construction site, and then installed according to the assembly sequence. The use of electromechanical prefabricated construction technology for super high-rise buildings can not only save construction resources and ensure the quality of the construction period, but also has a significant effect on reducing environmental pollution during the construction process [1-3].

In order to maximize the construction efficiency, ensure the construction quality, and maintain the on-site environment, through the constructed BIM model, combined with the digital component

ISSN: 2414-1895 DOI: 10.6919/ICJE.202308_9(8).0014

processing equipment, the digital and precise processing of prefabricated and pre-processed components can be realized, so as to ensure the engineering quality of the corresponding parts and greatly reduce the The impact of traditional on-site processing of components on the construction period can effectively cooperate with the general contractor to achieve the overall progress and quality, environmental and health goals of the project [4-5].

2. Process Principle

Overall, in the application of BIM-based building electromechanical modular prefabricated assembly line, BIM optimization and modular design in the early stage of the project, after selecting the appropriate functional modules, the corresponding modules can be combined into a certain kind of structure by calling the node family that meets the connection requirements. Units with specific functions and structures, and the generated units are coordinatable. During project construction, different functional modules and nodes can be used for diverse connections according to requirements, and the same or different functional modules can be connected and matched to realize prefabricated factory production and assembly site. The prefabricated assembly process and method are as follows:

Table 1. Prefabricated assembly process and method

number	process	method
1	Draw machining details and prepare prefabricated parts lists	The project deepening team applies BIM technology to model, draws processing detailed drawings in combination with on-site technical review, and compiles a list of prefabricated parts in accordance with the professional system of plumbing, heating and electricity.
2	processing	The factory performs processing and prefabrication according to the processing details and lists of the plumbing and electricity professional system, mainly including finished support hangers, finished steel equipment bases, steel pipe bevels and pipe and flange welding, semi-finished air ducts (on-site assembly) and connector processing.
3	Rust and anticorrosion	All supports, hangers, steel equipment bases, and steel pipes that require derusting and anti-corrosion painting are all completed in the factory. After the project is installed on site, only the joints need to be repainted with anti-corrosion paint and topcoat.
4	QR code identification	In order to facilitate the on-site search and installation of prefabricated parts, QR codes are prepared for the prefabricated parts shipped out of the factory according to the professional system. The project site only needs to scan the QR code with a mobile phone to know which professional system and which part of the prefabricated part it is.
5	Pipe transportation	Loading and unloading by specialty, system, and part to avoid confusion; a delivery list needs to be compiled for each loading to facilitate unloading inventory and on-site installation.
6	Entry acceptance	The project department will organize Party A and supervisory engineers to inspect and accept the pipe fittings, and go through the inspection procedures.
7	On-site assembly	On-site assembly is carried out according to the construction drawings and processing drawings, and the two-dimensional code identification information on the pipe fittings.

ISSN: 2414-1895 DOI: 10.6919/ICJE.202308_9(8).0014

3. Key Technologies of BIM Prefabrication Application

3.1 BIM Detailed Design of Air Duct Prefabrication

According to the professional mechanical and electrical construction drawings and the latest building structure drawings, carry out BIM in-depth design, and comprehensively arrange the pipelines according to the layout principles of mechanical and electrical pipelines and the net height requirements of the owner. Produce component processing lists and construction drawings, specific steps: on-site measurement and proofreading of building structure models; construction of professional BIM models; pipeline adjustment and optimization; adding support and hanger components; decomposing component processing drawings; producing component processing lists and drawings.

3.2 Prefabricated Machine Room BIM Deepening Design

The BIM model after the in-depth design of the refrigeration room is completed, and through the necessary pipeline segmentation, data conversion, mechanical design, classification and labeling, etc., the BIM model is converted into prefabricated processing design drawings to guide the factory's production and processing.The input of the prefabrication process is the detailed design drawings for pipeline installation, and the output is the prefabricated pipe sections delivered to the installation site for assembly.

