Field measurement of indoor environment of underground garage in winter and analysis of its influence on people

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Abstract. Since the National Fitness has become a national strategy, people's enthusiasm for fitness has also been increasing. When winter comes, the outdoor temperature becomes unsuitable for people to carry out exercise activities. Therefore, more community residents choose underground garages as a place for fitness activities. Due to the frequently entry and exit of vehicles and ventilation restrictions in the underground garage, whether the internal air quality in an underground garage meets the requirements of personnel activities remains to be studied. In this study, an underground garage in a residential area of Jinan was tested. The parameters involved CO₂, CO, PM2.5, temperature and relative humidity. Select areas where people often gather for measurement. According to the test results, the distribution of CO₂, CO, PM2.5, temperature and relative humidity in the underground garage were quantitatively analyzed. It is found that the air quality in some areas of the underground garage is poor, and long-term activities in this environment will affect people's health. To solve this problem, in this study, the area with relatively good air quality in the underground garage is found to provide personnel activities, and the optimization measures of winter ventilation in the underground garage were put forward.

Keywords: underground garage, fitness activities, field measurement, air quality, optimization measures of winter ventilation

1 Introduction

With the rise of national fitness as a national strategy, people's enthusiasm for fitness is increasing day by day. However, with the arrival of winter, the outdoor temperature decreases rapidly, coupled with the imperfection of supporting sports venues in the community [1]. The cold temperature has become a roadblock for mass fitness, so a number of people choose underground garages, which can shelter from the cold and wind, as a place for fitness activities (Fig.1). Since underground garages are closed or semi-closed building types [2], their internal space has less air exchange with the external environment, poor ventilation conditions, and poor air flow [3-4]. Whether its internal air quality meets the air quality requirements for human activities must be studied, so it is important to study the air quality in the underground garage where human activities are intensive.

Fig. 1. Personnel activities in the underground garage

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2 Research Methodology

2.1 Research Subjects

This study mainly selects the underground parking garage of a residential district in Jinan for testing, which is located in the first underground floor of the residential building, an area of about 7700 m². 266 parking spaces in the garage. Through the preliminary survey found that the concentration of vehicle access time is between 7:00 ~ 8:00 in the morning and 6:00 ~ 8:00 in the afternoon. The garage uses a combination of natural ventilation and mechanical ventilation, and the number of air changes is 6 times per hour.

2.2 Test items and test time

The inhalation of CO in human body can cause hypoxia, which can cause dizziness and weakness in mild cases, and even death in severe cases [5-7]. Temperature, relative humidity and CO₂ are an important indicator of air quality [9-10]. PM2.5 particles are small in size, rich in a large number of toxic and harmful substances, thus having a greater impact on human health and atmospheric environmental quality[11]. In summary, the measurement parameters selected for this test were CO concentration, CO₂ concentration, air temperature and relative humidity, and PM2.5 concentration.

The test time was arranged in the evening from 19:30 to 21:00, through the preliminary survey, this time belongs to people's rest time after dinner, and more residents choose to enter the underground garage activities during this time.

2.3 Measurement instruments and test methods

The instruments used for the measurements included the TSI8530 benchtop dust meter and Tsi7575 indoor air quality detector. Tsi8530 was used to measure PM2.5 in the air. Tsi7575 for measuring CO, CO₂, temperature and relative humidity. All the above equipment has been calibrated and verified by metrology and qualified to meet the requirements for use as specified in the testing specifications.

Since the number of cars in the garage varies every day, and the content of various components of the air in the garage also varies, if each measurement point is measured only once, the data will produce large inaccuracies. So that each point in the garage is measured continuously for seven days, and finally the measurement data of the seven days are averaged. The measurement point arrangement is shown in Fig. 2 below.

3 Measurement results

3.1 Measurement results of dust concentration PM2.5 in the garage

Residential underground parking garage vehicle in and out of the law is different from other buildings such as shopping malls. Vehicle access is mainly concentrated in the peak commuting period and the difference between the weekday and rest day traffic flow is large. Considering that pollutant concentrations are affected by the outside weather, the weather temperature during the test period was checked on the China Weather Network, as shown in Fig. 3.

In Fig. 4, the main aisle of the garage is measurement point A. The concentration of PM2.5 fluctuates greatly in the first thirty minutes of the test, that is, during the peak period after work. And the highest concentration exceeds 90μg/m³, which exceeds the limit value of PM2.5 is 75 μg/m³ as stipulated in the Ambient Air Quality Standard GB 3095-2012[12] and has an impact on people's health.

