The large space Investigation and Analysis of railway station in winter: Taking Zhengzhou east and Changsha south railway stations as cases

Fucheng Zhu¹*, Hui Zhang¹, Si Ding²

¹School of Civil Engineering and Architecture, Hubei University of Technology, Wuhan 430068, China
²Central South Architectural Design Institute Co., Ltd (CSADI), Wuhan 430068, China

*Corresponding author e-mail: 490119429@qq.com

Abstract. As the landmark building of the city, railway station has the characteristics of large space, dense crowd and comfortable characteristics, while the waiting hall is an important space form in railway passenger station, and its thermal environment directly influences the human's sensory experience. Taking Zhengzhou east station, Changsha south railway station as an example, through field testing and investigation in winter, to get the test parameters such as temperature, humidity, wind speed, and combining the investigation and study the thermal environment and comfortable condition, and discusses the possible problems.

1. Introduction
As we all know, China's railway station is in a period of rapid development. Newly built railway stations often have tall waiting halls, and more and more tourists take high-speed railways. So it is especially important to give passengers a good indoor thermal comfort in the waiting hall [1].

Some scholars have begun to study the thermal environment of the train station waiting room. XU ZiLong studied the summer thermal environment of Xi'an Railway Station in the master's thesis - Xi'an Railway Station Waiting Hall, and proposed to improve the thermal environment in Xi'an Railway Station [2]. The team led by Professor Di YuHui conducted a questionnaire survey on the winter thermal environment of Xi'an North Station. Through the analysis of the questionnaire results, the comfort of the winter thermal environment in Xi'an North Station was studied [3]. In this paper, the Zhengzhou East Railway Station and Changsha South Railway Station conduct on-the-spot tests and questionnaire surveys to study the thermal comfort of the high-speed railway station waiting hall in winter, and provide a scientific basis for improving the thermal environment of the waiting hall and creating good thermal comfort.

2. Building test and research plan
2.1. Building Overview
The research site is located at Zhengzhou East railway Station and Changsha South railway Station in hot summer and cold winter zone. Zhengzhou East Railway Station is the Beijing-Guangzhou high-
speed railway hub. The total construction area of Zhengzhou East Railway Station is about 412,000 square meters. The design of the station building is ‘Gate of the City’. The door shape, in which the building area of the station is about 150,000 square meters. Changsha South Railway Station is located in Yuhua District, Changsha City, Hunan Province. It is an important hub connecting Beijing-Guangzhou high-speed railway and Shanghai-Kunming high-speed railway. The total construction area of Changsha South Railway Station is about 447,000 square meters. The design of Changsha South Station, which have melted into the strong Xiaoxiang culture, reflects Hunan’s ‘Shanshuizhou City’ unique regional characteristics [4]. The test object is the waiting hall of two high-speed railway passenger stations. The test time for Zhengzhou East Station is from January 12 to January 13, and Changsha South Station is from January 15 to January 16.

2.2. Description of the distribution of measuring points
The waiting halls of each railway passenger station are divided into regions, and 12 basic measuring points are arranged on the planes of the two waiting halls (Fig1). The test is mainly for the daytime building operation phase, the time was 8:30-18:00, and the main parameters are the temperature, humidity and wind speed of the waiting hall.

2.3. Test equipment
In the actual measurement, it is necessary to measure the indoor temperature, the indoor relative humidity and the indoor wind speed [6]. Because it is the instantaneous data recorded once every hour, so we need higher accuracy of the instrument to ensure the accuracy of the experiment. The instrument overview and related features used in the measurement (Table1).

| Table 1. Measuring instruments and related features |
|----------------|---------------------------------|-------|
| Measurement item | instrument                               | Precision |
| Indoor temperature | Temperature and humidity recorder     | ±0.1°C |
| Indoor relative humidity | Temperature and humidity recorder | ±0.1%  |
| Indoor wind speed   | Electronic anemometer                | ±0.01 m/s |
2.4. Subjective questionnaire
In the actual research and test, the questionnaires are distributed to the passengers without disturbing the passengers. The questionnaires include: 1. Background information of the respondents; 2. Waiting time and waiting behavior; 3. The heat feeling of the respondents during the investigation, the heat The sensory value is expressed by ASHRAE's seven-level indicator [5] (+3 very hot, +2 hot, +1 Relatively hot, 0 Comfortable, -1 Relatively cold, -2 cold, -3 very cold); 4. respondents are waiting in waiting room The satisfaction of the space and so on.

3. Test data analysis
In the test, 12 test points’ data were obtained. Through the analysis of the data, the author found that the data of C1—C6 and C7—C12 obtained by Zhengzhou East Station and Changsha South Station are similar. After the author’s research, this data of the two groups is similar because the two high-speed rail stations are symmetrical in the north and south, and there are waiting halls in the waiting halls in the north and south. Therefore, the data of C1—C6 is selected for comparative analysis.

