Research on Energy-Saving Design Strategy of Traditional Residential Buildings in Hot Summer and Cold Winter Area

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ABSTRACT
With problems such as energy shortage and environmental pollution intensify, green protection and ecological balance are becoming increasingly concerned, and a green revolution is spreading around the world. Traditional dwellings in the hot-summer and cold-winter area in China have created a pleasant living environment with their unique ecological wisdom, common building materials and green pure energy-saving technology. Combining regional climatic characteristics, the article analyses the common architectural features of traditional dwellings in this area from the perspective of energy saving, and explores the energy-saving design strategies. Starting with the three aspects of the building's body shape, plan form and envelope structure, the project provides some suggestions about the use of in-site construction materials, the organization of natural ventilation and the use of shading measures, which are condutive to the energy-saving design of modern rural architecture and better integrate these ecological design concepts in traditional dwellings.

Keywords: *Hot summer and cold winter area; Traditional dwellings; Building energy efficiency; Modern regeneration*

1. INTRODUCTION

In modern society, urbanisation continues to accelerate. Environmental pollution and energy shortages have become a thorny problem in the economic and social development of the world in the 21st century. In order to respond to the call for energy saving and emission reduction, China has formulated a series of building energy saving standards, indicating the direction for the optimisation of energy saving in building design. China is a vast country with a rich history and a wide range of climatic regions. Traditional dwellings with regional characteristics is a unique local treasure and a microcosm of human civilisation. Traditional dwellings are the result of human wisdom, and their design elements, such as combining nature with climate, adapting to local conditions and using local materials, are the main elements that are used today to create a new living environment.Based on the climatic characteristics of hot-summer and cold-winter area, this paper studies the architecture characteristics of traditional dwellings from the perspective of green energy conservation, in an attempt to uncover the ecological design concepts, analyse and summarise their energy-saving design strategies.We hope to improve the residential comfort of rural dwellings and promote the rational use of energy-saving design in rural areas by combining ecological design concepts with modern rural residential building design .

2. CLIMATIC CHARACTERISTICS OF HOT-SUMMER AND COLD-WINTER AREA

According to China's current Thermal Design Code for Civil Buildings (GB 50176-2016): the coldest monthly average temperature in hot-summer and cold-winter area is 0~10℃, the hottest monthly average temperature is 25~30℃; days with the average daily temperature ≤5℃ are 0~90d,and the average daily temperature ≥25℃ are 40~110d.

China's hot-summer and cold-winter area is mainly concentrated in the middle and lower reaches of the

Yangtze River and around.The area is roughly south of the Longhai Line, north of the Nanling and east of the Sichuan Basin, including Shanghai and Chongqing, Hubei Province, Hunan Province, Jiangxi Province, Anhui Province, Zhejiang Provinceand other 16 provinces and cities.

The climate in this region is characterised by hot and muggy summers, cold and wet winters, so buildings in this region need to take into account both summer heat prevention and winter heat preservation in order to reduce energy consumption for heating and cooling. The annual precipitation is high, and the wind speed in the hot summer months is small, while the wind speed in winter is large, so the building should pay attention to comprehensive consideration of drainage and ventilation design; sunshine is low; the late spring and early summer is the rainy period in the middle and lower reaches of the Yangtze River[1].

3.ARCHITECTURE FEATURES OF TRADITIONAL DWELLINGS IN HOT-SUMMER AND COLD-WINTER AREA

Due to the vast area of the hot-summer and cold-winter area, Hanzhong in the north, Chongqing in the centre and Guilin in the south were selected as typical examples, and then to summarise the general characteristics of traditional dwellings in the hot-summer and cold-winter area, so as to propose corresponding energy-saving design strategies.

3.1. Traditional Dwellings in Hanzhong

Most of the traditional houses in Hanzhong were built along the road and in accordance with the mountainous terrain, with north-south orientation. The building plan is simple, usually in the shape of "一" or "L" (Figure 1 typical house plan), and the courtyards are outward-looking.Most of the doors and windows were made of wood.And most of the walls were made of rammed earth, which is locally sourced, cheap and less difficult to construct[2].

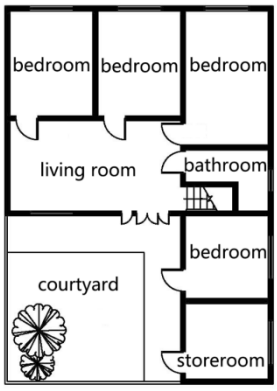

Figure 1 Typical house plan

3.2. Traditional Dwellings in Chongqing

Most of the rural buildings in Chongqing are built on hills, facing south.They are mostly bungalows, with partial sloping roofs, both of which are combined and set at different heights. The layout is mostly "一" or "丁" shaped (Figure 2 schematic plan layout).The traditional Bayu dwellings are often decorated with tiled roofs, carved wooden windows and white grey walls. Most of the doors used in rural residential buildings in Chongqing are wooden doors.