The design of the computer room mainly includes:

(1) Create families in equal proportions:

After the detailed drawing is approved and approved, the model can be built. According to the drawings and physical size parameters after in-depth approval Carry out modeling to ensure that the model is consistent with the size of the construction site, equipment and piping accessories in the future. In the early stage, the equipment and valve manufacturers provide the size parameter diagram, and the designer establishes the family library (later, it is corrected according to the actual size of the equipment and valves on site). If the structural building model has been established for civil engineering, the detailed design of electromechanical pipelines shall be carried out on the basis of correcting the model according to the actual measurements on site. If there is no structural building model, it is necessary for the in-depth designer to model according to the drawing, and adjust and correct it according to the on-site scanning data. To ensure that the built model is completely consistent with the site.

(2) Model bracket layout:

After the model is established, add the support and hanger at the appropriate position of the pipeline. The position of the support and hanger is required to be easy to install, easy to manufacture, and easy to control the size. The installation position of the support and hanger does not affect the assembly construction of the later pipe sections. When selecting the steel material for the support and hanger, The midas software force calculation is required for the support and hanger, and the spacing of the support and hanger meets the specification requirements.

(3) Review of the building structure of the computer room:

Feedback the actual size of the actual cut volume to the BIM model of the equipment room pipeline in the form of three-dimensional data for comparison, and consider the impact of the difference between the actual measurement value and the design value on the site construction. And adjust the BIM model of the equipment room pipeline or correct the existing structural components according to the measured values.

Segmentation of the pipeline in the equipment room is the key point.According to the adjusted or corrected BIM model of the pipeline in the equipment room, the BIM model of the pipeline in the equipment room is scientifically segmented and coded, and the transportation space and assembly space are considered comprehensively to form a processing drawing, Assembly drawings and general assembly drawings.Pay attention to the following points when dividing into sections and sections:

ISSN: 2414-1895 DOI: 10.6919/ICJE.202308_9(8).0014

Table 2. Precautions for pipeline segmentation and sectioning

number	Precautions
1	According to the limitations of transportation conditions and the convenience of transportation and hoisting, the size of the pipe section should be appropriate.
2	Try to avoid some short pipes, and try to combine the production of those that can be combined to reduce the splicing of pipe segments, reduce errors and the risk of joint leakage.
3	When the pipe section is divided into sections, consider the dimensional error caused by the flange connection and the installation of the flange bolts, and leave room for construction operations.
4	Dimensions and angle parameters that are difficult to control can be regarded as one section as a whole, and elbows and downstream tees of pipe sections should be avoided as much as possible.
5	When encountering the position of the pipeline valve, the valve can be used as a pipeline segment node.
6	Make sure that each horizontal pipe section is supported by hangers.
7	After the pipe section is completed, check and discuss collectively, check whether the position of the support and hanger is reasonable, and analyze whether the production process of the prefabricated pipe section is difficult, and the accuracy of prefabrication and assembly.After confirming that the sectioning scheme is feasible, number the pipe sections, produce detailed pipe section parameter diagrams, export CAD drawings at 1:1, perform dimensioning and wear a 3D view of complex pipe sections.

3.3 Prefabricated Bracket BIM Detailed Design

After the adjustment of the mechanical and electrical BIM integrated pipeline is completed, the positioning of the support and hanger components is deepened.The shared support and hanger is used in the pipeline-intensive area.The load analysis of the support and hanger is carried out to determine the specifications and dimensions of the shared support and hanger, and finally the factory processing drawing is produced.

4. Factory Prefabricated Processing

4.1 Air Duct Prefabrication Processing

Determine the size and route of the air duct according to the final BIM model, decompose the air duct into straight pipes and various pipe fittings, generate orders, and use the air duct production line, CNC plasma cutting machine, common plate flange machine, multi-functional auxiliary Bone machine, edge folding machine for processing, processed into L-shaped semi-finished products and then packaged and transported to the site for splicing.

