

Green Building Strategy of University Campuses in Cold Regions: A Case Study of Xi 'an

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Abstract. Building as a major body of carbon emission and energy consumption, how to reduce energy consumption needs to be solved. As a large building type that is closely related to people's lives, it is important to find green solutions according to local conditions. This paper explores the green building strategies of university campuses in cold regions by combining building climate zoning, especially taking Xi 'an as an example. By constructing and analyzing the green building simulation model, based on the basic model, the analysis method of control variables and scheme comparison is used to discuss the orientation, building type and envelope material, and evaluate the energy performance and environmental impact of different building schemes. The results show that, in the design of green campus in cold areas, different influencing factors of building energy consumption are selected according to various conditions, reasonable planning is made according to local conditions, and the optimal scheme is obtained by combining comparative experiment simulation or analysis and comparison, so as to obtain optimization strategy research, so as to reduce building energy consumption, realize green building design, and provide reference for green building practice in cold areas in the future. It provides a useful reference for the sustainable development of university campus buildings.

Keywords: Cold Regions; Green Building; Revit Model; Energy Consumption Analysis.

1. Introduction

Green building refers to a building that maximizes resource conservation (energy saving, land saving, water saving, material saving), protects the environment and reduces pollution, provides people with healthy, applicable and efficient use of space, and harmoniously co-exists with nature during the whole life cycle of the building [1]. Campus buildings, as one of the important sources of energy consumption and carbon emissions [2], have high staff density, multiple building types and diversified characteristics of campus energy consumption [3]. Solving the problem of energy consumption of campus buildings is a key step to realize the development of green buildings. The green design of campus energy saving and emission reduction can promote the sustainable development of resource-saving and environment-friendly society, help to protect the environment and save resources, and make positive contributions to green development.

In recent years, a number of standards and regulations on green building campuses have been gradually implemented. In 2013, the "Green Campus Evaluation Criteria" was officially implemented as the technical basis for China to carry out green campus evaluation; Since the beginning of the 21st century, the United States, the United Kingdom and other countries have promulgated corresponding green campus evaluation standards in 2006 and 2008 respectively [4-5] to promote the low-carbon transformation of campuses. And China implements the "double carbon" policy and takes it as one of the national development goals, that is, to achieve carbon peak by 2030 and carbon neutrality by 2060, and promote the development of green buildings to become the mainstream of The Times and contribute to improving people's living standards. In addition, from the current situation and trend of green development of university campuses, because the construction of green campuses is highly consistent with the national dual-carbon strategic goal, many high-efficiency campus buildings are gradually considering the application of green building concepts. Moreover, building a green campus and creating a comfortable learning environment for students conform to the development trend of humanistic care in colleges and universities, so the concept of green buildings is gradually implemented.



However, looking at the development of green buildings today, there are still many problems to be solved. From a micro point of view, non-renewable energy is mostly used for heating and cooling in traditional campuses, which is faced with large resource consumption, high energy consumption level and significant negative impact on the environment, and energy consumption accounts for a large proportion of total consumption [6]. At the same time, the "State of the Global Climate 2022" pointed out that the trend of long-term warming of the climate is unavoidable, which has a serious impact on human life and health and ecosystems, and the road of sustainable development has become a common theme facing mankind.

According to the analysis of the topic of this study, it can be found that there are still many gaps in the construction of green campus. Due to the late start of the domestic research on green building and the few renewable energy technologies adopted, the research is not comprehensive and there are bottlenecks [7], and there is a lack of continuous monitoring mechanism and evaluation standards for the environmental benefits of green buildings in the industry to quantify the energy consumption and value of the whole life cycle of buildings. However, for cold areas, due to the overall development level limitation and diverse climate, there are few green building practice cases in cold areas, and most of them apply stylized models, so it is difficult to find suitable solutions. In addition, the construction of the existing green campus only piles up the existing green advanced technology and materials, which is not innovative enough, and plays little role in guiding the design of green buildings in schools. The cost of new construction or renovation is high, there are many standards and norms for campus construction, and there are many difficulties in exploring the road. The lack of regional climate, geographical environment, resources and energy and other aspects of consideration, can not really do local conditions.

Therefore, in order to promote the sustainable development of green buildings, based on the green development design principles of university campus buildings, this study uses the method of comparative analysis to screen out some green design schemes that adapt to the environment through model simulation and energy consumption analysis, so as to achieve the purpose of reducing energy consumption, low-carbon and sustainable, and provide strategies and data for the future construction and transformation of green buildings.

