Research on Thermal and Humidity Environment of Cultural Relics Exhibition Room

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Abstract—In order to meet the needs of humanistic education, museum buildings have developed vigorously in recent years. The protection and display of cultural relics is an effective way to continue historical information, which has important social and cultural significance. During the design and operation of the building air conditioning system, both the thermal and humidity environment of the cultural relics exhibition room should be responsible for the safety of the displayed cultural relics and the thermal comfort of visitors should be considered. In this paper, the indoor thermal and humidity environment of a cultural relic exhibition room in Beijing was measured, and the indoor air velocity distribution and temperature and humidity distribution were obtained. The results show that the thermal and humidity environment of the cultural relics exhibition room is better, but the indoor temperature of the exhibition room is lower, which still has great energy saving potential. It needs to be improved in the future engineering practice to achieve double optimization of comfort and energy saving effect. In order to achieve accurate control of the indoor thermal and humidity environment of the cultural relics exhibition room, we built a data collection for thermal environment parameters and air quality, which is used for monitoring and data collection of the cultural relics exhibition room.

1 Introduction

People's requirements for the air conditioning system of ordinary buildings are to save energy as much as possible and meet people's requirements for indoor thermal and wet comfort, because the quality of indoor environment directly affects people's physical and mental health and comfort [1]. Large public buildings are characterized by large scale, high cost, complex spatial functions, etc. The health and comfort of their indoor environment deserve attention [2]. As the main place for the collection and exhibition of cultural relics and specimens, in order to protect the safety of cultural relics, the cultural relics exhibition room adopts a 24-hour operation mode, which means that the cultural relics exhibition room has great potential for energy conservation.

In the 1990s, people began to realize the importance of environmental temperature and humidity to the safety of cultural relics. The air conditioner in the cultural relics exhibition room operated strictly according to the temperature and relative humidity standards of the preservation environment of the collection, resulting in the low temperature of the exhibition room and affecting the thermal comfort of visitors. Now in the 21st century, with the in-depth study of cultural relics protection, the concept that cultural relics safety lies in constant humidity is becoming increasingly clear [3]. The requirements for indoor thermal and humid environment of cultural relics exhibition rooms are becoming more and more clear. On the premise of protecting cultural relics, the design and operation of air conditioning system should properly consider the thermal comfort needs of personnel.

In order to study the thermal comfort of the staff in the cultural relics exhibition room, this paper tests the on-site environmental parameters of a cultural relics exhibition room in Beijing and analyzes the indoor thermal and humid environment of the cultural relics exhibition room.

2 Requirements For Hot And Humid Environment Of Museums

The temperature, humidity, gas radiation and other factors in the cultural relics preservation environment greatly affect the duration of cultural relics preservation. Temperature and humidity have a very important impact on the preservation of cultural relics, because for organic cultural relics, if the humidity is too low, some cultural relics will become dry, cracked and edge warped due to dryness, and if the humidity is too high, insects and mildew are major problems; For inorganic cultural relics, if the humidity is too high, metal cultural relics will rust,

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and ceramic cultural relics will crack and flake. Therefore, controlling the change of temperature and humidity will prolong the life of cultural relics. On the contrary, allowing natural changes will cause unexpected harm. Only by effectively controlling the thermal and humidity environment for cultural relics preservation can we prevent or delay the changes in the physical and chemical properties of cultural relics to the maximum extent, so as to achieve the goal of long-term preservation of cultural relics.

The national standard for temperature and humidity in the museum warehouse stipulates the storage environment requirements for various cultural relics, but the temperature and humidity in the warehouse environment are very easy to change, and simple manual management is relatively weak. Therefore, in the museum, intelligent temperature and humidity monitoring system is usually used to ensure the stability of the warehouse environment by the way of detection and alarm and linkage.

3 Project Overview and Test Experiment

In order to analyze the indoor thermal comfort of the cultural relics exhibition room, first obtain the environmental parameter data of the real room through on-site testing [4]. Through the on-site testing of the indoor thermal and humid environment of the exhibition room, obtain the curves of indoor air temperature, relative humidity and air flow velocity[5], and analyze them.

