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Experimental Research on Thermal Performance Differences of Building Envelopes in Multiple Heating Operation Conditions

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Abstract

The thermal performance of building envelopes, including heat insulation performance and dynamic property in multiple heating operation conditions, was concentrated on this paper. The north wall of the experimental building has four kinds of envelope constructions, and thereby marked as the external insulation wall, internal insulation wall, intermediate insulation wall and solid brick wall, the lengths of which are all 650 mm in square. Results shown that the external insulation wall had the highest inner surface temperature and achieved the best indoor thermal comfort in the process of continuous heating, while the internal insulation wall had the fastest inner surface temperature change and obtained the best indoor thermal comfort during intermittent heating condition. Moreover, the closer to indoor low energy storage materials, the better thermal performance and energy efficiency of the envelope construction would achieve.

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Keywords: Building energy efficiency; Heating operation condition; Envelope construction; Heat insulation performance; Dynamic property

1. Introduction

On account of energy shortage and environmental degradation, researches on tactics of building energy efficiency have caused wide public concerns all over the world [1]. The heating operation condition and building envelope construction are two significant components to influence the building energy efficiency and indoor thermal comfort[2]. The design of energy efficiency on envelope constructions was initiated from the northern China for its

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climate characteristics and continuous heating requirements [3-4]. Therefore, many technologies (such as external insulation wall) were directly applied in southern China, but the energy efficiency of which were not good due to huge discrepancies of the above regions in heating conditions [5-6]. The heating conditions are affected by local economic development, living habits, the nature of work, outdoor climate and other factors.

In recent years, some studies have mentioned the energy efficiency potential of building envelope constructions in multiple heating operation conditions, and mainly focused on energy consumption analyses by software or by numerical simulations. Li [7] applied the power meter data-split method to analyse the energy consumption of air conditioning of 560 household, and results shown that there were obvious differences between the air conditioning demand and the actual usage of air conditioning. Vytchikov [8] studied energy consumption and heating time of the multilayer envelope construction during intermittent heating processes by applying an approximate analytical method, and results shown that energy consumption and the heating time would be reduced when insulated inside using extruded polystyrene foam. Badran [9] found that energy consumption was reduced when the system was intermittently operated for 14h per day compared with continuous operation in insulated buildings from the macroscopic point of view. Tsilingiris [10] found that the closer insulation layer was to the internal of the building, the more beneficial it was to improve the indoor environment and building energy efficiency during intermittent heating for the Athens climate. Barmpas [11] proposed a three-dimensional computational fluid dynamics method to numerical simulate the flow and heat transfer, by which to determine the thermal behavior of simplified building envelopes, and to account complicate effects of parameters referring to building material properties.

The thermal energy that derived from heating apparatus, is not merely used to heat indoor air but also consumed by envelope construction. The indoor temperature is constantly valuable during continuous heating process. Hence, the indoor thermal environment, comprising indoor air temperature and inner surface temperature of envelope construction, is in steady-state, while that during intermittent heating condition is in the dynamic process. Moreover, the types of envelope construction will influence dynamic property. This basic research on thermal performance differences of building envelopes in continuous versus intermittent heating, is still a blind spot at home and abroad. Therefore, a real building was constructed in Sichuan University, Chengdu, China, to research thermal performance differences of building envelopes in multiple heating operation conditions. The heat insulation performance was evaluated by heat transfer coefficient during continuous heating process. The inner surface temperature change was detected under the same indoor and outdoor environment condition, as it clearly defines dynamic property.

2. Experiment

2.1. Construction and material

The experimental building that located in Sichuan University was shown in Fig.1, containing two rooms that both were 3.5 m high, 3 m long and 2.2 m wide. The north wall of room 1 contained three kinds of insulation constructions and solid brick wall. The split type air conditioning was installed in the south wall of room 1, the model of which was known as KFR-35GW/HFJ+3. The interface between each wall structure pattern, made with polystyrene, was created to make each wall structure pattern form a one-dimensional heat transfer.