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Study on application of concrete sandwich insulation material in library building insulation

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Abstract: Energy shortage is the short slab that restricts the development of social economy, and the rational and effective use of energy is the principle of sustainable development. Building energy consumption accounts for about 30% of total social energy consumption, and this ratio has continued to rise, so the energy saving potential is great in the construction sector. In view of the building energy consumption problem, we produce green insulation building materials with the crop straw, and improve the construction of hot and humid environment. In this paper, we take concrete sandwich straw blocks in library building as the research object, through the experiment to test its winter heat consumption and summer power consumption indicators, carry out experimental study on thermal insulation performance, and explore the overall thermal and energy saving performance of concrete sandwich straw blocks in library building.

1. Introduction

According to statistics, China's per capita share of coal resources is 1/2 of the world average, and per capita oil occupancy is only 1/10 of the world average. However, the total consumption of coal resources accounts for more than 40% of the world total's, and oil consumption is also ranked in the world second. China's dependence on overseas energy is up to 50%. Energy shortage is the short slab that restricts the development of social economy, and the rational and effective use of energy is the principle of sustainable development. In the context of rapid economic development in China, the primary energy consumption has increased dramatically, while the building energy consumption accounts for around 30% of the social total energy consumption, and this proportion has a rising trend [1, 2]. Therefore, the energy saving potential of the construction industry is very big, which is of great significance to further accelerate the construction of a resource-saving and environment-friendly society and to ensure the energy security of our country.

Under the environment of building energy saving material, the concrete sandwich straw block as a new wall insulation materials, which is widely used in cold region and the hot summer and cold winter area, it meets the needs of energy-saving reform, and has broad market prospects[3]. A series of studies in this paper provide experimental basis for the extensive application of concrete sandwich stalks in buildings. The study of concrete sandwich stalks has great academic value, engineering significance and economic benefit.

2. The experimental procedure

2.1. Test equipment

The Laboratory has the equipment that the experiment requires; they are BES-C, SM1210B temperature and humidity data acquisition module, SLHT4 temperature and humidity sensors, heat sinks and so on.

1) Temperature and humidity acquisition module

SM1210B temperature and humidity data acquisition module supports 1-12 temperature and humidity sensors, and it can achieve low-cost temperature and humidity monitoring of the practical integration module.

This module can be used to: SMT industry temperature and humidity data monitoring; electronic equipment long temperature and humidity data monitoring; cold storage temperature and humidity monitoring; warehouse temperature and humidity monitoring; pharmaceutical GMP monitoring system; environmental temperature and humidity monitoring; telecommunications room temperature and humidity monitoring; and other various occasions that need to monitor the temperature and humidity.

Technical parameters and features: display temperature range: -40℃~123.8℃; sensor nominal temperature accuracy ± 0.5 ℃; display humidity range: 0-100RH; power consumption 2W; storage temperature -40 ℃ ~ 85 ℃.

2) The temperature and humidity sensor

The sensor consists of a capacitive polymer hygrometer and a temperature-sensitive element made of a gap-gap material, and on the same chip, it is seamlessly connected to the 14-bit A / D converter and the serial interface circuit. Therefore, the product has excellent quality, ultra-fast response, and anti-interference ability and so on. The temperature measurement accuracy is ± 0.4 ℃, and the humidity measurement accuracy is ± 3%.

3) BES-C portable microcomputer multi-channel data acquisition instrument

The instrument is mainly used for energy-saving building wall surface temperature, indoor and outdoor temperature, heat flux and other parameters of the field test. It integrates measurement, display, communication and other functions in one and has the characteristic of high precision measurement, full-featured, easy to use and so on. It is suitable for energy-saving building envelope thermal resistance, heat transfer coefficient of the field test, thermal testing of building materials and environmental monitoring and other occasions.

The technical parameters: Heat flow measurement channel: 16 road; range: 0 ~ ± 20mV; the measurement accuracy: ≤0.03mV; and the heat flow sensor use a plate heat flow meter. It is mainly used for wall heat flux measurement. The sampling period: 10 seconds to 24 hours (optional). Data storage capacity: 128,000 data can be stored.

2.2. Experimental program

This test is divided into two parts: winter test and summer test. In the concrete sandwich straw block building of library, we arrange two temperature and humidity collection points (1#, 2#) in the room. The distance between the collection point and the ground is about 70 cm, and the collection point not directly affected by the heat source. We arrange one temperature and humidity collection point (3#) in the outdoor, and this collection point is out of the sun. Therefore, we use the instrument to record the data of temperature and humidity collected by the three acquisition devices for 10 minutes.

In the winter experiment, we use the warm air blower to heat the library building of concrete sandwich straw block. In the summer experiment, we use the air conditioner to chill this building. Meanwhile, we use the ammeter to record the power consumption of the heater and air conditioner for seven days.

2.3. Experimental procedure

From February to March, the winter experiment is carried out in library building of concrete sandwich straw block. In the library, we use two rated power of 2500W heaters for winter heating. The first stage is constant power heating, and the second stage is constant temperature heating, set the temperature is 18 ℃. With the meter to collect heating power consumption during heating, and install the collection device of the temperature and humidity inside and outside, and then record the indoor and outdoor temperature and humidity changes during the test.