Figure 1. Digital blanking

ISSN: 2414-1895 DOI: 10.6919/ICJE.202308_9(8).0014

Figure 2. Automatic production line processing

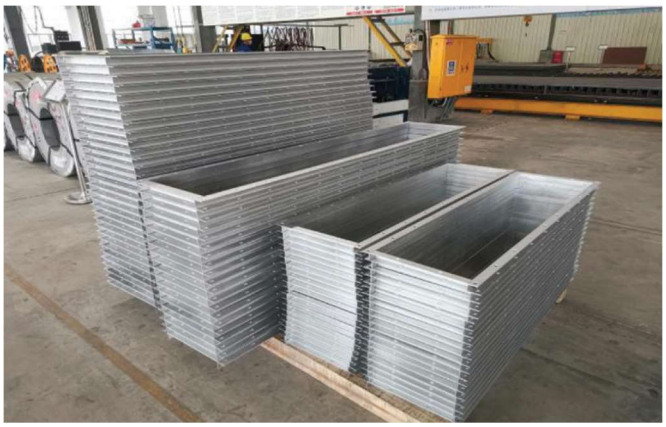

Figure 3. Finished angle steel flange

Figure 4. Semi-finished air duct

Air duct prefabrication type: Combined with prefabrication work requirements, determine the type of prefabrication, determine the prefabrication standard, and carry out standardized production. The specific air duct prefabrication process is shown in Figure 1-Figure 4.

4.2 Machine Room Pipeline Prefabrication Processing

According to the pipeline prefabrication processing design drawings, the processing plant uses advanced production line equipment to complete the pipeline blanking, beveling, intersecting line opening, automatic assembly, automatic welding, rust removal and painting, paste QR code and other processes,Finally, the finished product protective package is transported to the construction site.

ISSN: 2414-1895 DOI: 10.6919/ICJE.202308_9(8).0014

The main construction process includes: pipe cutting and processing, pipe acceptance, pipe anticorrosion and coating, QR code posting and finished product protection.

4.3 Co-frame Prefabrication Processing

The processing plant processes the bracket according to the processing drawing of the support and hanger, and pastes the QR code label on the integrated bracket according to the drawings after the processing is completed.Ship to the site and install according to the location of the QR code information.

Through BIM technology + factory production, the production efficiency is greatly improved and the quality of the bracket is guaranteed.

4.4 Quality Assurance Measures for Prefabrication Processing

The quality assurance measures for prefabrication processing are shown in Table 3.

Table 3. Quality Assurance Measures for Prefabrication Processing

number	Precautions
1	Strictly implement the technical disclosure system, conduct detailed technical disclosure before the start of each construction process, conduct quality publicity to each operator from time to time, and set up display boards at the display positions of the processing site to ensure that each product meets the specification requirements.
2	Establish a complete information data system to ensure that the information and sample drawings of each product are accurate and effective, and ensure a high degree of matching with the construction site.Strengthen the information feedback on the construction site, and correct the deviation in production in time.
3	Strictly implement the material entry inspection system.After passing the self-inspection, the supervisor and the owner are invited to the processing plant for inspection to ensure that each batch of materials meets the national standard.Detailed inspections are carried out before leaving the factory and after arriving at the site to ensure that the materials enter the site, on-site processing, The quality of the whole process of finished product delivery and transportation is controlled.
4	The processing plant sets up a professional management team to supervise the whole process.Establish a perfect quality tracking system, the responsibility is assigned to the person, So that each product can be traced back to the source to ensure product quality.Use new processing equipment and tools, implement regular inspection and maintenance systems, and increase some processing tools to ensure that the production progress of products will not be affected by machine tool maintenance.
5	Adjust and formulate a reasonable product production cycle according to the on-site construction progress, and minimize the impact of product quality and production efficiency due to factors such as product backlog and labor rush.Strengthen the protection of materials and finished products in the process of stacking and transportation to ensure that the quality of products will not be reduced due to factors such as weather and human factors.Set up a professional transportation team, formulate a reasonable transportation method, assign special personnel to manage, and coordinate with the competent government departments to improve transportation efficiency and ensure product quality during transportation.Incorporate the quality control of the processing plant into the project quality management system, and implement comprehensive supervision and control.

