CALCULATION AND EVALUATION OF BUILDING THERMAL ENERGY CONSUMPTION AND CARBON EMISSIONS BASED ON BIM TECHNOLOGY

by

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In order to calculate the carbon emissions in the construction process to achieve low-carbon buildings and low-carbon construction, the author puts forward the calculation and evaluation of building thermal energy consumption and carbon emissions based on building information modeling (BIM) technology. The author first proposed the important value and application of BIM technology in energy consumption evaluation of green buildings, taking a gymnasium as an example, a carbon emission accounting system for building construction and installation process is established based on BIM technology, and the carbon emissions in building construction and installation process are calculated and analyzed. The results show that the carbon emission during the construction and installation of a gymnasium is 766300 tons, of which the carbon emission caused by building materials is 737200 tons, the carbon emission caused by mechanical equipment is 4500 tons, and that caused by office and living is 34500 tons, accounting for 94.90%, 0.59%, and 4.51%, respectively. In conclusion through data analysis, determine the largest carbon emission source in the construction process, and then propose targeted carbon emission reduction measures in the construction process of the construction industry.

Key words*: BIM, building construction, carbon emission accounting, low carbon development*

Introduction

Global warming has become the most urgent environmental problem that our whole society must face together. The surface temperature from 1883 to 2013 has been continuously higher than any decade since 1850, and the three decades since 1983 have been the hottest in the Northern Hemisphere since 1400. In the 32 years since 1880, the global average sea and land surface temperature has increased by 0.85 °C, showing a linear upward trend as a whole. The reason for the continuous rise of average temperature is undoubtedly the increase of greenhouse

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gases. Since 1975, due to many human activities, the amount of CO_2 in the atmosphere has increased to levels that have not been seen in the past 800000 years. Since the rapid development of the economy, the amount of CO_2 has increased by 40, because of the use of fossil fuels and land use changes [1]. In the 260 years since 1750, the CO_2 emissions caused by the consumption of fossil fuels and the production of cement were about 375 billionns, the CO_2 emissions due to deforestation and land use are about 180 billionns. Everything aforementioned are anthropogenic CO_2 emissions, so the cumulative anthropogenic CO_2 emissions are 555 billionns. According to relevant statistics, about 40% of these anthropogenic CO_2 emissions are from the construction industry.

Currently, BIM has become a popular concept and technology in the construction industry, is the application and implementation of information technology in the construction industry, and is the new technology and type of production in the information age. Therefore, the concept and technology of BIM has been applied to the research of low-carbon buildings, and visualization, testing, data integration and other characteristics of BIM technology. have been used in full, providing good conditions for carbon emission calculation of the whole life. of buildings [2, 3].

Literature review

Feng [4] They combine BIM technology with the construction process of prefabricated buildings, create a digital control of the workplace, and determine the specific application of BIM technology. in the construction process, provide some theories and important ideas for the development of prefabricated buildings. Kuok *et al*. [5] are considering the feasibility of BIM to design the necessary water equipment to accurately collect and record immediate discharge data. This will use Autodesk Infraworks 360 software. Questionnaires will be used to evaluate and analyze the matching results based on the collected data. Taman Uni Central area in Kota Samarahan was chosen as the target of this study. Drainage information, such as the size, length, and height of the well, is imported into a GIS model in Autodesk InfraWorks 360. Autodesk InfraWorks 360 will perform a preliminary analysis, calculation with sea level analysis, to improve the water loss of the rainfall intensity of 2, 5, 10, 20, and 50 years (ARI). Then, export the InfraWorks model to Autodesk Civil3D for a detailed hydraulic analysis. The results show that the two Autodesk software packages can be integrated into the existing water storage facilities to create the necessary equipment and test its adequacy to meet the water demand. In the newly created area of the catchment area.

Taking the park as an example, this paper has developed a carbon emission accounting system for infrastructure construction and installation process based on BIM technology, obtaining carbon emissions during construction editing and setting, and bringing out statistics and analysis. Based on the data analysis, determine the maximum carbon emission during construction, and then publish the carbon emission plan [6].