The summer experiment is carried out in August, in the library, use the air conditioning for the summer cooling of the house, and the cooling temperature is set at 26 degrees. We use the meter to record the power consumption during air conditioning and cooling, and use the temperature and humidity data acquisition instrument to record the indoor and outdoor temperature and humidity during the test.

2.4. DeST software

DeST software structure is composed of a number of separate modules connection, and it implements the concept of phased simulation [4, 5]. The software structure diagram is shown in Figure 1.

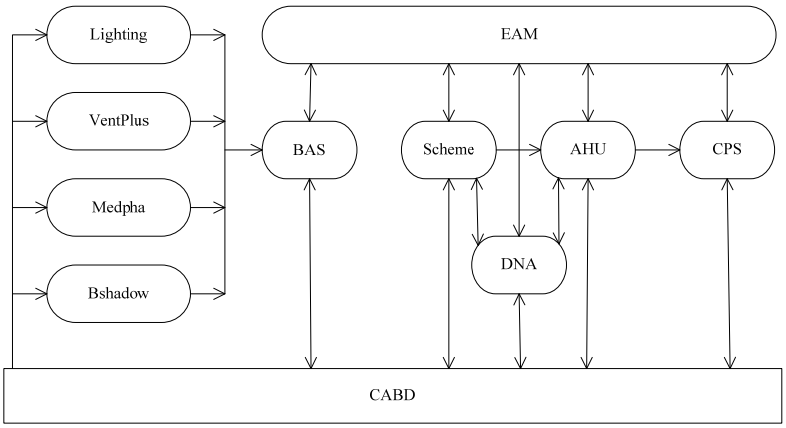

Figure 1. DeST simulation software structure

(1) Building shadow calculation module BShadow: use the geometric projection method to calculate the shadow details of the surface of the building at any time throughout the year.

(2) Outdoor meteorological parameters module Medpha: according to the design needs, we provide year-round meteorological data for the simulation analysis with extremely high temperatures, extremely low temperatures, very high solar radiation, minimal solar radiation and extremely high enthalpy.

(3) Natural lighting calculation module Lighting: responsible for indoor lighting calculation.

(4) Natural ventilation simulation module VentPlus: use the multi-regional network model to form a fluid network, and use the Newton method to obtain the air flow of each branch.

(5) Building thermal characteristics calculation module BAS: the core module of the building's thermal characteristics calculates the temperature and the load of the building.

(6) Air conditioning system design module Scheme: by simulating the performance of buildings under different air conditioning options, designers can explicitly use different solutions to produce results.

(7) Mechanical ventilation system analysis module DNA: mechanical ventilation system analysis module, which can complete the wind system design calculation and check the calculation.

(8) Air handling equipment AHU: through the simulation means of the designer's air treatment program to carry out annual verification, and it provides a quantified basis for the designer's program.

(9) Cold and heat source and water system simulation module CPS: after the designers determined the air treatment program, through the CPS simulation to analysis operating energy consumption of different cold and heat source system and water system, and provide designers with comparison data of different schemes.

(10) CABD: the graphical user interface, the designer can directly through the interface to carry out data design of various buildings (material, geometry, thermal interference).

(11) Economic evaluation module EAM: it can economically evaluate the life cycle costs of HVAC programs and provide economic basis of program options for HVAC designers and engineering construction departments.

3. Experimental results and analysis

3.1. Winter constant power test

In this experiment, the power offering is constant. Two heaters continue to run at constant power and measured the average daily power consumption is 94 degrees. The indoor temperature increased with the increase of the outdoor temperature, and the daily average temperature in the test stage reached 26.64 ℃. At this point, the indoor temperature is too high, and the humidity is relatively low. This brings discomfort to people's work and life, and the heaters constant power work consume a lot of energy, which is detrimental to energy saving and environmental protection. The winter constant power temperature chart is shown in Figure 2, and the winter constant power humidity chart is shown in Figure 3.

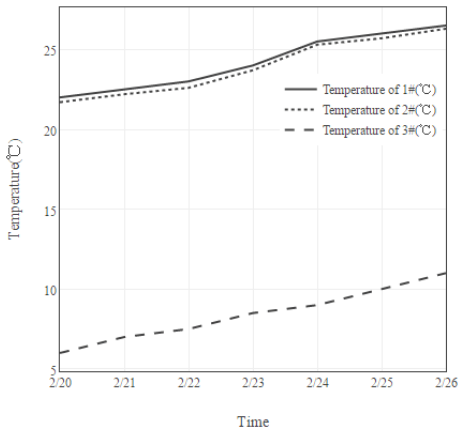

Figure 2. The winter constant power temperature chart

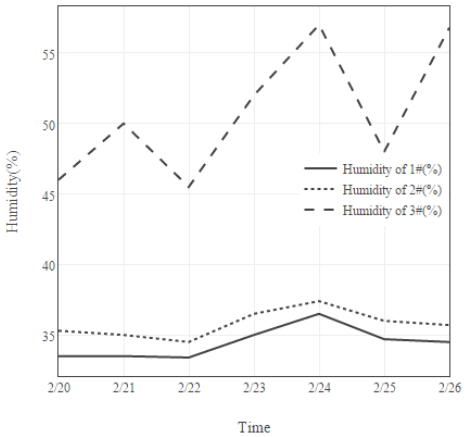

Figure 3. The winter constant power humidity chart

In the constant power test stage, the indoor humidity is relatively stable, about 35%, and the change of outdoor humidity is great. The indoor humidity is less affected by the change of the outdoor humidity.