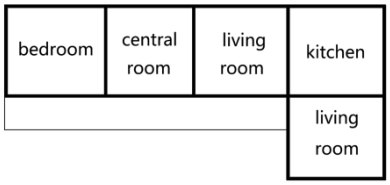

Figure 2 Schematic plan layout

3.3. Traditional Dwellings in Guilin

Guilin's rural dwellings are southern patio-style dwellings, with small patio sizes, shallow depths and long(Figure 3 Layout form).Under the prevailing summer wind direction, the interior of the dwelling is mainly ventilated by wind pressure, with the air flowing from the patio to the outdoor space above the patio (Figure 4 Air ventilation diagram)[3].The walls are mainly made of green bricks.And the walls are mostly fiush gable walls.

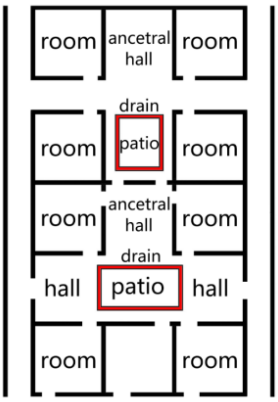

Figure 3 Layout form

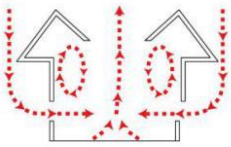

Figure 4 Air ventilation diagram

3.4. Common Features of Traditional Dwellings on Hot-summer and Cold-winter Area

As from the characteristics of traditional dwellings in the three typical area mentioned above, traditional dwellings in hot-summer and cold-winter area.

3.4.1. Building Orientation

It is common to adopt the traditional feng shui pattern of sitting in the north, backing the mountains and facing the water, for which the mountains can be used to block the cold winds from the north in winter, and the water can be used to cool the monsoon from the south in summer, while also fully absorbing the south-facing sunlight to warm the interior in winter[4].

3.4.2. The Roofs

The sloping roofs of the buildings not only help to protect the building from rain, but also allow the space beneath the sloping roof to be used as an air insulation layer to reduce the temperature of the room. The roof extends over the eaves to reduce direct sunlight into the interior and to protect against rain.

3.4.3. Building Materials

Most of the traditional dwellings are made of timber frame, and the walls are made of masonry, which is only used for enclosure and division.Stone is used for both the building and the courtyard paving.

3.4.4. The Patios

The buildings are mostly built with patios and gables to give full play to the role of ventilation, light and drainage[5].

4. ENERGY EFFICIENT DESIGN OF TRADITIONAL DWELLINGS IN HOT-SUMMER AND COLD-WINTER AREA

4.1. Rational Building Shape and Plan Form

The shape and plan of buildings have a great influence on the quality of the insulation.In the current energy efficiency design standards for buildings, the building's shape factor is an important parameter in controlling the building's heating energy consumption. From the point of energy saving design, the smaller the area of the external envelope,the smaller the heat consumption of the indoor thermal environment.In order to reduce the energy consumption of a building, the shape factor should be kept at a low level.The plan of rural residential buildings in hot summer and cold winter areas is relatively homogeneous, mostly in the shape of "一" or "L", and in some areas the buildings adopt an enclosed layout.The two buildings with a "一" (large width) and "L" (large depth) plan have a small shape factor, less concave and convex surfaces, which is conducive to energy conservation.Buildings with an enclosed layout have a large exterior area and shallow depths, and consume more heat and cooling (Figure 5 Shape contrast). Therefore, a reasonable control of the building shape factor should increase the depth or width of the building to reduce the exterior area and reduce the energy consumption of the building[6].

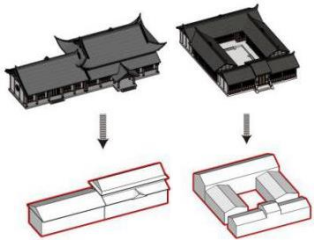

Figure 5 Shape contrast

4.2. Energy Efficient Design of the Building Envelope

4.2.1. External walls and floors

Most of the rural residential buildings in the hot summer and cold winter areas are built with wooden frames(Figure 6 Post and lintel construction,column and tie construction), using rammed earth walls, which are made from local materials, largely reducing the consumption of energy in the process of material transportation, etc.At the same time, these building materials have certain heat insulation and thermal insulation properties.And stone is often used for building floors and courtyard paving courtyard in Hanzhong), with its high strength, durability, ease of extraction, and purely physical process[7].

Figure 6 Post and lintel construction,column and tie construction

4.2.2. Doors and windows

In order to effectively control the heat consumption of buildings, the area of external windows should be strictly controlled in the energy-saving design of buildings, and the indicator of this is the window-wall area ratio (Table 1 Limits of window-to-wall ratio for residential buildings in hot-summer and cold-winter area).

Table 1. Limits of window-to-wall ratio for residential building in hot-summer and cold-winter area

Oritation	Window to wall ratio
North	0.40
East,West	0.35
South	0.45
Every houses allows one room	0.60

The abundance of forestry and rainfall in the hot summer and cold winter regions made wood a natural material for building.In rural residential buildings in this region, the vast majority of window frames and doors are made of wood. The thermal insulation properties of wood are relatively good.