Research methods

Important value of BIM technology in energy consumption evaluation of green buildings

In the current construction industry, the evaluation system of green buildings is mainly divided into four types. The first is LEED, the main purpose is to promote the continuous improvement of green building evaluation standards, and resolutely resist the idea of green building becoming superficial and formal. The second is BREE-AM, a sustainable green building evaluation system proposed by the UK according to its national characteristics, and a large number of laws and regulations have been formulated on this basis. The third is CASBEE, which is a green building evaluation system proposed by the Japan Building Association and is also the main evaluation standard at this stage. The fourth is HQE, a green building evaluation system proposed by France in the 21st century, which has been widely recognized by all sectors of society and has become the main evaluation system on the path of sustainable development in France [7].

In the traditional process of energy consumption evaluation of green buildings, the building model provided for analysis can only use design schemes and construction drawings for integration and analysis of building information, which not only seriously reduces the efficiency and quality of the green building evaluation system, but also increases the working time and energy of technicians in the process of analyzing construction drawings. Therefore, the traditional green building energy consumption evaluation software and methods can no longer meet the social development and needs, and only the green building energy consumption evaluation system and methods are constantly improved and upgraded. The emergence of BIM technology provides a reliable technical guarantee for the optimization and improvement of energy consumption evaluation of green buildings.

From the development process of the green building energy efficiency assessment and standards, although the green building energy efficiency assessment is encouraged the development of the community to be sustainable to some extent, because there is no more teaching, research and necessary, there is a lack of good analysis in the process of creating the model, so there is some uncertainty one side. For example, although CAD technology has some advantages in its functions, which can create aircraft models, it requires a lot of workers, equipment and capital, which not only reduce the progress of the whole project, but also increase the risk of errors [8]. However, the application of BIM technology in energy efficiency measurement of green buildings is not only perfect, but also very powerful. In building model construction, it can convert the plane model into a 3-D model, allowing analysts to conduct comprehensive analysis and evaluation in a more intuitive and vivid way, it also improves the accuracy and effectiveness of building energy consumption mode in essence, provides technical support for walking on the road of sustainable development, and also improves some new problems of green building energy consumption a large extent.

In view of the situation of the current development of our country, because the level of economic development has been slow in the past, and science and technology have been backward better compared with other developed countries, the concept of green buildings appeared late, and complete energy efficiency analysis for green buildings has not been developed. The application of BIM technology has promoted China's research on energy efficiency assessment of green buildings to a greater step, and has gradually attracted interest from all over the world. center of life. It not only puts forward a higher requirement for energy conservation and emission reduction in industrial areas, but also improves the recognition of energy efficiency. survey of green buildings in construction, led many researchers to explore and analyze. It is also important for China's ecological and economic development.

Specific application of BIM technology in energy consumption evaluation of green buildings

In the overall construction project, the key factors to reduce building energy consumption are mainly the building envelope, heating, lighting and other systems in the building structure. The use of BIM technology can provide more professional and specific data information reference in the design and construction of these systems, the improvement and analysis of these system data information can promote the building structure to be more scientific and reasonable, and effectively reduce energy consumption [9-12].

The BIM based carbon emission calculation model in building construction stage

With the deep integration of BIM technology and low-carbon buildings. The BIM model can be used to obtain all the data required by the actual construction process of the building project, which provides technical support for the rapid, accurate and low-cost carbon emission measurement in building construction, at the same time, BIM technology can be used to obtain the information of mechanical equipment and materials in construction, and finally calculate all carbon emissions in the construction process.

Calculation principle of carbon emission during building construction

Determination of emission boundary

Carbon emissions in the construction and installation stage are generally divided into three parts, that is, carbon emissions caused by building materials, carbon emissions caused by use electricity and carbon emissions generated by the use of electricity in residential areas during construction and installation.

