UDC 621.311

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EXPLORATION AND ANALYSIS OF ENERGY SAVING RENOVATION OF OLD RESIDENTIAL PROJECTS IN NORTHWEST CHINA

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Анотація

Останніми роками економіка Китаю швидко розвивалася. З розвитком суспільства та процесом урбанізації споживання будівель зростає з кожним роком. У Китаї просування та впровадження енергоефективності будівель почалося відносно пізно, а споживання енергії будівель зростає з року в рік. Розвиток енергоефективності будівель та енергозбереження та зменшення викидів є неминучим вибором для сприяння сталому розвитку. У міських житлових будівлях північно-західного регіону на будівлі з високим споживанням енергії припадає велика частка, а на старі житлові будівлі припадає понад 30%.Старі житлові райони мають величезний потенціал для економії енергії та зменшення викидів. На цій основі в цій статті як об'єкт дослідження розглянуто енергоефективність ремонту структури обслуговування будівель за допомогою порівняння даних та методів моделювання енергоспоживання будівлі в Північно-Західному регіоні, щоб запропонувати енергоефективні дослідницькі ідеї для відновлення старих житлових будівель в жорстких холодних районах.

Ключові слова ：Північно-західні холодні райони; енергоекономний ремонт будинку; розрахунок споживання енергії; моделювання.

Abstract

In recent years, China's economy has developed rapidly. With the development of society and the process of urbanization, building consumption has increased year by year. In my country, the promotion and implementation of building energy conservation started late, and building energy consumption has increased year by year. Developing building energy conservation and vigorously promoting energy conservation and emission reduction are inevitable choices to promote sustainable development. Among urban residences in the northwest region, high-energy-consuming buildings account for a large proportion, and old residences account for more than 30%. Old residential areas have huge potential for energy conservation and emission reduction. Based on this problem, this paper takes an energy-saving residential project in Northwest China as the research object. This study aims to examine the energy efficiency of building maintenance and structural renovation through data comparison and building energy consumption simulation methods, and aims to provide research ideas for the energy-saving renovation of old houses in severe cold areas.

Keywords ：Northwest Severe Cold Region; Residential energy-saving renovation; Energy consumption calculation;

Simulation.

Project Overview

This energy-efficient residential building is located in Jiayuguan City, Gansu Province, China. It was built in 2000 and has 7 floors above ground. The height is 20.68 meters, facing north and south. 1 elevator, 2 households, each with an area of 80 m^2, a total of 4 independent units. The building covers an area of 4480$m^2$and was originally a brick concrete structure with a structural layer made of 240mm porous bricks. The exterior walls have no insulation layer;According to professional instrument identification, the heat transfer coefficient of the exterior wall of the building is1.625W/(m·K). The doors and windows are deformed, with gaps between them and the walls, and obvious thermal bridging phenomenon. The heat transfer coefficient of doors and windows is 6.30W/(m·K), and the roof insulation is basically ineffective, resulting in waterproof damage. After instrument identification and calculation, the heat transfer coefficient of the roof is 3.362W/(m·K).

Building maintenance structures include building walls, building roofs, doors and windows, which are in direct contact with the external environment and are a key factor in reducing building energy consumption. A good building maintenance structure can effectively reduce heat transfer and reduce heating and cooling requirements, especially for severe cold areas. It can reduce indoor heat loss in winter and reduce heating energy consumption, but improve insulation performance; by adopting new technologies and new materials for building maintenance components, implementing long-term energy-saving management and maintenance, we can maximize structural functions, improve insulation performance, and reduce building energy consumption.

Table 1— Thermal insulation material parameter table

Serial Number	Original wall structure	Thickness（mm）	Thermal conductivity W/(m·K)	Thermal storage coefficient
1	Cement..mortar plastering	20	0.92	11.08
2	XPS	80	0.031	0.32
3	Porous brick wall	240	0.57	7.51
4	Internal plastering	20	0.94	11.09

Table 2 — Parameters of doors and windows materials

Door and window scheme	Thickness（mm）	Densit（kg/m³）	Transmittance	Hading Coefficient
Single glazed	6	2.5	90	0.90
Insulatig glass	24	No	56	0.49
Alumiumalloy	1.4	2.7	No	No
Broken bridge aluminum	1.8	2.7	No	No

Determine the thermal performance parameters of exterior walls, doors and windows, and roofs. Including thermal resistance, heat transfer coefficient, and thermal inertia.

Before the renovation, the heat transfer coefficient of the wall was 1.628 W/(m·K). After the renovation, the heat transfer coefficient is 0.288 W/(m·K), which has been significantly reduced and meets the energy-saving standard of ≤0.45 W/(m·K), in severe cold C zone. It can be seen that the insulation performance of the wall has been significantly improved.

