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Recent research on the law of rock deterioration damage by dry-wet cycle

Zhang Kai
（College of Civil Architecture, Anhui University of Science and Technology, CHINA）

ABSTRACT: *The dry-wet cycle of rock refers to the cycle process of water retention and water loss of rock. A single cycle has little effect on rock deterioration and cannot achieve the expected effect. Multiple cycles can make this effect continue to accumulate until the rock reaches a state of failure. In order to truly show the change of water content in deep rock, the dry-wet cycle is usually used to simulate the dry-wet cycle. The law of rock deterioration and failure caused by dry-wet cycle is studied, which provides a reliable theoretical basis for rock excavation and support, and applies it to engineering practice.*
KEYWORDS: *dry-wet cycle; mechanical properties; deterioration effect; theoretical basis*

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I. INTRODUCTION

In recent years, with the rapid development of science and technology, the shortage of resource industry chain has led to a new height of resource demand. Because of the easy exploitation and low cost of shallow resources, they are overexploited and increasingly scarce. Therefore, the topic of deep resource utilization has gradually entered the field of vision of experts at home and abroad. The utilization of deep resources is the requirement of the development of the times and the need of economic development. Relevant data show that the resources we use today account for 20 % of the total proven recoverable resources, and there is still a lot of room for exploitation. Affected by the excavation of deep resources, the depth of mines in China has reached thousands of meters. With the increase of excavation depth, the difficulty of excavation has soared, which has also greatly increased the cost of mining. Because the environment of deep rock is more complicated than that of shallow rock, the influencing factors of its physical and mechanical properties are more diverse, and the physical properties will also change.

In the process of excavation and reinforcement of surrounding rock in underground engineering, it is bound to encounter problems such as relaxation deformation of surrounding rock that threaten the safety of underground works. Therefore, it is necessary to study the factors affecting the physical and mechanical properties of rock, so as to provide theoretical basis for the excavation and reinforcement of deep rock.

There are many factors that affect the physical and mechanical properties of deep rock. Among them, the long-term action of groundwater on rock makes the relaxation deformation of rock more serious, and in the process of deep excavation, such as subway tunnels, roadways, urban underground transportation hubs, etc. In the construction process, it is easy to cause the loss of water in the surrounding rock through the cracks generated by excavation, and the water content in the rock also decreases. At the same time, the water in the external rock flows from the high concentration area to the low concentration area through diffusion, so that the lost water in the surrounding rock is supplemented, forming a water cycle between the inside and outside of the rock. In the past 20 years, major accidents have occurred frequently in foundation pit engineering and underground engineering. Among them, the probability of accidents in areas with abundant groundwater is high. According to the analysis of the causes of related accidents, long-term intermittent precipitation is one of the important factors for most accidents. For this reason, many scholars at home and abroad have studied it. Experiments show that [1], the interaction between rock and water will have a serious impact on the physical and mechanical properties of rock. Therefore, in order to study the law of deterioration of rock mechanical properties by dry-wet cycle, the dry-wet cycle of rock is usually carried out in the laboratory to simulate the change of water content in deep rock, and then further mechanical properties analysis is carried out. Therefore, the conclusions can be widely used in engineering practice, and provide theoretical basis for rock excavation and support engineering.

II. Research status

The drying-wetting cycle of rock refers to the process of saturation-drying of rock. A small number of cycles have no obvious effect on the deterioration of rock mechanical properties, but multiple cycles can accumulate this deterioration effect until the rock is destroyed, causing catastrophe.

The dry-wet cycle test of rock is to soak the test block in distilled water with an average temperature of 22±3°C for 24 hours, and then place it in an oven at 105°C for 24 hours. This process is a dry-wet cycle. Due to the different degrees of cumulative damage caused by the dry-wet cycle of the rock, the current domestic and foreign scholars have a variety of test methods for the dry-wet cycle, and the focus is also very different. Therefore, in the dry-wet cycle simulation experiment, the environment of the rock should be analyzed to select the best experimental scheme.

At present, researchers have carried out a large number of experiments on rock deterioration damage caused by dry-wet cycles. Liu Xinrong [2-3] and Fu Yan [4] systematically tested the deterioration law of shear strength of sandstone under dry-wet cycles. It was found that the shear strength of sandstone under saturated state was much lower than that under dry state. When pH = 4, the shear strength of sandstone gradually decreased to 30% of the initial strength with the increase of the number of dry-wet cycles. The rate of decline at pH=7 and pH=9 was significantly lower than that at pH=4. It can be seen that the shear strength of sandstone in acidic environment is the most serious, followed by alkaline and neutral. The lightest. At the same time, Liu Xinrong and Fu Yan carried out research on the meso-degradation damage of rock by periodic dry-wet cycles. It was found that the damage of rock changed rapidly in the early stage of dry-wet cycles, and the damage evolution rate of rock gradually decreased when the number of dry-wet cycles was greater than 3. This is similar to the research results of Zhang Liang [5] and Li Ning [6].

