Mechanical Properties and Apparent Morphology of Sandstone under Chemical Corrosion Conditions

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Abstract. The rise of the underground engineering provides more guarantee and convenience for human life, and the mechanical property of the surrounding rock is gradually lost, which has great harm to the long-term stability of the project. In that context of the environmental background of the project under the base of this article, firstly, a sandstone sample is taken at the site, a test sample of suitable size is made in the chamber, and then the test sample is arranged in a special device to simulate the simulated corrosion in the background of the simulation environment. Finally, the mechanical properties and apparent morphology of rock samples under different corrosion conditions were studied. The results show that the loss of the mechanical properties of the rock under different corrosion conditions is large, and the change of the acid and alkali of the solution is larger and the rock is The more obvious the damage difference of mechanical properties is, the more obvious the difference is that the pH value is from low to high, the peak strength loses 52%, 27.7%, 7%, 23%, 54% respectively. The failure morphology of corroded sandstone shows special conical morphology. Finally, the equivalent strain principle is used to interpret the corrosion of sandstone. The research results can be used for reference and reference for the long-term stability control of underground engineering based on water corrosion environment.

1. Introduction
With the rapid growth of the domestic economy, the "One Belt And One Road" policy implementation, people's underground exploration has also had a further development. In the absence of recognizing the characteristics of rocks in the underground environment, unreasonable and blind excavation and construction, there will be serious safety risks in the construction, so the study of rock characteristics is essential. The location of rock is more complex, different factors have different effects on its influence, and water chemical factor is one of the main factors affecting rock characteristics \cite{1}, it is urgent to study the characteristics of rock in water chemical environment.

Some research on rock in water environments is also common, Feng Xiaoting and others\cite{2} have passed the tests under different stress states, The erosion of the chemical environment of the rock fracture characteristics was examined; Chen Sili and others\cite{3} conducted a granite uniaxial compression and fracture test under chemical corrosion, Actual observation using digital microobservation system; Ding Wuxiu and others\cite{4} studied the triaxial compression damage process under penetration and precast fracture sandstone through CT scanning test; Han Tielin and others\cite{5} studied the physical and mechanical properties of sandstone after soaking in different aqueous chemical solutions, The corrosion degree of pH, concentration and hydrochemical composition of

\[ pH = \text{constant} \times (\text{concentration}) \times (\text{hydrochemical composition}) \]
solution to sandstone were analyzed. The water chemical corrosion mechanism of sandstone specimen is discussed. So far, many scholars have compared and analyzed the corrosion degree of sandstone by solution pH value, concentration and hydrochemical composition, and its mechanical properties [6-8], and the characterization of rock and its mechanism in the hydration state [9-11]. Similarly, the study of pH values and microscopic particles is important for mineral flotation [12-14].

However, the above results are the effects of mechanical or surface damage in a single study and are not organically combined. Based on the above research, indoor simulation test, study the mechanical characteristics of sandstone samples in five different hydration states, use data obtained from uniaxial compression test to calculate tensile and bending strength, and evaluate the damage form of sandstone samples under different water chemical states during the experiment, which provides important engineering significance for the safe construction of geotechnical engineering in hydrochemical corrosion environment.

2. Corrosion Environment of Sandstone Mechanical Properties Test

The blocks used in the test were quartz feldspar sandstone. The irregular blocks obtained on the site obtained the Φ50mm*60mm cylindrical specimen through the rock core rig, and then polished the sample surface, smooth and placed in the ventilation place for air dry treatment.

According to the actual situation of the field water chemical environment, the configured solution concentration [15] is shown in table 1.

| Table 1. Design ratio of aqueous chemical solution* |
|-----------------------------------------------|
| Solution Number | Ingredient | Solution Concentration/mol/LpH |
| 1              | HCL        | 0.1                           |
| 2              | HCL        | 0.1                           |
| 3              | Distilled Water | /                  |
| 4              | NaOH       | 0.1                           |
| 5              | NaOH       | 0.1                           |

*Remove several samples every 30 days at the YR-2000 rock creep for uniaxial compression test

See table 2 for the parameters.

| Table 2. Main technical parameters of yr-2000 rock creep meterb |
|-----------------------------------------------|
| Maximum axial load | Axial force measurement accuracy | Dismeasurament range | Dismeasurament accuracy | Deformation limit value Axial and Radial direction | Demeasurament resolution |
|-------------------|---------------------------------|---------------------|------------------------|-----------------------------------------------|-----------------------|
| 2000kN            | <=1%                            | 1-100mm             | <=1%                   | 5mm、2.5mm                                     | 0.001mm               |

bUsing the displacement control method, the designed displacement load rate of 0.5mm/min, damage detection threshold is 50%, and it is believed that when the strain of the rock sample reaches the peak strength, the strain has weakened to 50% believes that the rock sample has damaged [16].

