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Application of BIM Technology in Building HVAC Construction

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ABSTRACT. HVAC project is a large energy consumption project. In order to effectively establish and perfect the energy saving supervision and management mechanism, BIM technology can be jointly applied to give full play to the advantages of BIM technology in optimizing environmental protection on the basis of shortening the construction period of the project. Therefore, this work started from the content of BIM technology and analyzed the characteristics and advantages of BIM technology. Combined with the actual cases, the work deeply excavated the matters needing attention in the construction of HVAC construction system based on BIM building, and formed a systematic, standardized and efficient HVAC construction system to improve the engineering benefit in an all-round way, expecting to provide the corresponding reference basis for the construction of HVAC in the new period.

KEYWORDS: Building HVAC, Bim technology, Characteristics, Application

1. Introduction

With the expansion of construction project scale and the increase of complexity, the traditional method has gradually shown its shortcomings and loopholes in the multi-professional collaborative design. These shortcomings and loopholes in the construction phase will cause delays in the construction period, and the resulting products are of uneven quality and cause other problems, which seriously damage the interests of all parties involved in the construction project. BIM technology is based on the information delivery manual IDM, international dictionary framework IFD, and information exchange format IFC [1]. It uses parameterized technology, professional collaborative technology, and building modeling simulation technology to realize the conversion of information from simple information to specific use information, which can improve the synergy between various specialties in the construction process. Therefore, using BIM technology in HVAC construction projects can ensure that all HVAC construction parties get accurate information, which plays an important role in improving the 3D parameterization and construction standardization of HVAC design.

2. BIM Technical Overview

2.1 Definition of BIM Technology

BIM, the Building Information Modeling, is another computer application technology in the construction industry after Computer Aided Design (CAD) technology, and it is praised as the revolutionary force of construction industry reform. In 1975, Chuck Eastman of Georgia Institute of Technology (the father of BIM) proposed a project on building description system, and the study of building models has officially begun. In 2002, Autodesk formally established Building Information Modeling (BIM), which made a great innovation in building design and was applied in many practices with remarkable benefits [2].

2.2 Role of BIM Technologies

Based on 3D digital technology, BIM is a model that integrates engineering data of all relevant specialties in the whole construction project. However, BIM technology is a digital office method for design, construction and management, involving many aspects of construction engineering, which can improve efficiency and reduce cost and energy consumption. It can basically realize the modeling of air conditioning, ventilation, smoke prevention and exhaust system and stroke system, and partially realize the modeling of air conditioning chilled water system, refrigerant system, condensed water system and expansion pipe modeling.

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2.2.1 Duct System Differentiation

One of the differences between BIM and CAD is that the system can not be distinguished by defining layers, but different wind systems can be created by “system family: air duct system” and different line styles, colors, line widths are set to distinguish wind systems. In the 3D view, it is distinguished by defining filters and specifying colors for different wind systems. By defining the wind system, it is not only intuitive and easy to distinguish, but also conducive to the editing and modification of the air duct, which greatly improves the working efficiency of drawing.

2.2.2 Optimal Layout of Pipelines in Narrow Spaces

The interconnectedness of different views is one of the main advantages of BIM technology. In the narrow and small space with strict requirements for net height, applying BIM technology for pipeline optimization layout, and correlating with plane, elevation, profile, and 3D views is convenient for HVAC designers to confirm the spatial position of pipelines from multiple angles, effectively avoid pipeline collision, and meet the requirements of high purity. The optimized layout of pipelines in a narrow space requires very high modeling accuracy [3]. It is necessary to consider not only the cross-section size of the pipeline, but also the insulation layer thickness of the pipeline, the radius of curvature of the pipeline accessories, the size of the flange, and the space for installation and testing of the pipeline. These are difficult to realize in traditional two-dimensional design, but the advantages of BIM technology in virtual visualization can be easily solved.

2.2.3 Machine Room Layout

In the citizen construction plan, the space reserved for HVAC equipment in building specialty is often relatively tight, so how to arrange equipment reasonably becomes the key and difficult problem in HVAC construction. The equipment sizes of different brands are different, and the brand cannot be designated during the construction stage of HVAC, which also becomes an uncertain factor for the layout of the machine room. Applying the advantage of parameter design of BIM technology, and creating parameter block family for machine equipment in the design stage is convenient to modify the entity size of equipment. By comparing more visualization scheme design process equipment placement, and considering the three dimensional space equipment installation space, interface position and silencing plenum size, the parameter can be modified to verify the rationality of the room layout, simulate equipment installation process and provide design optimization scheme for Party A.

2.2.4 Integrated Pipeline Collision Detection

The application of BIM technology for pipeline comprehensive collision detection can prove the quality of construction drawing design, which is a huge advantage of BIM technology, but also a basic application of BIM technology. Many domestic design institutes mastering BIM technology will basically apply this advantage in the design process. The main application directions of HVAC professional designers in pipeline integrated collision detection are: detecting the collision between wind system and structural beam, structural column, staircase, ramp and other components; detecting the collision between water system and structural beam, structural column and other components; detecting the collision of internal pipes of HVAC specialty; pipeline installation space and reserved maintenance space detection.