After the renovation, the heat transfer coefficient of doors and windows decreased from 6.29W/(m·K)to1.49W/(m·K). After the roof renovation, the heat transfer coefficient decreased from 3.636W/(m·K)to0.37W/(m·K). After energy-saving renovation work, the overall insulation performance of the building has been improved, energy consumption has been reduced, and the energy-saving standard requirement of heat transfer coefficient C≤ 0.45 W/(m·K)has been achieved.

Now, select one 80m2 housing unit in this renovation project for modeling and energy consumption simulation analysis to verify the quality and effectiveness of energy-saving renovation.

Arrangements are as follows. Rhino is used for building geometry modeling, Grasshopper is used for parametric modeling, and Ladybug and Honeybee plug-ins are used in the construction simulation process project. Ladybug is responsible for weather data and solar radiation analysis, Honeybee is responsible for connecting energy consumption simulation engines, and EnergyPlus is responsible for building physical computing and energy consumption engines.

Use Rhino to create the original form of the building. Define space usage, divide functional blocks, and set different construction layers.

The content includes the thermal performance of components such as walls, roofs, floors, doors and windows , and the usage mode is the annual occupation schedule, equipment load, and lighting demand. The mechanical system selects the HVAC system type and efficiency parameters, and ventilation and permeability include natural ventilation strategies and permeability settings.

Find the corresponding construction material in HB Search Materials and create the material.

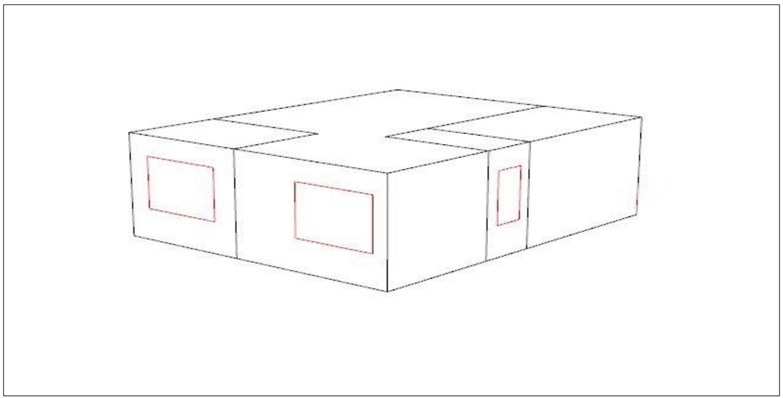

Figure 1— Rhino software modeling

Set up the model, load blocks and windows Import weather data: First import EPW format meteorological data, and then import Gansu Jiayuguan EPW weather file.

Use Honeybee to connect EnergyPlus and run an annual energy consumption simulation.The output data includes various energy consumption items for each month.

Use GH to draw a monthly energy consumption stack bar chart and output the annual total EUI (kWh/m^2). By comparing the images and data of “before renovation vs after renovation”, the energy-saving effect can be obtained.

Load displays the monthly "heat input and output sources" of the building, that is, the heat demand of the building. Before the renovation, the building had a capacity of 519.846591 kWh/m^2 , and after the renovation, it has a capacity of 379.599452 kWh/m^2 .

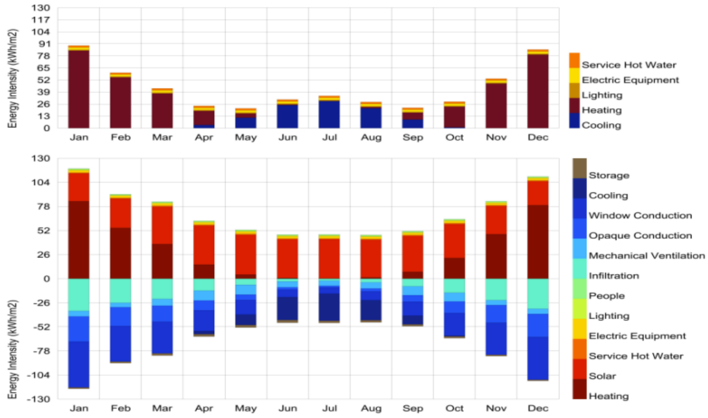

Figure 2 — Load diagram and load balance diagram before renovation

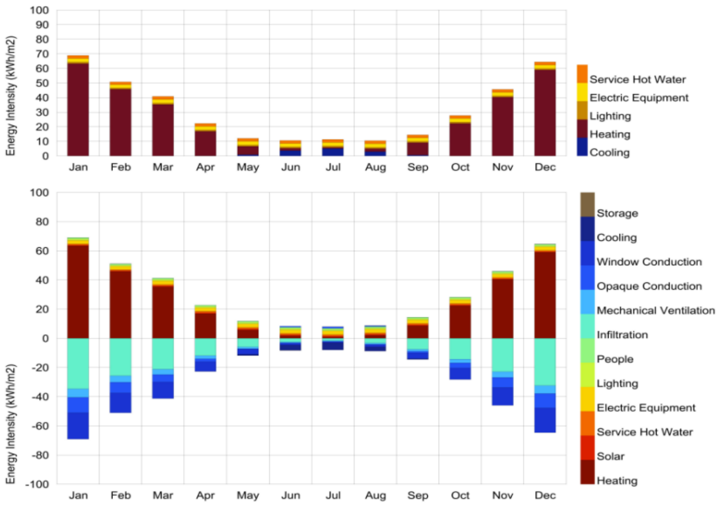

Figure 3 — Load diagram and load balance diagram after renovation

EUI results. Before the renovation, it was 456.782kWh/m^2, and after the renovation, it was 296.364kWh/m^2.