2. Method

By constructing and analyzing the green building simulation model, this study takes the university campus in the cold area of Xi'an as the research object, and adopts the method of control variables and comparative analysis to explore the green building strategy step by step.

Revit modeling method is the basis of this research. According to the building climate zoning, the climate characteristics of the study area are analyzed in detail, so as to determine the green building design principles suitable for cold areas, and build a basic model as the starting point for subsequent research. By using the building Information Modeling (BIM) software, the basic three-dimensional model of the campus building is created and the basic building attribute conditions are set to improve the accuracy of the design, which is helpful to realize the real physical performance of the building and the analysis of energy consumption in the subsequent simulation analysis. Simulation experiment method is an important method to evaluate energy consumption and environmental impact of basic building design scheme, so as to determine various building energy attribute parameters. After the construction of the model, energy analysis is used to analyze the energy consumption performance of the Revit model, and the energy consumption data of the basic model in operation can be obtained by inputting parameters such as the geographical location, orientation, function and material characteristics of the building, so as to comprehensively understand the direct impact of different building attributes and design schemes on energy consumption. The application of control variable method ensures the independence of each variable in the experiment, which is convenient for subsequent comparative study. By fixing certain conditions (such as building area, shape, as well as internal and external factors such as geographical location and surrounding environment) and only

making changes in specific study conditions, such as orientation, building type and envelope material, this makes it more accurate to identify the specific impact of each design option on energy consumption. It also improves the reliability of experimental results and the operability of implementation in architectural design and reconstruction practice.

3. Basic Case of Green University Campus Building Simulation in Cold Regions

According to the Code for Thermal Design of Civil Buildings, the average temperature of the coldest and hottest months is taken as the object of thermal design, and China is divided into 5 climate zones. Xi 'an is located in north China (108°55 '25.00 "E, 34°32' 27.00" N), located in the middle of the Weihe River basin in Guanzhong Plain, belongs to the warm temperate semi-humid continental monsoon climate, the summer temperature is higher, winter temperature is lower, the four seasons change drastically, heat production and cooling energy consumption is serious, so the building energy saving demand is high.

Through the analysis of basic climate information such as temperature, precipitation, relative humidity, dry bulb temperature and sunshine hours in Xi 'an, it can be found that Xi 'an is cold and dry in winter, hot and humid in summer, with large sandstorms and short time in spring and autumn, large annual temperature difference, long sunshine hours and large amount of solar radiation received.

Considering climate and environmental conditions comprehensively, Revit modeling is used to establish the basic model of this study. The total construction area is 6568 square meters, covers an area of 1333 square meters, a total of five 20 m floors, the building type is the school teaching building, showing symmetrical layout characteristics. The detailed information, appearance and layout of the model are as follows (Table 1 and Figure 1).

Table 1. Basic Information of the Basic Model

Gross floor area	6568.00m ²
Building footprint	1333.00m ²
Usable area of room	6568.00m ²
Number of floors	5 floors
Building height	20m
Length and width dimensions (in terms of longest side)	64m*23m
Layout characteristics	Symmetrical layout
Number and size of rooms	6*8*8 rooms, 10*12*4 rooms

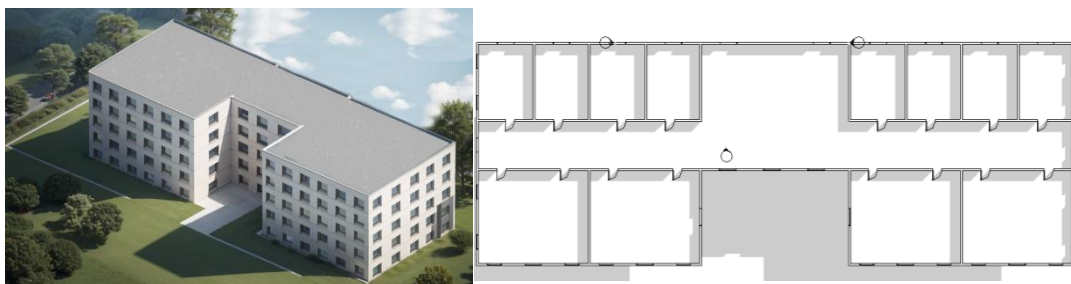


Figure 1. Basic Model Rendering and Floor Plan

The experimental model is a teaching building of a year-round university, with lightweight structure and double-layer insulating glass as its enclosure structure. The total energy of the site is 6658.84GJ, the total source energy is 14840.70 GJ, and the total window-to-wall ratio is 11.71%. The system

report of the teaching building was obtained through revit energy analysis, and it was established as a control group and measured as a standard. The basic building attributes of the model are shown in Table 2, 3 and 4.