3. Application of BIM Technology in Building HVAC Construction

3.1 Project Profile

A building HVAC construction project area is 55484 m^2, which is for teaching, office, dormitory and related supporting facilities. The building category is multistory civil public building, with 5 floors above ground and 1 underground. The building height is 24m. The main functions of the aboveground part of the campus are teaching, office, dining hall, auditorium and dormitory, while the main functions of the underground part are parking garage, electromechanical and supporting rooms.

3.2 Construction Design of Building HVAC Based on BIM

3.2.1 Determining System Load

The annual cooling and heating load of air conditioner in this project is calculated by DEST energy consumption calculation software. The heating load of air conditioner and design load of domestic hot water are shown in Table 1.

Table 1 Load Statistics

Project	Cooling		Heating				Domestic hot water
	Auditorium Restaurant	Teaching Building	Auditorium Restaurant	Teaching Building	Dormitory	Ventilation	Restaurant, shower
Design load/ kW	560	1250	522	1481	287	560	142
Air conditioning area indicator $(W/m)^2$	135	119	126	64	67		

3.2.2 Develop an Air Conditioning Plan

In the construction of HVAC in this school, the office building uses radiator heating + multi-online air conditioning; restaurant uses circulating air conditioning + fresh air system + fan tube tray; dormitory uses radiator heating + split air conditioning; teaching building uses fixed air volume full air heat recovery air conditioning system + floor radiation duty heating + radiator heating.

3.2.3 BIM Technical Analysis

This school uses Magi CAD software to design HVAC construction. The software is developed on the Revit and CAD platforms, and it is mainly for engineers, designers and other professional designers. Additionally, it is suitable for the design of building information model software. BIM technology is used in office buildings, teaching buildings and restaurants of the school, mainly including air conditioning water system, ground source heat pump, heat exchange station, air conditioning air system, and air conditioning water system [4-5]. In terms of construction design content, BIM technology has more obvious effect than two-dimensional design, which is mainly reflected in:

(1) Means of expression. The main body of the two-dimensional design is the line. Through the superposition and combination of the lines, the relative positions of equipment contour line, pipeline contour line and valve are expressed in two-dimensional projection drawing, and the height relation and size information are represented by text. The main body of BIM design is the product. By selecting the model of the product and pipeline, the height and size of equipment and pipeline are displayed in the 3D information model. Figure 1 is the model of the ground source heat pump room with the most concentrated HVAC pipelines in this project, and it can be seen that the two design expressions are different.

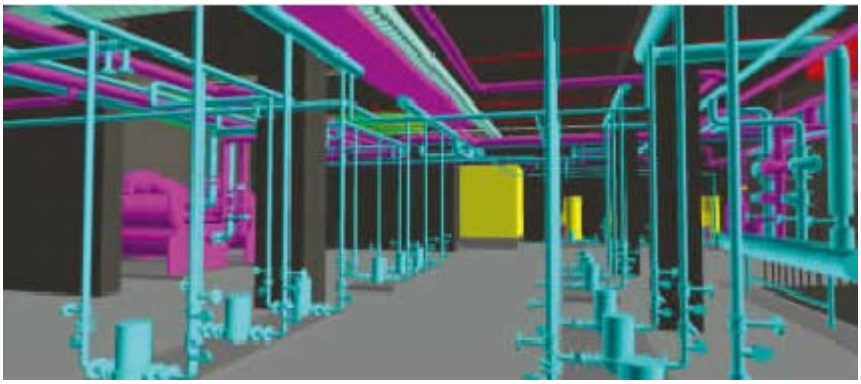

Fig.1 Model of Ground Source Heat Pump Room

(2) Drawing method. An important work of BIM design is to ensure that the selected products, pipes form a connection from point to surface, and finally realize the complete connection system of HVAC system. The connection of the branch pipe in the air conditioning pipe is the most intuitive embodiment of the difference between the two drawing methods.

(3) Mapping efficiency. The expression mode and rendering method of BIM design are composed of products, pipelines and other entities. The rendering process requires a large amount of pipe diameter, size and other information to form a model that meets the requirements of designers and provides an intuitive image. However, due to the heavy workload of input information and the great difference between BIM software and 2D design software, BIM software cannot be popularized among designers, and its drawing efficiency is low.

(4) Collaboration efficiency. Professional collaboration in BIM design is carried out through 3D information model, in which the shape and position of each professional component can be displayed intuitively in the model, which greatly reduces the possibility of professional collaboration errors. Through the unified data platform, mutual cooperation, real-time access, sharing information, communication is smooth and timely, and cooperation between professionals will be more smooth.

(5) Pipeline synthesis. In BIM design, pipeline synthesis is one of the achievements of professional collaboration. Pipelines in all areas have been intuitively displayed in the model, and pipelines crossing and collision are also clear at a glance. There is no need to draw additional new models to specifically reflect pipeline synthesis.

(6) The result of BIM design is a 3D model containing information parameters such as HVAC equipment, pipe material and thermal performance. Simply open the model and the shape and position of the device and pipe after installation will be displayed, as shown in Figure 2.

Fig.2 Restaurant (Left), Garage (Right) Model

4. Summary

As a result, it is a general trend that BIM technology replaces two-dimensional design in HVAC construction design. BIM technology can improve design quality, reduce construction difficulty, save construction cost, and reduce building materials consumption. Its advantages, such as high collaboration ability, 3D visualization and information sharing, will make the construction industry burst into a new revolution. With the continuous promotion and improvement of BIM technology in HVAC design, it will have a far-reaching impact on the entire HVAC design industry.

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