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Current Situation Analysis of Low-carbon Community Based on BIM Technology and Related Problem Solving Measures

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Abstract: In the low-carbon construction target system, low-carbon buildings play a crucial role in achieving the goal of reducing carbon emissions. As China's urbanization development continues to deepen, communities have become the primary living environment for both urban and rural residents. Consequently, research on building carbon emissions has shifted from individual buildings to encompassing low-carbon community building facilities. Against the backdrop of digital intelligence and new quality productivity development, promoting the use of Building Information Modeling (BIM) technology for low-carbon transformation in community buildings can effectively contribute to China's low-carbon goals. The utilization of BIM technology enhances planning and construction efficiency across various types of communities while minimizing rework and energy consumption. Furthermore, applying BIM technology to equipment and materials management enables better control over carbon emissions during building operation and maintenance stages, thereby fostering harmonious development between urban energy consumption and the community's ecological environment.

Keywords: Low-carbon community; BIM technology; Digital intelligence; Reduced carbon emissions.

1. Introduction

To comprehensively promote the great rejuvenation of the Chinese nation, Chinese-style modernization has made a comprehensive and important strategic deployment, and its realization is bound to have the harmonious development of man and nature. As a major country, China has put forward the "double carbon goal" : to achieve a carbon peak by 2030 and carbon neutrality by 2060, and take the initiative to shoulder the world's responsibility for environmental protection. At present, various localities and fields in China actively advocate the development of new quality productive forces, and put forward new requirements for the integration of emerging industries, future industries and traditional industries. According to the 2023 Government Work Report, the urbanization rate of China's permanent resident population has increased to 65.2%[1]. As a micro-unit of urban construction, the community is an important scene of the integration and symbiosis of urban civil architecture and residents' lives. In recent years, BIM technology, as a digital intelligence computing tool combining computer and building engineering, effectively promotes the development of digital buildings and provides digital technical support for improving production efficiency and reducing energy consumption. To better monitor and control the carbon emissions of buildings, BIM technology is used to control the whole life cycle of community buildings and improve the carbon emissions of community building facilities from construction to operation and maintenance, so that the community can reach the expected "low carbon" carbon emission index.

2. Research Status

Relevant studies show that building carbon emissions account for 54% of the country's total energy carbon emissions, and low-carbon deployment of buildings is an important field for China's carbon peak. At present, BIM technology is mainly applied to new buildings, but old communities still have high carbon emissions. BIM technology can be applied to the renovation of old communities to monitor carbon emissions and achieve simulation optimization to improve energy conservation and emission reduction efficiency. China has formulated standards related to carbon accounting for buildings. Existing research on carbon emissions in the building field shows a large number and differences in accounting boundaries.

American scholar Kwok-Wing chau et al. established a visual 4D model on the basis of BIM 3D model to solve the problem of mismatch between material estimation, construction site layout, safety management and actual site conditions[2]. Meanwhile, BIM technology was used to guide and correct the management progress and decisions of engineering projects. T. Qu et al. studied the combination and conversion of BIM model data and 3D technology in the whole life cycle of buildings[3]; Ting Wang et al. established fire simulation models and personnel evacuation simulation models [4]. Chang Li and Qibo Liu took Yifu Library of Chang'an University as an example to elaborate on the application process of BIM technology in energy conservation design analysis of existing buildings, and summarized the advantages and characteristics of BIM technology as an auxiliary tool for energy conservation design[5]. In addition, the input-output method and process analysis method are mainly used for carbon emission accounting. Building carbon emission accounting is the cornerstone of predicting trends and carbon reduction paths, and the clarity of boundaries will directly determine the reliability of accounting results. In this paper, the urban community is divided into proposed districts, existing communities and low-carbon communities for research and analysis.

3. Problems in Low-carbon Research of Urban Communities

3.1. The proposed community lacks visual 3D processing.

The proposed community lacks the use of advanced 3D visualization technology to demonstrate the construction and layout of the community during the planning and design phase. In addition, visualization 3D processing technology is still in the development stage in China, compared with developed countries, there is a certain gap in technical level. Secondly, the proposed community visual 3D processing is still facing a lack of economic support and insufficient awareness of importance. These factors affect the quality and efficiency of community planning.

3.2. Existing traditional communities are in urgent need of upgrading and renovation plans.

Existing traditional community structures and facilities can no longer meet the needs of low-carbon development and need to be transformed and updated to improve their low-carbon performance. These communities still have aging infrastructure, energy-intensive buildings and traditional transportation modes that are important factors affecting community carbon emissions. The low-carbon construction of existing traditional communities needs to develop a comprehensive transformation plan, including updating infrastructure, improving building energy efficiency, improving transportation systems and other measures, to achieve low-carbon transformation and sustainable development of urban communities.