3.1 Project overview

Figure 1. Plan of a Cultural Relics Exhibition Room

We studied the indoor thermal and humid environment of the cultural relics exhibition room (as shown in Figure 1). The exhibition room is divided into 9 small areas and 45 exhibition cabinets, displaying unearthed cultural relics such as ceramics, Buddha statues, ancient bricks, metal appliances, and files. In summer, central air conditioning is used to cool and dehumidify the exhibition room, providing a good collection environment for cultural relics and improving the comfort of indoor personnel.

3.2 Test conditions

The instruments are used in this test experiment, as shown in Figure 2, (1) Hand-held laser rangefinder; (2) Split digital thermometer and hygrometer; (3) Hand held high-precision high-temperature temperature measuring gun; (4) Hand held thermal anemometer; (5) Heat index meter. These five instruments have the advantages of stable performance, high sensitivity, convenient carrying and simple operation, and are respectively used to measure the size of the room partition area; indoor temperature and relative humidity; surface temperature of display case; indoor air flow velocity; indoor black ball temperature.

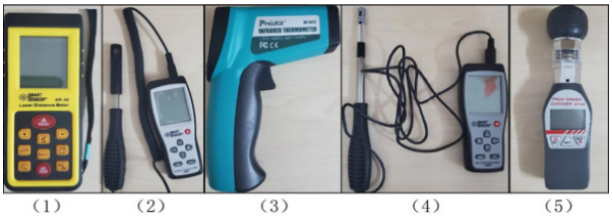

Figure 2. Test instrument

According to the National Indoor Air Quality Standard (GB 18883-2002) and JGJT 260-2011 Technical Code for Testing of Heating, Ventilation and Air Conditioning Engineering, the principles of test point layout are as follows: (1) The number of sampling points is determined according to the size of the monitored indoor area and the site conditions, so as to accurately reflect the indoor air parameter. In principle, at least 5 points shall be set above 100m^2. Evenly distributed on diagonal or quincunx. For more than 100m^2, 1~2 test points shall be added as appropriate for every 20~50m^2 increase (evenly arranged); (2) The test points shall be arranged at the same height 0.7m-1.8m above the ground, and shall be no less than 0.5m away from the exterior wall surface and the cold and heat sources; (3) The test points shall be arranged at representative locations.

According to the divided area of the room and the site conditions, 33 indoor test points with a height of 1.5m are evenly set in the 9 areas separated by the cultural relics exhibition room. As shown in Figure 3.

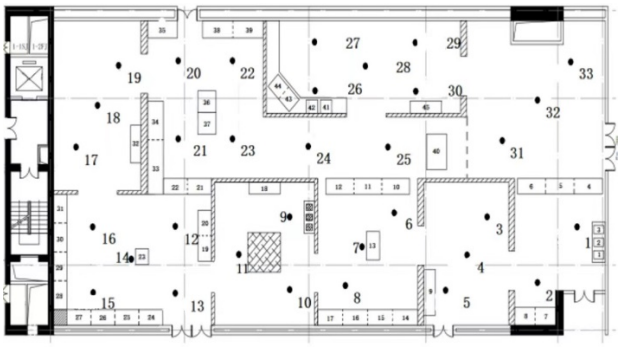

Figure 3. Layout of test points

3.3 Test result and analysis

In this experiment, the cultural relics exhibition room was tested for 3 days: (1) July 2, 2021, the test time is

3:00-4:00 p.m., and the outdoor ambient temperature and humidity are 29℃ and 55%. (2) On July 3, 2021, the test time is 3:00-4:30 p.m., and the outdoor ambient temperature and humidity are 28℃ and 63%. (3) On July 6, 2021, the test time is 9:00-11:30 a.m., and the outdoor ambient temperature and humidity are 30℃ and 49%. The thermal and humidity of the same test point in three days were compared. The comparison curve is shown in Figure 4 and Figure 5.