Table 2. Basic Building Attributes of the Basic Model

Building type	School or university
Building operating schedule	Year-round university
Hvac system	Central VAV, HW heating, chiller 5.96COP, boiler efficiency 84.5
Fresh air information	Fresh air per person(P):8.00L/s
External mass wall	Lightweight construction - typical mild climate insulation
Volume interior wall	Lightweight construction - no insulation
Volume roof	Typical insulation - light roofing
Bulk glass	Double clear - no coating

Table 3. Basic Model Sites and Energy Sources

	Total energy[GJ]	Energy consumption of gross building area[MJ/m ²]	Energy consumption per building area[MJ/m ²]
Total site energy	6658.84	1013.83	1013.83
Net site energy	6658.84	1013.83	1013.83
Total source energy	14840.70	2259.55	2259.55
Net source energy	14840.70	2259.55	2259.55

Table 4. Window Wall Ratio of the Foundation Model Envelope

	Total	North(315°-45°)	East(45°-135°)	South(135°-225°)	West(225°-315°)
Total wall area[m ²]	3931.47	1303.56	671.16	1285.59	671.16
Window opening area[m ²]	460.40	145.53	68.36	178.16	68.36
Total window wall ratio[%]	11.71	11.16	10.18	13.86	10.18

4. Comparative analysis and optimization strategy of building schemes

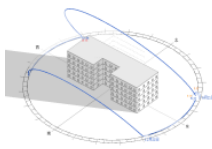
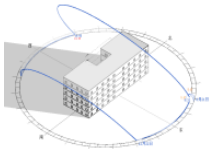
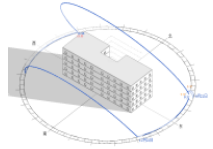
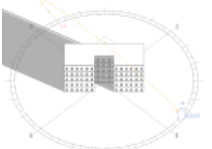
Because Xi 'an is located in a cold area, the annual temperature difference is large, and the demand for cooling in summer (mainly reflected in air conditioning energy consumption) and heating in

winter (mainly reflected in heating energy consumption) is large. Therefore, in the process of design exploration, it is necessary to consider multiple practical problems such as thermal insulation and energy saving heating. In order to explore the application of green buildings in university campuses in cold regions, this paper applies revit software to the basic simulation model of teaching buildings in Xi 'an established in the previous chapter, considers three factors affecting building energy consumption such as changing orientation, building type and envelope material, and generates an energy analysis report for comparative analysis, so as to find the optimal design scheme.

4.1. The influence of orientation

In different seasons, the sun height Angle, light intensity, radiation heat and other factors are different (Table 5). Before simulation, the interaction between orientation and season (south to reduce heating energy consumption, north to reduce cooling energy consumption) and the time to receive sunlight exposure (the same height Angle of the sun, the longer the time, the more heat absorption) are understood, and then through simulation experiments. Determine the correlation between the positive and negative effects.

Table 5. Energy Consumption Analysis with Different Orientation of Teaching Building Model

Stats	East-West	South-North(max)	West-East (min)	North-South
Summer solstice - winter solstice solar path map				
Total site energy	7016.45GJ	7117.45GJ	6994.01GJ	7085.69GJ
Total source energy	16117.26GJ	16292.52GJ	16150.08GJ	16251.25GJ
Site energy per unit area	1068.28MJ/m ²	1083.66MJ/m ²	1064.86MJ/m ²	1078.82MJ/m ²
Source energy per unit area	2453.91MJ/m ²	2480.59MJ/m ²	2458.90MJ/m ²	2474.31MJ/m ²
Total annual energy consumption for refrigeration	3199.46GJ	3273.64GJ	3154.94GJ	3244.91GJ
Total annual energy consumption for heating	1459.26GJ	1486.10GJ	1481.36GJ	1483.07GJ
Cooling peak relative humidity	51.70%	50.91%	51.64%	50.76%
Peak relative humidity of heating	26.04%	25.55%	25.74%	26.67%
Cooling peak wall delay sensible heat	29402.37W	29368.34W	29620.13W	30025.03W
Peak wall delay sensible heating	48468.8W	48492.7W	48569.0W	48563.1W