Carbon emission accounting principle

According to the carbon emission boundary, the calculation formula for determining the carbon emission during building construction:

$$E_{CO_2} = A_{electricity}F_{electricity} + \sum_{i=1}^{n} A_i k_i T_i + \sum_{i=1}^{n} M_i Q_i m_i + \sum_{i=1}^{n} A_{fiel} F_{fuel} \tag{1}$$

where $A_{electricity}$ [kWh] is the total power consumption of construction area, living area and office area in the construction and installation stage, $F_{electricity}$ [kgkWh^{-1}] – the electric power emission factor, and A_i [kJ per year] – the energy consumption value of office vehicles during construction.

Selection of emission factors

Carbon emission factors of building materials

The carbon emission coefficient of the building materials used in this paper mainly refers to the carbon emission coefficient of the whole life operation of the building materials related to the impact Environmental impact of the life cycle of household products by the American Standards and Technology Association, tab. 1.

Carbon emission factors of fossil fuels

The author selected the case of the construction process mainly using gasoline, diesel, electricity and other fossil fuels. The carbon emission factors of fossil fuels are mainly related to the Guidelines for the Preparation of Greenhouse Gas Products in the State. The CO_2 emission factor of gasoline is 2.9251 kg/kg, that of diesel is 3.095 9 kg/kg, and electricity is 0.884 3 kg/kWh [13, 14].

Table 1. Carbon emission calculation of materials used in the construction phase of a gymnasium

Serial number	Name of building materials	Consumption	CO_2 emission factor [kg(kWh)$^{-1}$]	CO_2 emissions [t]
1	Cement	1402540 m^3	128.96	180871.56
2	Concrete block	250365 m^3	220	55080.30
3	Concrete	1654210 m^3	66.51	110021.50
4	A steel bar	275410 tons	146.41	40322.78
5	Aluminum plate	62300 m^2	62.15	3871.94
6	Latex paint	21000 m^2	5.06	106.26
7	Mortar	1102540 m^3	132.62	146218.86
8	Face brick	820540 m^2	98.05	80453.95
9	Granite	82650 m^2	101.57	8394.76
10	Decorative metal plate	1825420 m^2	22.22	40560.83
11	Glass	50000 m^2	3.67	183.51
12	Plasterboard	162031 m^2	77.84	12612.48
13	Asphalt	1021520 m^2	47.48	48501.77
total	–	–	–	727200.50

Result analysis

Examples of carbon emission accounting analysis in the construction stage

Based on the aforementioned research, we can see that carbon emissions in the construction phase are mainly from the use of building materials, construction machinery and equipment and fire. Electricity in office and residence.

Carbon emissions caused by building materials

Taking the stadium as an example, building materials and energy consumption in the construction phase are calculated by BIM software, and the total carbon emissions of the project are finally obtained together with the actual construction process. First, create the project plan from the BIM model software, then add the material parameter information required by the construction process, and finally get all the information materials and other information of the project, as shown in tab. 1. It can be seen from tab. 1 that the building materials used in the construction and installation stage of the stadium are only Including cement, concrete*, etc.* According to the calculation, the carbon emission is 727200 tons. See tab. 1 for specific statistical results.

Carbon emissions caused by mechanical equipment

Through the BIM software, the number of construction machinery, replacement machinery, electricity and other construction in the construction phase of the stadium is obtained for statistics, and CO_2 emissions of mechanical equipment in the construction and installation stage is 4500 tons. See tab, 2 for specific financial analysis results.

Table 2. Calculation of carbon emissions caused by mechanical equipment in the construction phase of a gymnasium