3.1. Analysis of temperature and humidity test
The author tested the data of Zhengzhou East Railway Station waiting room on January 12th and January 13th. We took the average of 2 days as the data of this test and plotted the table. The temperature of C1—C6 point changes with time (Fig.2).

![Figure 2. Temperature vs. time curve of C1—C6 point in Zhengzhou East Railway Station](image)

Similarly, the temperature versus time curve of the C1—C6 point of Changsha South Station can be obtained (Fig.3).

![Figure 3. Temperature vs. time curve of C1—C6 point in Changsha South Railway Station](image)
From the temperature curve of Zhengzhou East Station, it can be clearly seen that the temperature is gradually increasing. The temperature difference is not large, but the temperature of the C5 measuring point is slightly higher than the other five measuring points. This is because the C5 measuring point at the entrance of the platform, the flow of people is larger and the temperature is higher than other areas. From the temperature curve of Changsha South Railway Station, it can be found that the temperature at point C2 is significantly lower than other test points. This is because the C2 point is at the entrance of the waiting hall, and the outdoor temperature has a greater influence on the C2 point, while the other five The measuring point is located in the waiting hall, which is less affected by the outdoor environment, and the temperature difference is not large, and the degree of influence with time is not large. The average temperature of the test section of Zhengzhou East Railway Station was 12.77℃, and the outdoor temperature was 0-6℃. The average temperature of the test section of Changsha South Railway Station was 20.9℃, and the outdoor temperature was 4-13℃. For the indoor humidity data, the author calculated the average humidity of the waiting hall every day, and obtained the daily average humidity table of the waiting hall of Changsha South Railway Station of Zhengzhou East Station (Table.2).

| Table 2. Zhengzhou East Railway Station and Changsha South Railway Station Waiting Hall Daily Average Humidity Meter |
| --- |
| Maximum humidity(%) | Minimum humidity(%) | Average humidity(%) |
| January 12 Zhengzhou East Railway Station | 24.3 | 19.6 | 21.84 |
| January 13 Zhengzhou East Railway Station | 32.5 | 22.6 | 27.42 |
| January 15 Changsha South Railway Station | 37.6 | 26.9 | 0.59 |
| January 16 Changsha South Railway Station | 46.9 | 40.3 | 42.59 |

During the four days of testing, January 12 and January 15 were sunny, and January 13 and January 16 were rainy. It was also evident from the change in humidity that the average humidity was significantly improved. However, the Zhengzhou East Station has a relatively low humidity and does not meet the human body's appropriate thermal comfort humidity standards.

3.2. Wind speed test analysis
Since the wind speed data test is a half-hour instantaneous record, the data does not change closely with time. Therefore, the author calculated the wind speed data tested by Zhengzhou East Railway Station and Changsha South Railway Station, and took the average value of each test point. In contrast, in the process of collating data, the author found that the 12 points of measurement data showed a trend from south to north, and the change in the east-west direction was not obvious, so 12 test points could be divided into three areas ( C1, C4, C7, C10 are Zone A; C2, C5, C8, and C11 are Zone B; C3, C6, C9, and C12 are Zone C), Zhengzhou East Station, Changsha South Station Zone A, Zone B, and Zone C are all The average wind speed at the measurement point is shown below.(Table.3)
Table 3. Average wind speed at points in Zhengzhou East Station and Changsha South Station Area A, Zone B and Area C

|                        | Area A wind speed (m/s) | Area B wind speed (m/s) | Area C wind speed (m/s) |
|------------------------|-------------------------|-------------------------|-------------------------|
| Zhengzhou East Railway | 0.07                    | 0.10                    | 0.62                    |
| Changsha South Railway | 0.13                    | 0.22                    | 0.69                    |

Through the table, it can be found that the wind speed of the A zone and the B zone is lower than that of the C zone. The test points in Zone A, Zone B and Zone C of the two high-speed rail stations are from west to east, and the test selection time is exactly in January of winter. The northeast wind is prevalent in both climate zones. During the test, Zhengzhou East Station and Changsha South Station had windows on the south facade for ventilation. From the experimental data, it can be clearly found that the influence of ventilation on the south is large, resulting in the average wind speed in the south is much larger than the middle and north. This has a great impact on passengers waiting in the south.

3.3. Field survey data analysis

During the on-site testing, the survey was conducted in conjunction with the survey questionnaire to conduct a survey of passengers' thermal comfort status. Since the station staff and the merchandising staff stayed in the waiting room for a long time and fully adapted to the thermal environment in the waiting hall, the survey object was only for the waiting passengers. In this survey, we distributed 1,000 questionnaires and recovered 939, recovery rate was 93.9%, of which 828 were valid questionnaires. The effective questionnaire rate was 82.8%, including 410 from Zhengzhou East Railway Station and 418 from Changsha South Railway Station.