Song Yongjun [7] and Xie Kainan [8] used nuclear magnetic resonance (NMR) to study the influence of dry-wet cycle on the damage characteristics of sandstone. It is concluded that the area and porosity of T2 spectrum gradually increase with the increase of dry-wet cycle times, and the rate is the largest in the stage of N<3, then the growth rate decreases continuously and finally tends to be stable. The functional relationship between dry-wet cycle and damage degree is established. It is found that with the increase of dry-wet cycle times, the damage rate of the specimen decreases continuously until it tends to a fixed value. This conclusion is similar to the research results of Liu Xinrong and Fu Yan. Regardless of the rock deterioration curve in acidic environment, alkaline environment or neutral environment, with the increase of dry-wet cycle times, the damage degree of dry-wet cycle to rock tends to be fixed.

Song Chaoyang [9] studied the microscopic deterioration mechanism of sandstone under dry-wet cycles by saturated water experiment, scanning electron microscope and acoustic emission test. Yao et al. [10] used microscope to study the evolution law of sandstone crack propagation and the process of instability and failure of sandstone specimens under dry-wet cycle. The research on rock deterioration damage caused by dry-wet cycle is mainly carried out by scanning electron microscopy, nuclear magnetic resonance technology, acoustic emission technology and so on. In fact, the process of crack propagation and failure during rock loading is essentially a process of energy release and dissipation, which can better characterize the nature of rock deformation and failure from the energy point of view [11-12]. Chen Ziquan [13], Jiang Jingdong [14] and Li Tianbin [15] studied the effect of water content on rock energy damage, and found that the change of water content will lead to the storage and release mechanism of rock energy becoming more sensitive. Zhang et al. [16] studied the influence of water content, bedding and pore size on the tensile strength and energy of phyllite by carrying out Brazilian splitting test, and found that the anisotropy of tensile strength and the number of cracks were positively correlated with water content. Wang Zijuan [17] studied the effect of periodic dry-wet cycles on the properties of sandstone. Through uniaxial compression and triaxial compression tests, it was found that with the increase of the number of dry-wet cycles, the potential energy decreased logarithmically. By monitoring the long-term dry-wet cycle in simulated seawater environment, Sherif Yehia [18] found that there are salt deposits and micro-cracks caused by dry-wet cycle in cement slurry due to the penetration of seawater. The experimental results show that this phenomenon will affect the long-term durability of the structure and lead to the deterioration of the internal structure of the concrete, which will reduce the service life of the structure to a certain extent.

III. Conclusion and foresight

In summary, the dry-wet cycle has a significant deterioration effect on the physical and mechanical properties of rocks, and has a non-negligible impact on engineering projects involving rock mining and support. Therefore, it is necessary to study the physical and mechanical properties of rock under the action of dry-wet cycle, and great progress has been made. However, at present, the research objects of domestic scholars on the dry-wet cycle experiment of rock are relatively single, mostly sandstone and mudstone. There are many studies on the influence of acid-base solution on rock, mainly from uniaxial compression, triaxial compression, scanning electron microscopy and Brazil splitting. In terms of uniaxial compression and triaxial compression,

the variation trends of compressive strength, shear strength and triaxial creep of sandstone under dry-wet cycle conditions are mainly studied. In the scanning electron microscope (SEM) test level, the influence of dry-wet cycle and acid-base test on the internal of the specimen was observed by electron microscope at the micro level, and the cross analysis was carried out in the aspects of rock erosion corrosion and physical and mechanical properties. In the Brazilian splitting test, in order to measure the tensile strength of rock simply and effectively, the splitting test is usually used to study the variation of mechanical parameters and failure modes with the bedding direction from both experimental and numerical aspects, which is also one of the common methods for measuring the tensile strength indoors.

Previous studies on the dry-wet cycle of rock have been very perfect, and the physical and mechanical properties of rock have been studied in many aspects. However, there are few studies on the combination of concrete and rock, and the relevant data are also poorly understood. In the supporting stage of underground engineering, the rock and the solidified concrete form a supporting structure, and the water in the rock will also be transferred to the concrete, forming a dry and wet cycle, causing damage to the supporting structure and affecting the safety of the underground structure. At present, the research does not take the combination as the experimental object, and the deterioration damage data of the dry-wet cycle of the combination is not perfect. Therefore, the relevant experiments can be improved from the following aspects by replacing the research object from the rock to the combined test block of concrete and rock, and combining the existing research results at home and abroad :

(1) In the aspect of dry-wet cycle experiment, it is also necessary to extend the experimental period of dry-wet cycle for the construction period of underground engineering, so that the research results are more suitable for engineering practice, and have more reference value for areas with sufficient rainwater.

(2) In the aspect of acid-base experiment, the material ratio of the combined test block should be studied in depth, and the control test should be carried out according to the type of fiber and the particle size of sand and gravel particles, so as to develop the mix ratio of concrete and rock combination which is more suitable for acid-base environment and improve the safety and durability of the structure.

(3) In the aspect of chloride ion erosion experiment, the concentration of ion erosion during construction in coastal areas should be further understood. The ion erosion experiment should be carried out indoors to study the performance of components under random ion erosion depth, and the corresponding fatigue life prediction should be established for the erosion of concrete components in splash zone.

(4) It is still necessary to comprehensively study the durability of the combined test block under the coupling of multiple factors. The combination of dry-wet cycle, acid-base corrosion and chloride ion erosion is used to systematically study the fatigue performance of the combined test block.

At present, the author will take the above four points as the research focus, conduct an in-depth study on the failure law of concrete composite under dry-wet cycle, further integrate the effects of dry-wet cycle, acid-base corrosion and chloride ion erosion on practical engineering, and apply the theory to practical engineering.

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