Chapter 2
Simulating Passive Design Strategies of Rural Residential Buildings in Severe Cold Regions of Northeast China

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ABSTRACT

With a strong dependency on regions and climate, passive design is the most economically effective strategy to reduce energy consumption. Using Climate Consultant 5.5 software, data analysis is conducted to analyze 16 cities in Northeast China. The independent and integrated effectiveness of nine kinds of passive design strategy are studied like sun shading of windows, high thermal mass, high thermal mass night flushed, direct evaporative cooling, two-stage evaporative cooling, natural ventilation cooling, passive solar direct gain low mass, passive solar direct gain high mass, wind protection of outdoor spaces. The results show that passive solar heat gains are the most important passive design strategy, whether in the heating or non-heating season, with an average contribution rate of 14.64% and 28.38%, respectively. This study provides suggestions on passive design in severe cold regions in Northeast China. The effectiveness-evaluation tables proposed can be referred to by architects in their passive designs.

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INTRODUCTION

The “Twelfth Five-year” Building Energy Saving Special Planning program of The Housing and Urban-rural Development of China set the goal to save 116 million tons of standard coal by the end of “12th five-year” through building energy conservation. According to the data of second national agricultural census data of the three northeast province, there are 14.658 million rural households and 1.17 billion square meters of building area, and the trend is rising. The main source of energy consumption in severe cold regions is the heating in buildings. Most rural residential buildings are self-built without the use of scientific design and construction methods and as such they consume 2-2.5 times more than those in the developed countries located in the same latitude (Jiang et al. 2009). This means there is a great potential for energy saving if the buildings, as mentioned, are designed and constructed to a new performance standard. With the improvement of rural residents’ living standards and the increase in commodity energy use, building energy consumption is rising year by year. The surveyed annual household income of rural residents in the severe cold regions is about 3200 dollars and by current world economic standard is comparatively low. It puts pressure on the rural residents in terms of the high energy costs.

Passive design concerns the planning, designing and environment configuration construction of buildings to improve and create a comfortable indoor environment that conforms to the natural principles of the sun, wind, temperature and humidity, in order to reduce the consumption of conventional energy (Mao, 2006). Scholars have carried out extensive research of passive design. Lam et al. (2006) used the bioclimatic method to study passive design strategies in China’s five climate zones. The paper identified nine passive design strategy zones and proposed design strategies for both summer and winter. Gong et al. (2012) studied the interactive effects between passive design parameters in different Chinese areas and put forward the optimization strategies, and summarized seven passive design zones in a map and the neighbor cities can use the same optimal combinations. Morrissey et al. (2011) studied passive solar heat gain for residential buildings and concluded that passive solar design should be considered in the design phase. Results showed that higher building energy efficiency standards are easier to apply to smaller dwellings, and costs are lower. Qiu and Liu (2011) researched passive solar design for rural residential buildings in the Northeast region of China, expecting to reduce the construction cost of farmhouses as well as reduce building energy consumption.

However, the studies mentioned have not taken the difference in effect into consideration between heating season and non-heating season. In this study, the whole year will be divided into the heating season and non-heating season, and passive design will be studied from the point of effectiveness of 9 kinds of passive design
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