

Original Paper

Applicability Analysis of Passive Building Energy Efficiency Technologies across Climate Zones

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Abstract

With the continuous development of China's economy, people's awareness of environmental protection is gradually increasing. Passive building energy conservation is achieved by utilizing the ecological building design principles of natural climate resources to endow buildings with energy-saving natural characteristics. Therefore, it is greener and environmentally friendly, more conducive to the sustainable development of human living environment, and has become a direction actively advocated for building energy conservation. Analyze the applicability of six passive building energy-saving technologies, including passive solar heating, natural ventilation, heat storage walls, induction + night ventilation, direct evaporative cooling, and indirect evaporative cooling, based on the climate characteristics of typical cities in various climate zones in China, and compare the applicability of various passive building energy-saving technologies in each climate zone.

Keywords

Passive technology, Building energy efficiency, Applicability analysis

1. Introduction

The contradiction between energy resource supply and economic and social development has become increasingly prominent. Building energy conservation plays a very important role in alleviating the contradiction between our country's energy resource supply and economic and social development and accelerating the development of circular economy. In developed countries, nearly 40% of energy consumption is in buildings. According to expert estimates, 2/3~3/4 of this can be saved through correct and ideal building measures. Passive building energy saving is an energy-saving technology that uses non-mechanical and electrical equipment intervention to reduce building energy consumption. Specifically, it refers to the reduction of energy consumption for heating, air conditioning, and ventilation in buildings through measures in architectural planning and design, such as rational orientation of buildings, installation of shading devices, thermal insulation and envelope enhancement technologies, and design of openings that facilitate natural ventilation. Therefore, passive building energy conservation is an important measure to implement sustainable development strategies, achieve national energy conservation planning goals, and reduce greenhouse gas emissions, and is in line with global development trends.

2. Research Methods

This study selected typical cities from different climatic regions as representatives (Beijing as the representative for severe cold and cold regions, Chongqing as the representative for hot summer and cold winter regions, Guangzhou as the representative for hot summer and warm winter regions, and Kunming as the representative for mild regions). Using Ecortect 5.0 to analyze the applicable time periods of passive building energy-saving technologies in typical cities, and conducting applicability analysis and comparison.

3. Results

3.1 Severe Cold and Cold Regions

Passive solar heating can be used for most of April and October in the Beijing area. In the region, most of the time from May, June, August, and September, as well as some parts of October, can achieve a comfortable indoor state while enhancing the heat storage capacity of the enclosure structure. For most of May and July, and for the majority of June, natural ventilation can provide a comfortable indoor environment. A small portion of August, July can utilize this passive regulation method to improve the indoor thermal and humidity environment of residential buildings. During most of May and September, as well as the majority of June, indoor comfort can be achieved through induction and nighttime ventilation. A small portion of October can utilize this passive regulation method to improve the indoor thermal and humidity environment of residential buildings. During most of June and most of May, July, August, and September, indirect evaporative cooling can achieve a comfortable indoor environment. Direct evaporative cooling is the process of directly reducing indoor temperature by evaporating water, while also increasing indoor humidity. From the graph, it can be seen that during some periods in May and September, this passive regulation method can achieve a comfortable indoor state. After effectively adopting the passive regulation method, active regulation should be used for heating throughout January, February, March, November, and December, as well as nearly half of April and October in the Beijing area. Active cooling should be used for most of July and August to improve the indoor hot and humid environment.

3.2 Hot Summer and Cold Winter Regions

In the Chongqing area, passive solar heating is not suitable due to the fact that most of the winter is cloudy and the amount of solar radiation is low. For the majority of March and November in the region, as well as half of April and October, enhancing the heat storage capacity of the enclosure structure can achieve a comfortable indoor state.

In most of May and September, as well as in most of June, natural ventilation can bring indoor comfort. In a small part of July and August, this passive adjustment method can be used to improve the indoor heat and humidity environment of residential buildings. In most of May and September, induced night ventilation can bring indoor comfort. In April A small portion of October can use this passive regulation method to improve the indoor thermal and humidity environment of residential buildings, while most of May and September can achieve a comfortable indoor state through indirect evaporative cooling. Due to the fact that direct evaporative cooling directly reduces indoor temperature through water evaporation, but also increases indoor humidity while cooling, this passive regulation method is not suitable for use in humid and hot areas such as Chongqing. After effectively adopting passive regulation methods, active regulation will be used for heating throughout January, February, November, and December, as well as nearly half of April and October in Chongqing. Active cooling should be

used for some parts of June to achieve comfortable indoor conditions, while active cooling should be used for most of July and August to improve the indoor thermal and humid environment. Due to the local meteorological characteristics being cold and humid in winter, with mainly rainy weather, the utilization of solar energy in winter is limited. So in winter, heating should be given special consideration in this region.

3.3 Areas with Hot Summers and Warm Winters

Passive solar heating can be used for some winter periods in January and December in Guangzhou. In the region, most of the time in October and November, as well as some time in December, can achieve a comfortable indoor state by enhancing the heat storage capacity of the enclosure structure. For most of April, May, September, and October, this area can achieve comfortable indoor conditions with natural ventilation. In June, July, and August, this passive regulation method can be used to improve the indoor heat and humidity environment of residential buildings. In most of October, indoor comfort can be achieved through induction + night ventilation and indirect evaporative cooling. After the effective use of passive regulation methods, active regulation should be used for heating throughout January and February, as well as for some parts of December in the Guangzhou area. Active cooling should be used for some parts of May and September to achieve comfort in the room. Active cooling should be used for most of June, July, and August to improve the indoor hot and humid environment.

3.4 Mild Regions

Passive solar heating can be used for some winter months in Kunming, including February, March, April, and November. Most of the time in January, February, and November in the region, as well as some time in March and April, can achieve a comfortable indoor state while enhancing the heat storage capacity of the enclosure structure. For most of March and April, as well as some parts of June, July, and August, this area can achieve a comfortable indoor environment with natural ventilation. Except for the majority of the time in January, February, November, and December, the rest of the year can achieve a comfortable indoor state through induction, night ventilation, and indirect evaporative cooling. The Kunming area belongs to a mild region, and there is not much need to adopt heat and humidity regulation. After effectively adopting passive regulation methods, the Kunming area will adopt active regulation for heating throughout December, as well as most of January, February, and November.

4. Conclusion

Based on the analysis of the above climate zones, it can be seen that the passive technologies suitable for use in representative cities of different climate zones have similar characteristics. Severe and cold regions have advantages in utilizing passive solar energy in winter compared to other regions, while natural ventilation and induced + night ventilation are more widely applicable in many areas. The use of direct evaporative cooling technology is not as effective in areas with hot summer and cold winter, as well as in areas with hot summer and warm winter. Mild regions have been in the comfort zone for a long time, so there are more types of technologies to choose from.

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