Mechanical name	Quantity	Energy consumption per shift	Number of machine shifts	CO_2 emissions [t]	Mechanical name	Quantity	Energy consumption per shift	Number of machine shifts	CO_2 emissions [t]
Tower crane	5	80 kWh	300	106.12	Mortar mixer	5	50 kWh	340	75.16
Large gantry crane	2	22 kWh	200	7.78	CO_2 welding machine	30	30 kWh	180	143.25
Crawler crane	2	125.7 kg diesel	300	233.49	DC welding machine	25	90 kWh	210	417.83
Truck crane	2	40.7 kg diesel	350	88.2	Air compressor	6	50 kWh	190	50.4
Crawler dozer	16	41 kg diesel	290	588.96	Angular grinding wheel grinder	20	15 kWh	160	42.45
Concrete pump	5	300 kWh	300	397.93	Semi automatic cutting machine	8	30 kWh	220	46.68
Concrete truck pump	4	50 kg diesel	290	179.56	Crane	2	30 kg diesel	210	39
Backhoe excavator	6	30 kg diesel	220	122.59	Manual forklift	5	40 kg gasoline	185	108.22
Backhoe excavator	5	60 kg diesel	200	185.75	Elevator	3	11 kWh	450	13.13
Dump truck	30	40 kg diesel	290	1077.37	Shearing machine	15	5 kWh	310	20.55
Flatbed truck	5	50 kg diesel	310	239.93	Air duct seaming machine	15	3 kWh	210	8.34
Vibrating spear	20	1.5 kWh	300	7.95	Hydraulic riveting machine	10	3 kWh	150	3.98
Reinforcing steel cutting machine	15	10 kWh	250	33.16	Grinding wheel cutting machine	12	2 kWh	210	4.45
Bending machine	25	3 kWh	200	13.26	Grinding machine	12	1 kWh	310	3.27
Reinforce-ment butt welding machine	5	90 kWh	220	87.54	Hydraulic punching machine	5	3 kWh	210	2.78
Woodwork-ing press planing	5	5 kWh	175	3.86	AC welding machine	35	30 kWh	195	181.07
Wood-working electric saw	14	3 kWh	150	5.57	Total	–	–	–	4 539.73

Table 3. Carbon emissions in office and living quarters of a gymnasium during construction

Category	Type	Specific energy consumption			Carbon emissions [t]
		Gasoline [kg]	Diesel [kg]	Electricity [kWh]	
Office vehicles	Car	8 015	–	–	23.45
	Passenger car	–	2 515	–	7.78
	Other	–	35 125	–	108.73
Administrative area	Lighting	–	–	721 540	638.05
	Air conditioner	–	–	1 852 000	1 637.73
	Other	–	–	1 025 410	906.76
Construction area	Lighting	–	–	7 520 000	6 649.94
	Air conditioner	–	–	15 240 000	13 476.72
	Other	–	–	12 550 000	11 097.96
Total		–	–	–	34 547.15

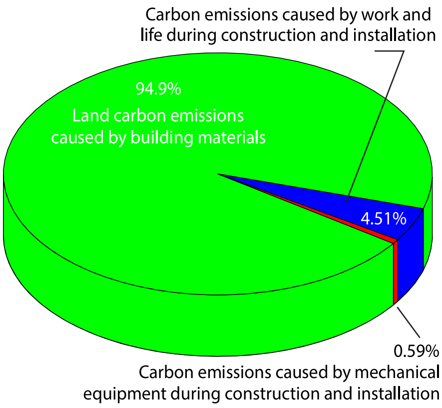

Figure 1. Proportion of different carbon emission sources during construction

Carbon emission of office and living in construction and installation stage

During construction and installation, office and domestic carbon emissions mainly come from power, gas and oil consumption of office equipment and living facilities. The author collects information about the energy consumption of the equipment in the workplace and on the territory of the construction of the playground through BIM, and obtained that the carbon dioxide emission of office and living in the construction and installation stage is 34500 tons, see tab. 3 for the specific accounting results.

Based on the previous calculation, it is concluded that the carbon emission during the construction and installation of a stadium is 766300 tons, among them, the carbon emission caused by building materials is 737200 tons, that caused by mechanical equipment is 4500 tons, and that caused by office and living is 34500 tons, accounting for 94.90%, 0.59%, and 4.51%, respectively, see fig. 1 for details on the next page.

Conclusions

- In the construction and installation stage, the carbon emissions caused by the use of building materials are the main sources of carbon monoxide, so the use of carbon monoxide in the process construction is the key to reduce carbon emissions in the construction phase.
- Before the implementation of the project, the construction industry can calculate the carbon emissions of different building models by building a number of building models, and then use the carbon emission calculation model in this paper to select the appropriate low carbon building model as the main basis for comparison and selection of building model.
- In the process of construction, management means such as water saving, energy saving and material saving should be strengthened in order to improve the level of business management copy and create a green low-carbon brand.

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