3. Mechanical Properties of Sandstone Under Corrosion Conditions

3.1. Stress - Strain Characteristics

The control variable method tests only the stress - strain curve under the same solution of pH. Sandstone stress - strain curve in different states is as shown in Figure.1-5.
In the process of stress start loading into the sample failure, the sample has experienced 5 stages: compression phase, elastic phase, yield phase, crack expansion phase, and failure phase.

The first stage is the compression stage. This phase is related to the microstructure of the rock. The gap inside the rock grew smaller under pressure. Until the press is to close, Overall, "U" shaped concave trend; The second phase is the elastic phase. The friction within the rock increases with stress. Make the interior of the rock even closer; The third phase is the yield phase. As the stress increases, According to Figure 1-5, no significant yield phase occurs except for pH=7. Other pH values all appear or have long or short yield stages; Stage IV is the crack expansion stage. The original cracks were significantly significantly, Mixed together with new cracks. Rock mass strength has decreased significantly. Stress growth rate is becoming significantly faster; Phase 5 is the destruction stage. The strain has no longer increased with the stress, The rock mass is seriously deformed and then damaged.
3.2. Changes of Mechanical Parameters of Sandstone Under Different Acid and Alkali Conditions

It is seen from Figure 8-10, there is a peak of 90d and greater than 60d and over 30d for the strain peak. Peak the lowest acidic and alkaline at pH= 5 and pH= 10, and the solution pH lower or higher than pH= 5 will increase the pH= 10. The peak elastic modulus of 30d is the highest, and similarly, the closer to pH= 7, the higher the peak elastic modulus of sandstone, and the overall trend presents a "convex" shape. The overall trend of the peak intensity is roughly the same as the peak elastic modulus.

3.3. Deformation Strength and Time Effect of Sandstone Under Different pH Degree

It is seen from figure 11-13 that in the solution with high acid base, the corresponding strain peak increase is significantly increased, with the largest difference between the rock peaks of pH= 2, 86% between 30d-60d, 25% between 60d-90d, and the difference between the rock peaks in the solution of pH= 13. The corresponding pH values of elastic modulus of rock samples in different aquochemical
solutions decreased from large to small are pH= 2, pH= 5, pH= 13, pH= 7, pH= 10, and the calculated data are 63% , 54% , 38% , 31% and 15% , respectively. Meanwhile, at the same time, the initial peak intensity of the rock sample corrosion was significantly higher than that of the later stage, indicating that the initial chemical reaction of the rock sample is the most intense and then becomes chronic chemical reaction.

4. Theoretical Interpretation of Sandstone Corrosion

Huo runke et[17]analyzed the damage constitutive model of rock.

If the initial damage state of sandstone is taken as the first state and the state after acid corrosion as the second state, the equivalent elastic modulus after acid corrosion can be expressed as:

\[ E = E_0(1 - D') \]  \hspace{1cm} (1)

In formula: \( E \) Equilastic modulus after acid corrosion of sandstone; \( E_0 \) Flexible modulus of unacid - corroded sandstone.

Based on the principle of Lemaitre and damage mechanics theory, the damage constitutive relationship of sandstone under uniaxial compression is as follows:

\[ \sigma = E \varepsilon (1 - D) \]  \hspace{1cm} (2)

In formula: \( \sigma \) Stress; \( \varepsilon \) Strain; \( D \) damage variable.

Using formula (1) into formula (2), the damage constitutive relationship of acid-corroded sandstone under uniaxial compression is:

\[ \sigma = (1 - D)(1 - D')E_0\varepsilon \]  \hspace{1cm} (3)
According to the previous data, the greater the acid and base degree of the solution, the more the H and OH-ions exist in the solution, the stronger the corrosion to the rock mass, the greater the damage is, the greater the D value. In the case of pH= 7, only a small amount of H ions and OH- ions are separately free in the solution, that is, the degree of sandstone damage in the solution of pH= 7 is less than that in the remaining pH solutions. According to formula (3), the stress - time curve form is a relatively high parabola, while with the increase of acid - base concentration, the sandstone stress - time curve form in its solution is a low parabola. This also corresponds with FIG. 14, with the sandstone stress - time curve form height in pH= 7 solution above the remaining pH and the lowest sandstone stress - time curve height in pH= 2 and pH= 13.

5. Conclusion
This paper observed the sandstone corrosion in different hydration states and drew the following conclusions:

(1) In sandstone, the stress - strain curve shows the front section and the back end.

(2) Sandstone in hydration state is more likely to destroy in the same force field environment. The sandstone failure form in pH= 7 solution is cylindrical fracture destruction, while the sandstone failure form in other pH solutions is mostly conical destruction.

(3) Significant mechanical performance loss of sandstone after corrosion of hydration solution. pH value ranged from low to high, with peak strength lost 52% , 27.7% , 7% , 7% , 23% and 54% ; after long corrosion, sandstone showed softening trend of 63% , 54% , 38% , 31% and 15% respectively. That is, different hydration solutions for different sandstone corrosion conditions, the greater the acidity and alkalinity, the more serious the corrosion situation.

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