4.2.3. Patio

The patio of rural residential buildings in hot summer and cold winter areas has a long and narrow shape. It is open to the sky and grounded. In summer, the density of cold air less than hot air. When the two meet, the hot air will rise and the cold air will naturally fall, naturally resulting in heat exchange and ventilation. Due to the specific angle of the eaves, the patio prevents direct sunlight from entering the room in summer (Figure 7 Diagram of patio ventilation).

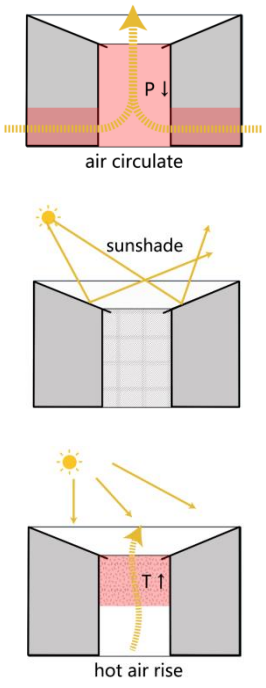

Figure 7 Diagram of patio ventilation

4.2.4. Roof

Traditional dwellings in hot-summer and cold-winter area often adopt sloping roofs, reflecting its structural measures to adapt to local climatic characteristics. The sloping roofs are insulated by the flow of air through the ventilation interlayer, which is constantly exchanged with the outdoor air and thus carries away the water vapour that seeps in from the interior. The eaves of the roof extend to facilitate drainage and shading in summer (Figure 8 interlayer for ventilation of terrace roof and pitched roof).

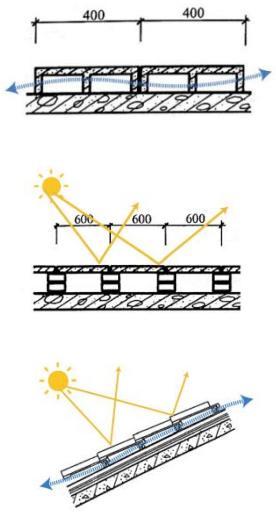

Figure 8 Interlayer for ventilation of terrace roof and pitched roof

5.MODERN “REGENERATION” OF ENERGY-EFFICIENT DESIGN OF TRADITIONAL DWELLINGSIN HOT-SUMMER AND COLD WINTER AREA

5.1. Use of In-site Construction Materials

In the actual construction process, most of the local characteristics of materials are used, which can reduce the energy loss in the process of material transportation and processing, reflecting the ecological idea of harmony between man and nature.In the hot-summer and cold-winter regions of China, where forest resources are abundant, timber and bamboo are often used as the main load-bearing structures.In modern rural residential architecture, traditional building materials can be used rationally, maintaining their original characteristics, strengthening the communication and integration of architecture and the natural environment.

5.2. Organising Natural Ventilation

5.2.1. Wind direction guidance by means of components

The building envelope is equipped with adjustable angle components such as window sashes and wind deflectors, which can be adjusted to guide the wind direction when the prevailing wind direction changes[10].

5.2.2. Plan layout to produce wind field

Reasonable control of building depth, so that the wind in the indoor easy circulation. The efficiency of natural ventilation is improved.

5.2.3. Roof ventilation and heat insulation

The installation of an overhead ventilation interlayer on the roof.The outstretched eaves can directly block the radiation from the sun,and the hot air can be taken away from the ventilation interlayer.

5.3. Use of Shading Measures

In modern rural residential buildings, the gables of traditional dwellings can be used to block some of the direct solar radiation from the interior. The roofs often have eaves that allow for drainage and shade. At the same time, the patio in traditional dwellings also serves as a combination of light, ventilation and drainage. If the patio is applied to modern rural residential buildings, it can also enrich the functions of the living space.

6. CONCLUSION

Residential architecture is the symbol of home, but also the root of Chinese cultural inheritance. Traditional residence is the fruits of labour in the long-term practice of coping with natural constrains, under the development of social productive forces, among which contains the ancients numerous experience.The experience includes the philosophy of the residence designand the connotation of "nature and humanity", which shows the harmony of nature and human being's overall view of nature.It also includes many concrete and detailed construction measures, from the selection of building materials for local use, to the application of energy-saving.Although the living mode of traditional residential houses can no longer adapt to the pace of modern social development, the ecological strategy of traditional residential buildings in hot summer and cold winter areas is particularly prominent. Although the living mode of traditional residential houses can no longer adapt to the pace of modern social development, the ecological strategy of traditional residential houses can still provide a good reference for modern architectural design. Combination of nature and climate, adaptive measures to local conditions and the situation, the practice of local materials and other design elements are the main content of today's people draw lessons from the traditional residential energy-saving technology to create a new living environment. These energy-saving design strategies have scientific rationality and climate adaptability, which can effectively improve the comfort of residential living, reduce building energy consumption, and make the overall design of the building communicate and integrate with the environment. We should pay attention to using the integration of human, architecture and nature in the traditional residential ecological thinking into the contemporary architectural design, construction concept, technology and materials, to create a modern, in line with the spirit of The Times ecological architecture.

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