3.2. Summer test

In this test, the daily average power consumption is 1.5°. The indoor temperature and humidity are relatively stable. The temperature is about 26℃, and the average humidity is about 70%. The changes of outdoor temperature and humidity are great. The indoor humidity is less affected by the change of the outdoor humidity. The summer temperature chart is shown in Figure 4, and the summer humidity chart is shown in Figure 5.

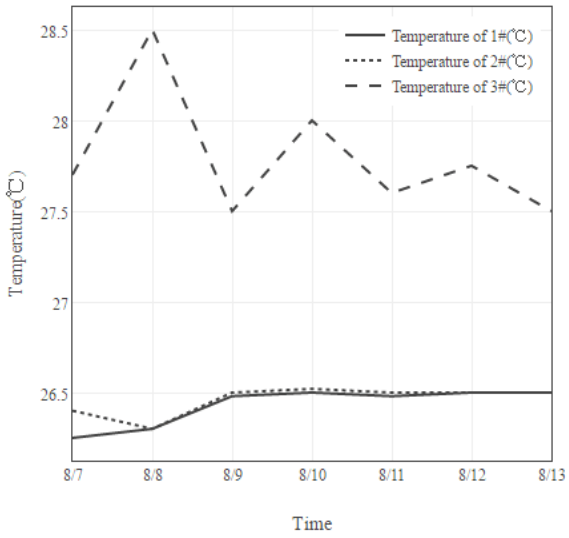

Figure 4. The summer temperature chart

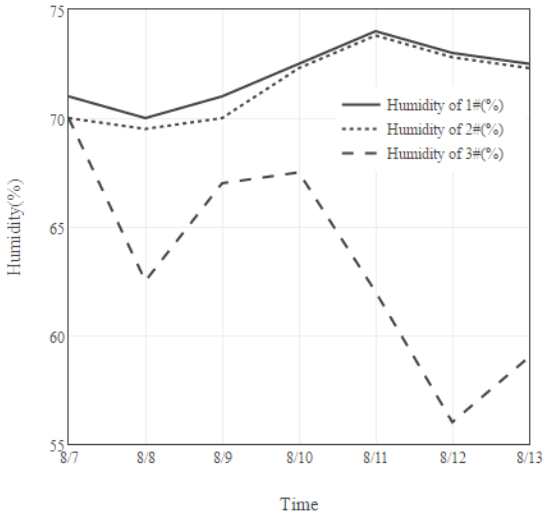

Figure 5. The summer humidity chart

3.3. Analysis of results

The humidity in the outdoor will affect the humidity inside the house based on the analysis of the relative humidity of the library building of the concrete sandwich straw block. But the hysteresis is existed in this process. In the short term, the indoor humidity environment is relatively stable. In the

long-term outdoor environment, the indoor humidity will be changed by the outdoor humidity, and the trend is basically identical.

During the test, the temperature inside the building is mainly affected by summer cooling equipment and winter heating equipment. The outdoor temperature has a certain effect on the indoor temperature in the general trend. But the effect is far less than the effect of indoor insulation equipment. Therefore, the insulation function of the library building of the concrete sandwich straw block is effective.

1) Thermal insulation property in winter

According to *The Energy Saving Design Standard for Construction of Residence in Shandong Province DBJ 14-2012*, winter heat consumption index around the region of Jinan is 14.8W/m^2 .From the calculation by experiment, the heat consumption index of this building should be 9.35W/m^2 under the constant temperature condition setting as 18℃. Therefore, this experimental building has good heat insulation in winter which is designed in accordance with the energy saving standard.

2) Thermal insulation property in summer

We use DeST to simulate the summer energy consumption of ordinary concrete building. We also compare it with the measured situation of the library building of concrete sandwich straw block. In the summer experiment of concrete sandwich straw block building, measured power consumption is 1.5°per day, and simulated power consumption of DeST is 13.5° per day. Therefore, this experimental building has good heat insulation in summer, thereby reducing the power consumption.

4. Conclusion

Based on the experimental study on the thermal insulation performance of the concrete sandwich masonry block in library building, it is concluded that the calorific value measured in the winter test of the concrete sandwich block in library building is in accordance with the local regulations. The power consumption index of concrete sandwich straw block in library building measured in summer test, which has the advantages of good insulating property and distinctive effect of energy saving. In the short term, the change of outdoor humidity has little effect on the change of indoor humidity environment, and the humidity control performance of the straw compressed block is not significant. However, the overall humidity of indoor environment will change with the change of outdoor humidity environment, and the process is relatively slow.

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