From the analysis of the two tables, it can be seen that the energy consumption in the south-north trend and west-east trend is the highest and the lowest respectively. Due to the difference in the area

of the facade in contact with the sunlight, the larger the area of the building facade to receive direct sun, the more solar radiation will be absorbed. Thus, the south-oriented teaching building can be more suitable for setting in cold areas. At the same time, the analysis of east-west energy consumption can be found that the shape of the building or mutual occlusion, window-wall ratio will also affect the building energy consumption, therefore, we should pay attention to the use of renewable natural resources such as solar energy and wind energy, comprehensive consideration in the building direction, such as increasing the application of solar photovoltaic panels and solar hot water systems, to maximize the use of winter sunlight, Reducing dependence on traditional energy can effectively reduce building energy consumption.

4.2. Building type

Energy consumption on university campuses mainly includes electricity, water and gas, among which heating and cooling, lighting, teaching equipment and electricity are the main sources of electricity. Therefore, the operation of air conditioning and heating, and electricity for lighting (a year-round university needs a stable and continuous supply of power system) are two important influencing factors (Table 6).

Table 6. Energy Consumption Analysis of Different Building Types in the Basic Model

Stats	Teaching building	Office building(12/7)	Dormitory	Dining & Entertainment (special)
Total site energy	6658.84GJ	4948.18GJ	5801.73GJ	8416.64GJ
Total source energy	14840.70GJ	11093.80GJ	12343.84GJ	18181.79GJ
Site energy per unit area	1013.83MJ/m ²	753.38MJ/m ²	883.33MJ/m ²	1281.46MJ/m ²
Source energy per unit area	2259.55MJ/m ²	1689.07MJ/m ²	1879.39MJ/m ²	2768.24MJ/m ²
Total annual energy consumption for refrigeration	1107.76GJ	2283.93GJ	2968.93GJ	4305.23GJ
Total annual energy consumption for heating	3193.38GJ	549.00GJ	533.61GJ	1380.26GJ
Total annual energy consumption of lighting	1047.87GJ	919.67GJ	919.67GJ	1268.03GJ
Total annual energy consumption of the equipment	1309.84GJ	1195.58GJ	1379.51GJ	1463.12GJ
Personnel immediate sensible heat	85650.02W	13334.73W	34362.58W	132013.86W
Personnel delay sensible heating	33643.88W	5215.60W	13441.79W	51978.84W
Latent heat of personnel	97885.74W	15239.70W	39271.52W	188591.23W
Radiant heat	84836.84W	70697.36W	70697.36W	91906.57W
Sensible heat of equipment	106046.05W	91906.57W	106046.05W	106046.05W
Exterior wall delay sensible heat	26827.16W	27047.34W	26829.29W	26297.52W

Through the analysis, it can be concluded that the building type has a great impact on energy consumption. The reasons mainly include the differences in the frequency of use, the time of use, and

the demand for heating and cooling. Among them, catering and entertainment are similar to shopping malls (some schools can consider buildings with similar functions). Due to certain particularity, energy consumption is concentrated in a specific period of time (lunch and dinner or weekend leisure and entertainment time), so the total energy consumption is large. Dormitories and office buildings (12/7 type: 12 hours a day /7 days a week) are only partially used, so the total energy consumption is lower. Therefore, according to the characteristics and uses of building types, combined with efficient green building technology, reasonable setting of energy-saving equipment, the development of energy saving schemes suitable for each building type, in order to reduce building energy consumption.

4.3. Enclosure structure materials

Since the heat transfer loss of the building envelope accounts for about 70% to 80% of the building heat loss, it is a top priority to upgrade the envelope structure and reduce energy consumption [8-9]. This simulation investigates the effects of green glass technology (high visible light transmittance and thermal radiation reflectance), material bulk density (reflected in the efficiency of heat transfer into the room), and reflective insulation coating effect (high refractive coefficient based on spectral color scheme) (Table 7).