3.3. Means for whole-process inspection of low-carbon communities are needed.

Existing assessment methods may be limited to specific stages or aspects of carbon emissions assessment, and cannot fully cover the entire life cycle of a community from planning, construction to operation. Therefore, the lack of comprehensive and systematic assessment means, it is difficult to accurately grasp the overall situation of community low-carbon. Low-carbon urban communities need to comprehensively consider the carbon emissions of community energy, buildings, transportation and other aspects, and conduct quantitative evaluation combined with actual data to support the comprehensive promotion of low-carbon community construction.

4. Solution

4.1. Design phase

The main content of type construction includes collecting accurate data, establishing a BIM model based on the design scheme, and checking it. Ensure the consistency of view representation and design integrity in architectural professional models; Ensure consistency in component dimensions and annotations in structural professional models [6]

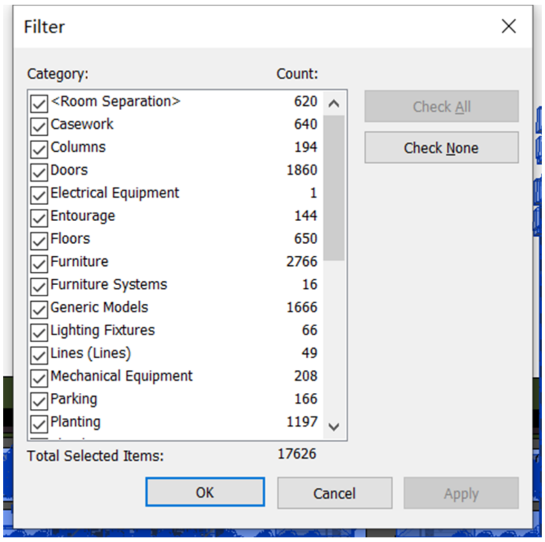

Figure 1. Number of components

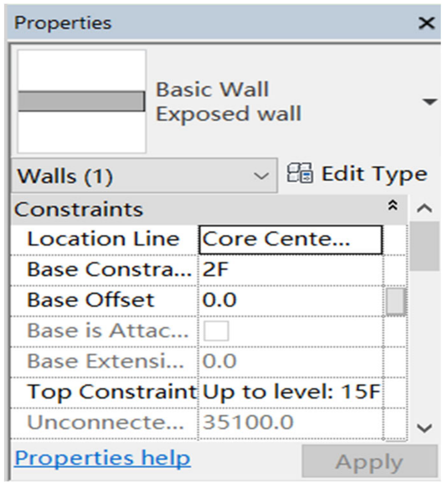

Figure 2. Component dimensions

4.2. Construction Phase

The use of BIM's 3D technology for collision detection and resolution of spatial relationship conflicts can optimize design and reduce the risk of reconstruction caused by construction errors. At the same time, it is also possible to optimize clearance and pipeline layout schemes. Construction personnel can use the optimized plan for technical communication and simulation before construction, while improving construction quality and communication skills with the owner.

Collision inspection utilizes the 3D visualization and time dimension functions of BIM models to simulate construction progress and compare actual progress.

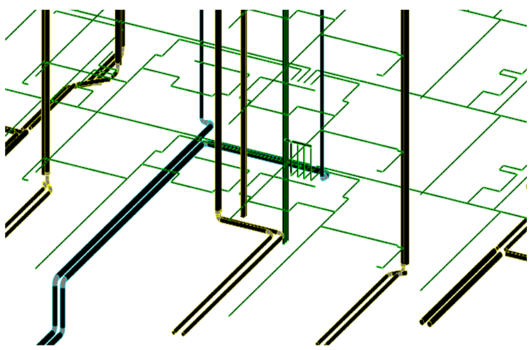

Figure 3. Collision check

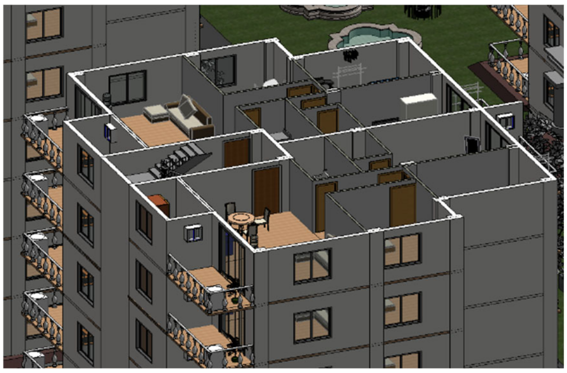

Figure 4. Progress view

Each participating party can have real-time understanding of engineering issues and situations, reduce quality and safety issues, and avoid rework and rectification. By utilizing BIM collaborative technology, information exchange is more efficient and decision feedback speed is faster. A modular construction approach can save work time and costs, achieving complete work at once.

