Scientific Research Publishing

Journal of Applied Mathematics and Physics, 2019, 7, 3186-3191
https://www.scirp.org/journal/jamp
ISSN Online: 2327-4379
ISSN Print: 2327-4352

Natural Radiation Protection and Analysis in Underground Caverns

Chong Zhou[1,2*], Qing Kang[1], Zhiqiang Shen[1], Shanjing Chen[1]

[1]Army Logistics University, Chongqing, China
[2]32654 Troops, Jinan, China
Email: *fxzhouchong@163.com

How to cite this paper: Zhou, C., Kang, Q., Shen, Z.Q. and Chen, S.J. (2019) Natural Radiation Protection and Analysis in Underground Caverns. *Journal of Applied Mathematics and Physics*, **7**, 3186-3191.
https://doi.org/10.4236/jamp.2019.712223

Received: November 3, 2019
Accepted: December 17, 2019
Published: December 24, 2019

Abstract

Underground caverns have important military and civilian uses, but their internal natural radiation may endanger human health, and it is necessary to implement protection. The protective measures taken for an underground cavern in Chongqing have obvious effects. The results show that cleaning the radiation source in the environment and sealing the gap of the hole can reduce the natural radiation intensity inside the cavern to a certain extent, reducing the ambient temperature can significantly reduce the natural radiation intensity inside the cavern, the use of press-in ventilation can greatly reduce the natural radiation intensity inside the cavern, the cumulative drop can reach 25.63%, and the protective effect is obvious. These protective measures can be used in underground caverns to improve the safety of military and civilian activities.

Keywords

Underground Cavern, Natural Radiation, Protection, Analysis

1. Introduction

Underground caverns are one of the main components of military and civil buildings and play an important role in production and life and air defense exercises. Studies have shown that due to the widespread presence of natural nuclides such as radon in the soil and soil, there is usually a higher natural radiation in underground buildings such as caverns [1] [2], which may have an impact on the health of staff or those who are conducting air defense exercises. Natural radiation can cause “late effects” such as leukemia, cataract, fetal abnormalities, and shortened lifespan [3], and radon can lead to lung cancer and other pathological diseases, which has been confirmed and widely concerned by countries around the world [4] [5]. National standards also make clear requirements for the concentration of radon in indoor environments [6] [7] [8] [9], and natural radiation protection is receiving more and more attention. Taking protective measures and analyzing the effect inside an underground cavern of Chongqing City has important guiding significance for exploring and doing a good job of natural radiation protection inside underground buildings.

2. Methods and Measures

2.1. Monitoring Methods

According to the national "Code for the Control of Indoor Environmental Pollutants in Civil Buildings" [7] and "Technical Specifications for Radiation Environmental Monitoring" [10], natural radiation intensity monitoring is carried out. 1) Equipment: The "Radalert 100X" multi-function radiometer developed by Medcom Company of the United States can quickly and accurately detect the dose rate and pulse count value of α, β, γ and X-ray. The range is 0 - 1100 μSv/hr, and the precision is 0.001 μSv/hr. 2) Object: Based on an underground cavern of the Army Logistics University, it is located in the university town of Shapingba District, Chongqing. The cavern is 8 m long, 4 m wide and 5 m high. The volume is small and the main body is steel-concrete structure. 3) Selecting points: select the inner central location of the cavern and the outdoor open space, fix the instrument with brackets, the height from the ground is 1.5 m, avoid interference caused by human activities. 4) Measurement: In order to improve the accuracy, the cumulative dose measurement method is selected. Continuous measurement 3 times to average.

2.2. Protective Measures

Considering that the natural radiation inside the underground cavern is affected by external environment, foundation soil, building materials, temperature and ventilation [1] [2], four main protective measures are taken, namely cleaning the base site and internal and external environment, and blocking the internal structure of the hole and other details, lowering ambient temperature and press-in ventilation, the specific steps are as follows.

The first step is to prepare for protection. Select a typical continuous high temperature weather (May 15, 2018) to monitor the natural radiation of the cavern and record the internal and external temperature and radiation intensity of the cavern as comparative data after taking protective measures. After the completion of the monitoring, the second and third steps will be carried out immediately.

The second step is to clean up the base address and the internal and external environment. Mainly clearing the construction waste and inventory building materials around the cavern, excluding abnormal radiation sources.

The third step is to block the detailed structure such as the internal seam of the building, sealing the internal walls of the building and the holes and fine cracks on the ground with cement and paint.

The fourth step is to reduce the ambient temperature. Due to the lack of large-scale cooling equipment, and in order to reduce costs, the "natural cooling method" is adopted, that is, the weather temperature is used to reduce the building body and internal temperature. After the previous steps are completed, combined with the weather changes, the radiation intensity monitoring is again performed after a continuous rainy weather for one week and a significant decrease in temperature (May 31, 2018).

The fifth step is to ventilate the cavern. Using the vents and ventilators that have been modified and installed, air is blown into the interior of the cavern while leaving a 5cm gap in the door to facilitate air discharge. Here, the press-in type is selected, and the extraction ventilation is not selected, in order to prevent the formation of negative pressure in the chamber during pumping, which may increase the precipitation of natural nuclide in the building materials and the pores, thereby affecting the protective effect. Only a small gap of 5 cm is left, on the one hand, in order to make the injecting air and the indoor air fully mixed, the radiation intensity inside the building is relatively uniform, which is convenient for point monitoring; on the other hand, in order to slow down the ventilation speed, it is convenient to monitor the radiation intensity change process from time to time.