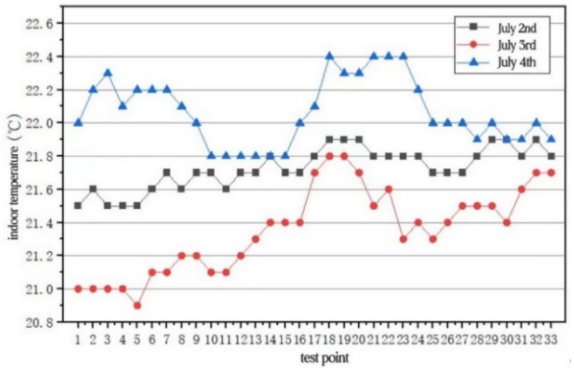

Figure 4. Indoor temperature distribution test result

It can be seen from the indoor temperature distribution data in Figure 4 that the indoor temperature in this room is relatively stable. The maximum daily fluctuations of the indoor temperature in the three tests are 0.4℃, 0.9℃ and 0.6℃, respectively. There is no significant daily fluctuation, and the daily fluctuation is within ± 1 ℃. In addition, the indoor temperatures at 17, 18 and 19 test points on the third day are the highest on the day, because there is no air supply outlet installed at the three test points.

It can be seen from the indoor relative humidity curve in Figure 5 that the relative humidity at each test point is stable, and the maximum daily fluctuations of the three tests are 1.6%, 3.4% and 2.1% respectively. There is no significant daily fluctuation, and the daily fluctuation is within ± 5%. The relative humidity measured from Test Point 1 to Test Point 33 shows a downward trend as a whole.

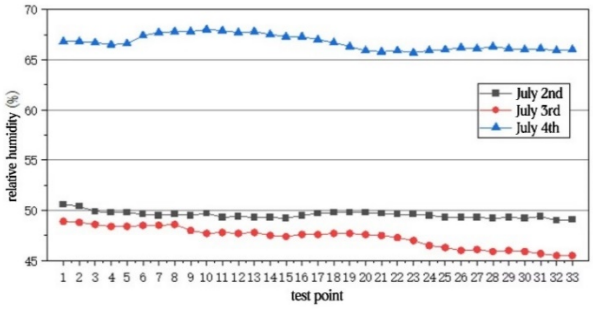

Figure 5. Indoor relative humidity distribution test result

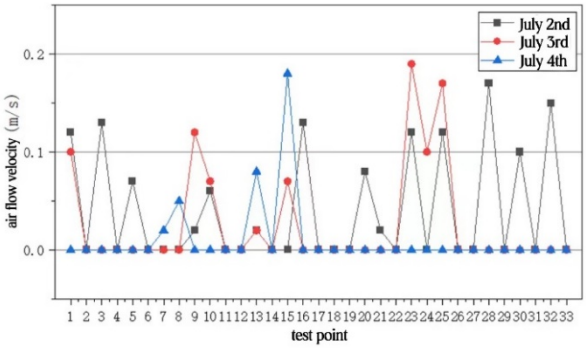

Figure 6. Indoor air flow velocity test result

The test data in Figure 4 and Figure 5 show that the temperature and relative humidity of the exhibition room are relatively stable, but the temperature and relative humidity change greatly in different days, so the constant temperature and humidity cannot be achieved.

In addition, the indoor air flow velocity is also measured in the test experiment, and the results are shown in Figure 6. It can be seen from the data that the air flow velocity at each indoor test point is less than 0.2m/s, so visitors will not have a bad sense of wind blowing. However, due to the frequent occurrence of low air flow velocity, it has a negative impact on human thermal comfort [6].

It can be seen from Figure 4 that the air temperature at the visitor's height in the exhibition room is close to the measured results, obviously unable to meet the requirement that the air conditioning temperature of public buildings in Beijing should not be lower than 26℃, resulting in energy waste.

3.4 Building networking monitoring system

In order to achieve the accurate control of the indoor thermal and humid environment of the cultural relics exhibition room, we built a *data collection for thermal environment parameters and air quality* [7]. The workflow is shown in Figure 7 and 9. This system can help the building management, operation and maintenance engineer better understand the indoor real-time environment of the building, and give early warning and control in case of problems.