4.3. Operation Phase

①Space and Asset Management

In traditional asset management, construction and operation information are separated from each other, leading to a lack of asset information for engineering projects in the early stages of operation by construction units, and manual input is prone to errors, which has a negative impact on asset management. By using BIM databases, construction units can accurately grasp engineering information, quickly query component related information and equipment parameters, reduce labor and time costs, thereby improving asset management efficiency and optimizing space utilization.

②Building and Equipment Maintenance

In the operation stage of the construction project, the BIM model is used to provide equipment parameters, and the maintenance management system is combined to develop a reasonable maintenance plan, timely equipment maintenance and record important maintenance information to reduce repair costs.

③Analysis of Building Systems

Analyze and evaluate energy consumption, lighting, and pedestrian flow using BIM database parameter information and other professional software to ensure that the building meets usage requirements and regulations, and take measures to optimize overall performance.

④Emergency Simulation of Unexpected events

Using BIM models and disaster simulation analysis software, simulate the process of disaster occurrence in advance and analyze the reasons, based on which avoidance measures and emergency plans can be formulated. In the event of an emergency, rescue personnel can use BIM models to quickly obtain relevant information about buildings, in order to take timely rescue actions[7].

4.4. Demolition Stage

During the demolition process, BIM technology predicts and simulates the structure and components after demolition through 3D models, which can avoid unreasonable plans, assess risks, predict progress and costs, and ensure safety and quality. For example, using BIM technology in conjunction with robotic arms can more accurately and safely remove pipelines and circuits, and carry out material recovery. Not only that, BIM technology can also perform precise cleaning and recycling work, avoiding environmental pollution.

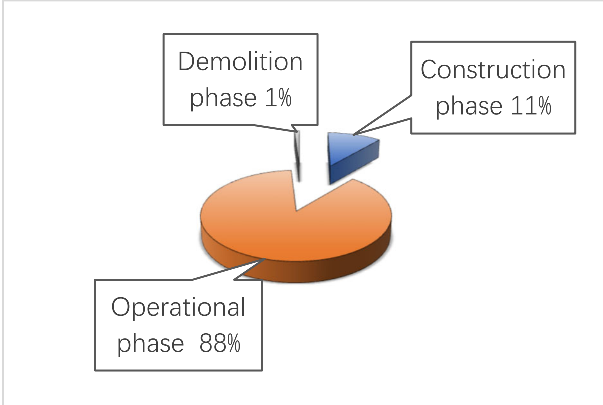

Figure 5. Schematic diagram of carbon emission share

5. The Final Effect

5.1. 3D visual management of the proposed community

The intelligent operation center is established in the community management office. As the brain of community operation display, it is the reporting center, command center and unified entrance to realize the visible, manageable and controllable operation of the community. Intensive community workbench to build a beautiful community visual management, docking with community environmental monitoring, energy consumption data, new energy, sanitation services, community convenience services and other system data, to achieve visual unified management and centralized display.

Figure 6. Old community model picture

5.2. Renovation plan of traditional residential area

By comparing the low-carbon model with other models, the heat transfer information of the enclosure structure contained in the BIM model can be directly used to simulate and analyze the energy consumption of the building, and the glass transmittance information can be used to analyze the indoor natural lighting, which greatly improves the efficiency of green analysis. At the same time, the results of building performance analysis can be quickly fed back to the improvement of the model, which ensures the implementation of the performance analysis results in the process of project design. BIM technology is used to simulate and optimize ventilation, lighting and air quality, and natural ventilation and lighting are utilized as much as possible to fundamentally reduce carbon emissions in building construction and residents' life.

Figure 7. Picture of the proposed community model

5.3. Whole process inspection of low-carbon community

In-depth analysis of developers and construction units on the use of clean energy, the use of low-carbon technology, the use of low-carbon building materials, ecological construction, low-carbon management and other realities. Based on the analysis of the first two communities by BIM technology and the understanding of excellent cases both inside and outside China, we can use BIM technology to build a low-carbon community, and its carbon emission index is compared with the collected research information, and it is defined as a low-carbon community. China's low-carbon community is not exactly the same as that of foreign countries, because when considering low-carbon, economic and social benefits should also be taken into account, whether it is in line with the living habits of domestic residents, and whether it is in line with China's population base and land area [8].

6. Summary and Prospect

The carbon emission in the whole life cycle of a building includes five parts: building material itself, building planning and design, building construction and installation, building use and maintenance, and building demolition and cleaning. Improve carbon emissions and energy consumption throughout the entire life cycle through BIM technology; To achieve similar to the standardization of manufacturing design, fine construction, information management, and industrial production to reduce more resources, energy consumption, reduce carbon emissions, to achieve a higher level of conservation and low-carbon.

At the same time, BIM technology is used for building simulation data analysis, and advanced technical means are used to achieve energy saving, low carbon and quality assurance. The use of information technology enables low-carbon development to be low-cost and simple, while forming a set of natural circulation "ecosystem" and achieving a new low-carbon concept.

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