Table 7. Energy Consumption Analysis of Different Building Types in the Basic Model

Stats	Basic model	Low-e glass	Heavy exterior wall	Dark roof
Total site energy	6658.84GJ	6340.36GJ	6803.21GJ	6652.21GJ
Total source energy	14840.70GJ	14521.56GJ	15349.46GJ	14866.08GJ
Site energy per unit area	1013.83MJ/m ²	965.34MJ/m ²	1035.81MJ/m ²	1012.82MJ/m ²
Source energy per unit area	2259.55MJ/m ²	2210.96MJ/m ²	2337.01MJ/m ²	2263.41MJ/m ²
Total annual energy consumption for refrigeration	1107.76GJ	1114.43GJ	1247.09GJ	1120.42GJ
Total annual energy consumption for heating	3193.38GJ	2868.22GJ	3198.41GJ	3174.09GJ
Cooling peak relative humidity	51.70%	46.92%	50.82%	50.88%
Peak relative humidity of heating	26.04%	25.93%	26.55%	26.10%
Cooling peak wall delay sensible heat	29402.37W	28081.86W	29140.05W	26896.77W
Peak wall delay sensible heating	48468.8W	44055.4W	75912.9W	43922.4W

According to the analysis, low-e glass, as a new energy-saving green technology, can further improve the thermal insulation effect and effectively reduce the transmission of ultraviolet light, which has the most obvious effect on reducing energy consumption [10]. The heavy wall with large material capacity has a very obvious effect of better heat insulation due to the largest proportion of area; Because the roof accounts for a relatively small part of the building surface area, the result is not very obvious difference, but according to the basic law of material reflectivity, the reflectivity of the dark surface is lower than that of the light color, that is, the heat absorption capacity of the dark color is better, so it can be selected according to the specific needs. At the same time, the conclusion shows

that the thermal insulation effect of conventional thermal insulation materials is limited, so appropriate materials and technologies should be selected according to climatic conditions, such as high-efficiency thermal insulation materials and double-layer or multi-layer glass insulation materials, and consider high-efficiency thermal insulation or low-radiation materials [11] to reduce heat loss and achieve the best energy saving effect. Combined with the development trend of energy efficiency in today's buildings, it can also be transformed into green roofs and walls, by planting plants suitable for cold areas, not only can provide additional insulation, effectively reduce the heat load of the building, but also enhance the ecological value of the building. In addition, it is necessary to pay attention to system optimization analysis, that is, to integrate cost-effectiveness and environmental performance.

In summary, the results of the three simulation and comparison experiments show that selecting the right factors and conditions for energy consumption can optimize the design of the existing green building campus, effectively improve the energy efficiency of the building and reduce energy consumption, so as to achieve green sustainable development

5. Conclusion

By taking Xi'an as an example, this paper studies the green building strategies of university campuses under cold climate conditions, simulates the green building strategies under different orientations, building types and envelope materials, and demonstrates the significant improvement of building energy consumption by optimized design.

The simulation model and case analysis show that in the design of green campus in cold areas, different orientation, envelope structure, building materials and other architectural attributes should be selected according to various external and own conditions, and reasonable planning should be made according to local conditions. Moreover, the optimal scheme should be obtained by combining comparative experiment simulation or analyzing and comparing the differences, so as to obtain optimization strategy research. In order to reduce the energy consumption in later use, ensure the reduction of building heating and cooling demand, thereby reducing building energy consumption, realize the design of green buildings, and provide strategic support for the construction of green buildings in colleges and universities.

The study is an attempt in the field of campus green construction, which can not only help reduce energy consumption and carbon emissions of buildings, but also provide practical reference for green building practices in cold areas. However, due to the excessive influence factors, comprehensive simulation can not be achieved, and the selection of regions has certain limitations, so it is necessary to continue to deepen to obtain the universal law. At the same time, there are still some challenges in the practice of green buildings, such as cost problems, technical problems, etc. Therefore, in future research, it is necessary to further explore how to overcome these challenges and continue to promote the sustainable development of green buildings on university campuses in cold regions. However, overall, the application of green buildings in the university campus development prospects are still very broad, to promote the application of green buildings in more fields, to contribute to global environmental protection and sustainable development, innovation and popularization is just around the corner. At the same time, this study can provide some practical reference for reducing building energy consumption and open up ideas for energy conservation development. On a global scale, it can mitigate global climate change, promote low-carbon building practices to a wider range, and call on the entire public to carry out green actions, but also promote the development of the entire green building industry, carry out technological innovation and breakthroughs, and encourage national policies and market drivers to play a more effective role.

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