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Fig. 2. Measurement point layout

Fig. 3. Weather temperature change in Jinan

Fig. 4. Variation of PM2.5 concentration
3.2 Measurement results of CO₂, CO, temperature and relative humidity in the garage

Fig. 5 shows the variation of CO₂ concentration during the test period, from which it can be seen that the CO₂ concentration at point 1 and 4 at the entrance and exit of the garage was at a high level during the first 60 minutes of the test, with the highest concentration reaching 575 ppm, and gradually decreasing with time. The CO₂ concentration at the two measurement points located in the main aisle of the garage was relatively low, fluctuating from 350 to 425 ppm. The CO₂ concentration at point 1 was slowly increasing, from 430 ppm at the beginning of the test to 504 ppm at the end of the test.

According to the Ambient Air Quality Standard GB 3095-2012, it is known that the standard concentration limits for carbon dioxide is 700 ppm [12]. Therefore, the CO₂ concentration in the underground garage did not exceed the limit.

The variation of CO concentration at different measurement points can be seen in Fig. 6. The location of measurement point 1 showed only a limited number of 0.1 ppm CO in the first 60 minutes of the test. The CO concentration at point 2 and 3 is less than point 1. The maximum CO concentration at point 2 being 0.3 ppm and the maximum at point 3 being 0.7 ppm. The limit value of CO is 24 ppm as stipulated in the Ambient Air Quality Standard GB 3095-2012[12], and it can be seen that the four measurement points in the garage are all below the concentration limit of CO, which meets the safety standard for human movement.

The temperature at point 1 is higher than the temperature at other locations, and the range of temperature change is 7~8.9°C, and the temperature gradually increases as the test proceeds. The temperature change range of point 2 and 3 is small, basically stable at 5.5~6.5°C, and the highest temperature appears at the time of test start, and gradually decreases whenever the test proceeds. The temperature change range of measurement point 4 is larger, from the beginning of the test 7.3°C has been down to 4°C, there is a large temperature drop.

Fig.8 shows the variation of relative humidity during the test period, which shows that the relative humidity of all four points is below 30%, and the relative humidity of points 1, 2 and 3 varies between 20% and 25% most of the time. The relative humidity of point 4 is higher than the other three points, and its fluctuation range is 25% to 30%. The relative humidity of the four measurement points is in a relatively stable state although there are variations.

4 Analysis and Discussion

From the above test, we can know that there are higher concentrations of pollutants are present at point A, where the traffic flow is high. People's health will be affected if they frequently conduct activities in the garage entrance location and stay for a longer time. The measurement points close to the interior of the garage cause less disturbance to the air because the traffic flow is less or the vehicle speed is lower. Therefore, the air environment is relatively stable and the concentration of pollutants is low, meeting the safety standards for personnel fitness activities. However, with the activities of the personnel, the CO₂ concentration in the interior location of the garage gradually increases.

Through the test, the pollutant concentration distribution is not the same at different locations in the garage. For example, the PM2.5 concentration distribution differs by more than 50%. However, the maximum difference in CO concentration between locations was 7 times. This indicates that the pollutant concentration distribution is strongly influenced by vehicle operation. The relative humidity of the air in each location in the underground garage is in a range below the appropriate relative humidity for the human body, and when the air is too dry the upper respiratory mucosa is
prone to infection and respiratory diseases such as colds [13-14].

In summary, the place of winter personnel fitness activities can be chosen in the underground garage, although attention should be paid to the operation of vehicles and the timing of activities, and the air environment in the underground garage to meet the safety standards of personnel activities.

5 Conclusion

1) In this study, the air quality in the underground garage was measured to analyse whether people could perform short-term fitness activities in the underground garage in winter.
2) The difference between the air environment of garage entrance and garage interior is obvious, because the garage entrance is the same as the outside environment, it is more influenced by the outside environment. Therefore, it is not suitable for personnel activities near the garage entrance and exit, and the difference between the air environment in the aisle inside the garage and the corner area of the load-bearing column of the garage is small, and personnel activities should be selected as close to the internal location as possible. Personnel activities need to pay attention to always ensure their own safety, as well as control the time of activities, cannot use the underground garage as a long-term activity place.

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