3. Results and Analysis

3.1. Monitoring Results

Table 1 shows the monitoring values and reductions of natural radiation intensity in the underground cavern at different stages. A total of 18 sets of data were recorded at 9 times. T1 indicates that the outdoor temperature is 28.5˚C, the indoor temperature is 30.2˚C, the wall temperature is 30.4˚C, the outdoor natural radiation is 0.169 μSv/hr, and the natural radiation intensity inside the cavern is 0.199 μSv/hr.

T2 indicates that the natural radiation intensity inside the cavern is 0.197 μSv/hr after cleaning the base of the cavern and the internal and external environment.

T3 indicates that the natural radiation intensity inside the cavern is 0.196 μSv/hr after blocking the internal structure such as the hole in the cavern.

T4 indicates that after the cavern is cooled, the outdoor temperature is 19.7˚C, the indoor temperature is 21.4˚C, the wall temperature is 21.3˚C, the outdoor

Table 1. Natural radiation monitoring results inside the cavern.

Time	T1	T2	T3	T4	T5	T6	T7	T8	T9
Radiation intensity (μSv/hr)	0.199	0.197	0.196	0.184	0.175	0.168	0.158	0.150	0.148
Decrease		1.01%	1.51%	7.54%	12.06%	15.58%	20.60%	24.62%	25.63%

natural radiation is 0.144 μSv/hr, and the natural radiation intensity inside the cavern is 0.184 μSv/hr.

T5, T6, T7, T8, and T9 respectively indicate that the cavern is ventilated for 5 minutes, 15 minutes, 30 minutes, 60 minutes, and 120 minutes. From the monitoring data, it can be seen that the natural radiation inside the cavern is decreasing, and the decreasing amplitude is increasing.

3.2. Effectiveness Analysis

Figure 1 more intuitively reflects the trend of natural radiation intensity and decrease in the cavern. At the time of T1, the natural radiation intensity inside the cavern is 0.199 μSv/hr, which is at the highest value before the protection measures are implemented on the cavern.

At the time of T2, after cleaning the base of the cavern and the internal and external environment, the natural radiation intensity inside the cavern was 0.197 μSv/hr, which decreased slightly, but it was not obvious, and the decrease was only 1.01%. This is due to the cleaning of construction waste and inventory materials around the cavern, which reduces the source of natural radiation to a certain extent, but this part of the radiation contribution is small, the effect is limited.

At the time of T3, the natural radiation intensity inside the cavern was 0.196 μSv/hr, and the drop was 1.51%. This is because the sealing of the holes and gaps inside the cavern reduces the natural radiation penetration in the foundation and soil, but the effect is limited.

At the time of T4, after the cavern was cooled, the natural radiation intensity inside the cavern was 0.184 μSv/hr, which decreased significantly, with a drop of 7.54%. On the one hand, due to the decrease of the temperature of the main body of the cavern, the natural nuclide activity in the wall and the ground soil is reduced, and the contribution to the internal natural radiation is reduced; on the other hand, due to the temperature drop, the background natural radiation intensity in the outdoor environment is also reduced, and the contribution to the natural radiation inside the cavern is also reduced.

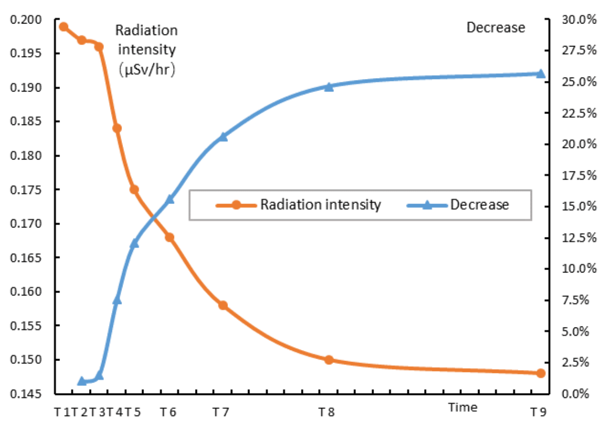

Figure 1. The trend of natural radiation inside the cavern.

At the time of T5, after the cavern was ventilated for 5 minutes, the natural radiation intensity inside the cavern decreased significantly, with a drop of 12%. At T6, T7 and T8, the natural radiation intensity decreased significantly, but the rate of decline gradually slowed down. At the T9 moment, after ventilation for 120 minutes, it basically no longer drops, the drop rate reaches 25.63%, and the natural radiation intensity inside the cavern is reduced to 0.148 μSv/hr, which is gradually close to the natural radiation intensity of 0.144 μSv/hr in the outdoor environment. This is because after the initial ventilation, the indoor air is gradually replaced by the outdoor air quality, and the outdoor air contains less natural radiation intensity than the indoor, so as the ventilation time is extended, the natural radiation intensity inside the building gradually decreases and approaches the outdoor natural radiation intensity.

4. Conclusion and Suggestion

The natural radiation protection measures for the underground cavern have obvious effects: cleaning the radiation sources in the environment and sealing the gaps of the holes can reduce the natural radiation intensity inside the caverns to some extent, and lowering the ambient temperature can significantly reduce the natural radiation intensity inside the caverns, press-in ventilation can greatly reduce the natural radiation intensity inside the cavern, which is close to the radiation intensity in the outdoor environment, with a total drop of 25.63%. Although it does not fall to a lower level or eliminate natural radiation, the protective effect is also obvious. It is recommended to monitor the internal natural radiation before engaging in military and civil activities invarious caverns. If necessary, similar protective measures can be taken, such as cleaning up the surrounding environment, blocking the gaps in the holes, and performing natural or artificial cooling and ventilation to reduce the internal natural radiation intensity,to reduce the psychological and physiological adverse effects of natural radiation on officers and soldiers.

Fund Project

Army Logistics Research Project (BY211C013); Shandong Science and Technology Major Project (2015JMRH0112).

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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