5. On-site Assembly Construction

The air ducts, supports, hangers, pipes and modules processed by the processing plant are transported to the construction site in sequence according to the construction sequence, and the site is installed according to the construction plan and assembly drawing.The construction requirements are shown in the table below.

ISSN: 2414-1895 DOI: 10.6919/ICJE.202308_9(8).0014

Table 4. Prefabricated Construction Requirements

number	Require
1	The equipment foundation should be pre-inspected before assembly, and installation can only be carried out after passing the test.The strength, coordinates, elevation, size and bolt hole position of the foundation concrete must meet the design or manufacturer's technical requirements, and the surface should be smooth and of good quality without defects such as honeycombs, pockmarks, cracks, holes, and exposed bars.
2	For large-scale electromechanical equipment that has not been prefabricated for overall equipment and pipelines, it should be placed in place in advance according to the equipment layout drawing, and measures should be taken to protect the finished products.
3	The prefabricated modules of equipment and pipelines should be numbered in advance according to the assembly sequence of the assembly construction plan, and assembled in strict accordance with the sequence of numbers.
4	The location, elevation and nozzle direction of equipment and pipeline prefabricated modules must meet the design requirements.When there is no requirement in the design, the error of plane displacement and elevation displacement shall not be greater than 10mm.
5	For prefabricated modules of equipment and pipelines, the allowable deviation of vertical and horizontal horizontality is 1%, and shall comply with the relevant technical documents.
6	For the assembly construction area where prefabricated modules are arranged in rows or densely, if conditions permit, the assembly method of ground assembly, overall lifting or jacking should be adopted.
7	The assembly of the prefabricated support and hanger modules shall comply with the relevant requirements of each electromechanical system, the key parts shall be appropriately strengthened, and the necessary parts shall be provided with fixed brackets.
8	The prefabricated modules of equipment and pipelines should be calibrated and positioned after being assembled in place, and temporary supports should be set up or temporary fixing measures should be taken in time.
9	After the overall assembly of equipment and pipeline prefabricated modules is completed, quality inspection, testing and acceptance should be carried out.

6. Conclusion

The prefabrication and assembly technology in this paper has been applied to varying degrees in many projects in Tibet, which has greatly improved the safety and efficiency of building electromechanical construction. The application is good and remarkable results have been achieved. The main advantages are:

(1) The construction speed is fast, The construction period of the machine room, refuge floor and standard floor can be shortened by more than 30%;

(2) The material saving effect is remarkable, and the material loss rate of the factory intelligent typesetting system is 6% lower than that of on-site processing;

(3) The social benefits are obvious. The prefabrication factory processing production and on-site assembly using prefabrication assembly technology have won unanimous praise from the owners and government personnel.

References

[1] Geng, D., Dai, N., Guo, P., Zhou, S., & Di, H. (2021). Implicit numerical integration of highly nonlinear plasticity models. Computers and Geotechnics, 132, 103961.

[2] Geng, D., Guo, P., & Zhou, S. (2018). Implicit numerical integration of an elasto-plastic constitutive model for structured clays. Acta Mechanics, 50(1), 78-86.

ISSN: 2414-1895 DOI: 10.6919/ICJE.202308_9(8).0014

[3] Zhao, X., Geng, D., Cheng, Z., Bai, Z., Long, M., Chen, Y., ... & Ying, W. (2023). Study on the Performance of Active Embedded Steel Wire Knot Form in Silicone Graphene Composite Thermal Insulation Structure Integrated System. Buildings, 13(3), 705.

[4] Zhang, D., Cheng, Z., Geng, D., Xie, S., & Wang, T. (2021). Experimental and numerical analysis on mesoscale mechanical behavior of coarse aggregates in the asphalt mixture during gyratory compaction. Processes, 10(1), 47.

[5] Bao, Y., Wang, H., Su, L., Geng, D., Yang, L., Shao, P., ... & Du, N. (2022). Comprehensive analysis using multiple-integrated techniques on the failure mechanism and dynamic process of a long run-out landslide: Jichang landslide case. Natural Hazards, 112(3), 2197-2215.