According to ASHRAE's 7-level thermal index (+3 very hot, +2 hot, +1 Relatively hot, 0 Comfortable, -1 Relatively cold, -2 cold, -3 very cold), the temperature thermal sensation obtained by the on-site questionnaire is carried out. Finishing, the distribution results are shown below (Table.4).

Table 4. Distribution of passengers' thermal sensation in Zhengzhou East Railway Station and Changsha South Railway Station Waiting Hall

|                          | -3 Very cold | -2 Cold | -1 Relatively cold | 0 Comfortable | +1 Relatively hot | +2 Hot | +3 Very hot |
|--------------------------|-------------|---------|-------------------|---------------|-------------------|--------|-------------|
| Zhengzhou East Railway Station | 3.4%        | 11.4%   | 33.2%             | 44.1%         | 6.3%              | 1.2%   | —           |
| Changsha South Railway Station | —          | 2.9%    | 8.1%              | 68.4%         | 17.7%             | 2.6%   | —           |

As can be seen from the table, only 44.1% of passengers at Zhengzhou East Station felt that the temperature in the waiting room was comfortable. 33.2% of the passengers felt that the temperature in the waiting room was cold. 11.4% of the passengers felt that the temperature was cold, and less than 10% of the passengers feel hot. Nearly 70% of the passengers at Changsha South Station felt that the temperature in the waiting room was comfortable. Only 8.1% of the passengers felt cold, and 17.7% of the passengers felt hot. In general, the passengers in the Zhengzhou East Railway Station waiting room feel cold in the winter, while the passengers in the Changsha South Railway Station waiting room feel good about the environment. To a certain extent, the indoor thermal comfort of Changsha South Station is higher than that of Zhengzhou East Station.
4. Conclusion

(1) The average temperature of the test section of the waiting hall of Zhengzhou East Railway Station was 12.77°C, lower than comfortable temperature; the average temperature of the test section of the waiting hall of Changsha South Railway Station was 20.9°C. Refer to GB50736-2012 “Code for Design of Heating Ventilation and Air Conditioning for Civil Buildings” for the winter comfort air-conditioned room temperature of 18-24°C. The questionnaire also confirmed that the passengers feel cold to Zhengzhou East Station and feel comfortable to Changsha South Station. During the test, Zhengzhou East Station and Changsha South Station were ventilated by opening windows on the south facade. This has a relatively large impact on indoor temperature. It is especially obvious at Zhengzhou East Station, and it will be colder feel. The two high-speed railway stations use different pit layouts, which also have a certain impact on the temperature change. The temperature in the middle atrium area of Zhengzhou East Railway Station is significantly higher than that on both sides of the aisle, as for Changsha South Railway Station, the atrium is almost the same temperature on both sides. It is suggested that Zhengzhou East Railway Station can improve the passenger's thermal comfort by appropriately raising the air-conditioning temperature. The layout of the Changsha South Railway Station is more reasonable than the Zhengzhou East Railway Station.

(2) The relative humidity of Zhengzhou East Railway Station waiting room was 21.84% on sunny days and 27.42% in light rain; the relative humidity of Changsha South Railway Station waiting room was 30.59% on sunny days and 42.59% in light rain. According to “GB50736-2012 “Code for Design of Heating”, Ventilation and Air Conditioning for Civil Buildings”, the relative humidity of the winter comfort air-conditioned room was 30-60%. The humidity in Zhengzhou East Railway Station is low; the humidity in Changsha South Railway Station is in a comfortable range. Zhengzhou East Railway Station is recommended to increase the indoor humidity by adding equipment or changing the working conditions of air-conditioning equipment, thus giving passengers a good thermal comfort environment.

(3) The south part of Zhengzhou East Railway Station and Changsha South Railway Station Waiting Hall has a large wind speed exceeding 0.6m/s, and the north and central regions have smaller wind speeds, all of which are less than 0.3m/s. According to GB50736-2012 “Code for Design of Heating Ventilation and Air Conditioning for Civil Buildings”, the wind speed of the air-conditioned room in winter comfort is ≤0.3m/s. This has a great relationship with the ventilation of the facade of the waiting hall. Therefore, for the use of large-scale railway passenger stations in winter, when natural ventilation is required, windowing or other ventilation should be carried out according to local climatic characteristics and environmental characteristics. The means of ventilation should ensure the comfort of the indoor wind environment of the waiting hall while ventilating and ventilating.

(4) The air conditioning of the Zhengzhou East Railway Station waiting room in winter can't fully meet the passenger's thermal comfort requirements. According to the actual situation of passenger flow, the air conditioning opening strategy under different working conditions can be tested under the premise of energy saving and emission reduction to improve the passenger's heat comfort; the air conditioning in the shelter of Changsha South Station in winter can basically meet the passenger's thermal comfort requirements and can maintain the present circumstance.

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