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Field Research on The Summer Thermal Environment of Traditional Folk Tibetan-style Houses in Northwest Sichuan Plateau

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Abstract

The majority of traditional folk Tibetan-style houses, located in the Northwest Sichuan Plateau, China, rely on firewood for keeping warm. However, this traditional way can't longer completely meet the requirements of thermal comfort, and also ruins the environment. Thereby, in order to reveal the actual situation of thermal environment and to explore optimal passive technologies, a field testing and simulation are carried out in a Barkam's traditional Tibetan-style house in summer. Research results suggest that: in summer, it's cool with the average indoor air temperature of 19.03 ℃ and the maximum outdoor air temperature difference of 24 ℃. Meanwhile, the local house's thermal environment is better than that of the whole area because of the effect of building micro-climate. Additionally, the stone house has good thermal performance and good thermal adaptability, but because it's spontaneously built by farmers, and it's also lack of design, there is only 19.9% of heat gains benefiting from direct solar, and the optimizing effects don't coincide with that of psychrometric chart. So it's better to rationally design based on life-cycle theory and simultaneously combine with optimal passive technologies for improving the summer thermal environment.

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Keywords: Tibetan-style houses; Summer thermal environment; Passive design strategies

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1. Introduction

The Northwest Sichuan Plateau is the second largest Tibetan-populated area after Tibet area [1], belonging to the cold climate zone. The limited studies of the area focus on settlement planning, village structure, architecture of religious culture, dress-up features, architectural morphology, the construction mode and etc. [2]. Stone pillbox, plank house, mud huts and tents are the four basic categories of houses continuing to play a role in the life of the provincialist [3]. Unfortunately, traditional heating ways, even though 63.03% of users are still using the stove to heat [4], cannot completely meet the requirements of thermal comfort and also ruin the environment. Thereby, some traditional houses are refurbished by using architecture technologies which worsen there thermal comfort and destroy their cultural value. And some are vacant and abandoned, while others are even completely replaced by the high energy-intensive modern buildings against geography and climate [5]. Thus, it's urgent to research how to create comfortable thermal environment and ensure the sustainable development in the refurbishment process simultaneously.

Nomenclature

T_i	the indoor air temperature
T_o	the outdoor air temperature
RH	the relative humidity
T_{is}	the inner surface temperature
T_{os}	the outer surface temperature
RH_i	the indoor relative humidity
RH_o	the outdoor relative humidity

Thermal environment of traditional houses have been conducted for many years, whether in abroad [6] or domestic [7], generally been divided into summer [8] and winter [9] thermal environment. This paper will mainly discuss the former. Some field testing are conducted to analyze the present situation. Such as shading is the most important element of the design characteristics of Chinese traditional residential buildings in Wannan, suggested by a field study [10]. As Tibetan-populated area in Sichuan, the majority of studies focus on the winter thermal environment [11], and a few focus on summer. Fortunately, in these minority studies, some measurements are put forward to improving the summer thermal environment of the Northwest Sichuan Plateau. For example, setting up additional sun room for intermittent use in the south is taken as a good heat-collector and climatic buffer of its inner room [12]; passive solar energy and thermal mass are thought to be the most suitable passive design strategies for local residence design, which comprehensive effective time ratio can be reached 21.3% and 20.8% respectively [4].

According to above analysis, as a study supplement, the research of summer thermal environment of a Barkam's house is conducted. Combined with the psychrometric chart, appropriate passive optimization techniques are proposed. So this research not only enriches the research contents of traditional Tibetan-style houses, but is also useful to improve the thermal environment and promote the sustainable development of the local houses.

2. Analysis on field testing of the typical traditional house

2.1. Description of the typical tradition house and the measured points

The typical traditional house is selected from Mosidu village, located in Barkam County, Aba Tibetan and Qiang Autonomous Prefecture, China. The typical house of stone timber structure is shown in Fig. 1(a). It's measured at 14.458m (L) ×12.444m (W) ×13.302m (H) and a total of four layers. The 1000mm or 620mm thick wedge shape outer walls of the house are constructed by using block stone with mud on both sides; the interior walls use 50mm thick board; the 530mm thick clay floor and 380mm thick flat clay roof use wood, grass as the structural layer. To prevent water erosion, the flat clay roof is covered with a steel plate, while the 20mm thick stone pitched roof is built over the 4th-floor. Its wooden box windows are constructed by using a 6mm thick ordinary single glass,

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