The system is designed according to the requirements of the building on environmental parameters, mainly including temperature and humidity sensors, air flow velocity sensors, etc. The data information collected by the sensor is stored in the database, and the corresponding data processing is carried out. Finally, it is displayed on the front page. Through computers and other terminal equipment, the engineer looked up and analyzed the relevant data information to timely understand the problems in the thermal and humid environment of the building and deal with them. The system equipment box and sensors are shown in Figure 8. The composition and function of system hardwares are shown in table 1.

Among them, the collection of real-time data is the basis for data visualization to ensure that the monitoring

work can meet the requirements of follow-up work [8]. The accuracy of data collection will affect the judgment and measures of the building operation and maintenance engineer. At the same time, the more parameters the data acquisition system obtains, the more accurate the system operation can be learned [9].

During the actual operation of the system, the monitoring content is constantly updated and adjusted according to the actual needs of the building, so that it can effectively meet the needs of the cultural relics exhibition room for indoor environmental parameter monitoring, provide accurate environmental parameter monitoring information for the operation and maintenance engineer, and ensure the safety of cultural relics and the thermal comfort of indoor visitors under the premise of green and energy-saving building operation.

Table 1. Composition And Function Of System Hardware

	Component	Model	Purpose
1	Temperature and humidity sensors	YGM450Ex	Acquisition temperature and humidity
2	air flow velocity sensors	IN80-101N2005	Acquisition air flow velocity
3	Man-machine interface	6AV6 648-0 CC11-3AX0	Recording and displaying information
4	Filter	DNF05-H-10A	Maintain stable working condition of power supply
5	Power supply	CPSNT 48W 24V 2A	Provide energy
6	Programmable Logic Controller	SIMATIC S7-200	Data processing and storage

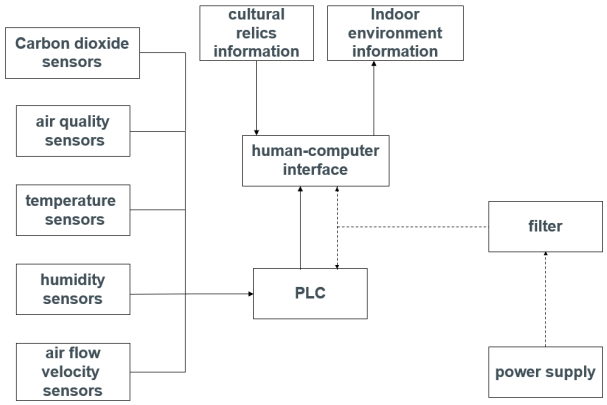

Figure 7. Thermal environment parameters and air quality data collection system

Figure 8. Equipment of building networking monitoring system

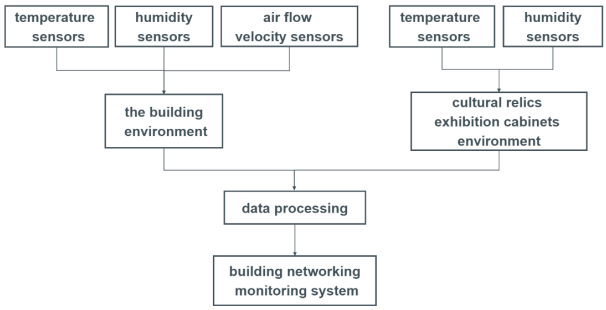

Figure 9. Flow chart of building networking monitoring system

4 Summary

With the improvement of people's living standards and education level, the comfort requirements of the thermal and humidity environment of the cultural relics exhibition room are becoming higher and higher. The indoor air conditioning system should not only protect the cultural relics, meet the comfort of visitors, but also need to save energy. According to the measured results, as the research object, the indoor temperature and humidity of the cultural relics exhibition room fluctuate slightly, and the air flow velocity is small, but the indoor temperature is distributed at 21℃ - 23℃, which obviously does not meet the energy-saving temperature standard of 26℃, resulting in a large waste of energy. For cultural relics that do not require strict temperature control, the air supply temperature can be appropriately increased; for cultural relics that need to be strictly controlled within a certain temperature range, local air supply system can be adopted. In the future engineering practice, it is necessary to start from operation and maintenance to achieve double optimization of comfort and energy saving performance.

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