The overall annual energy consumption density of the building has decreased by 160.418 kWh/m^2,a reduction of approximately35.1%, which is a significant energy-saving achievement.

From the comparison of the energy consumption composition of the two images , it can be seen that the energy-saving effect after the renovation is significant.

Before the renovation : The energy consumption during peak months (such as January and December) was close to 90kWh/m^2. Through analysis, heating and cooling demand dominated the energy consumption.

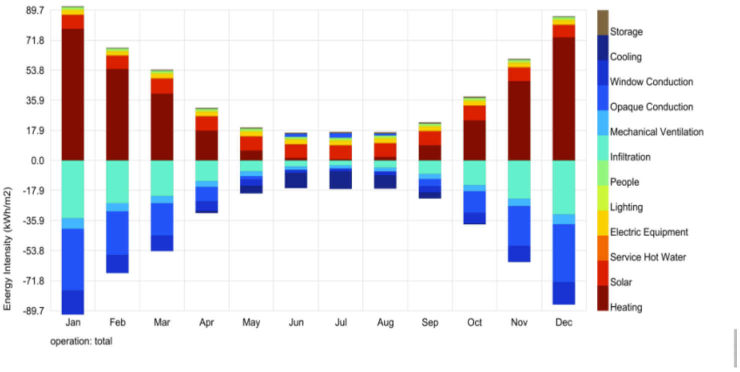

Figure 4 — Energy balance diagram before renovation

After the renovation, the peak energy consumption in the same month significantly decreased to about 56 kWh/m^2. The overall average annual energy consumption level has decreased, especially in the winter and summer seasons.

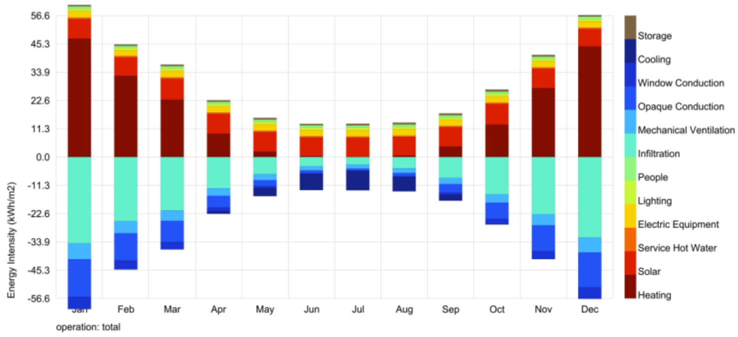

Figure 5 — Modified energy balance diagram

Conclusion. The renovation has reduced the overall energy consumption intensity of the building and improved energy efficiency.

Heating energy consumption. Before the renovation, the heating load in winter was extremely high. After the renovation, there was a significant decrease, especially in December. Cooling energy consumption. After the renovation, the cooling load in summer also slightly decreased, and the load curve became smoother.

Conclusion. It indicates that the optimization of building envelope structure has improved the energy-saving ability in winter and summer.

Compared before and after the renovation, the heat loss of Window Conduct and Opaque Conduct has significantly decreased. Indicating the replacement of high-performance doors, windows, and insulation materials.

Conclusion.The thermal insulation performance of the enclosure structure is enhanced, effectively reducing the loss of cold and hot energy.

Infiltration and Mechanical Ventilation:After the renovation, there was a slight decrease, indicating an improvement in air tightness and an increase in energy efficiency of the ventilation system.

Lighting&Equipment:Almost consistent, indicating that the renovation mainly focuses on the building envelope structure and thermal environment system.

Compared before and after the renovation, the solar energy heating remains relatively consistent. Speculation.Due to the unchanged orientation or external shading of the building, it is estimated that the negative impact may have been reduced through Low-E glass.

Through modeling and software simulation, it is known that the energy consumption and load of the project have decreased after the renovation, which verifies that the quality of the skill renovation of the project is qualified.

Energy saving renovation of old residential areas is an important project that combines economic, environmental, and social benefits. Energy saving renovation is not only a technological upgrade, but also a key measure to promote sustainable development, social equity, and urban resilience. In the short term, it improves people's livelihoods; In the long run, it provides a practical path for low-carbon cities and inclusive growth, which has profound significance.

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