Research Progress of Unsaturated Strongly Weathered Sericite Schist Residual Soil

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Abstract. The settlement and deformation of soft rock are the main problems hindering the construction of tunnel engineering. The use of soft rock and its residual soil has become the focus of engineering development at home and abroad. Sericite schist is an extremely soft rock, and most of the sericite schist residual soil in nature is in an unsaturated state. The Baishitou Tunnel of Dali-Lincang Railway is located in Yun County, Lincang City, Yunnan Province. The surrounding rock in the tunnel is mainly soft rock, such as sericite schist and carbonaceous schist. Due to the action of the earthquake, the rock mass is easily broken and its strength is low, making construction extremely difficult. Strongly weathered sericite schist has the characteristics of soft rock, easy to weather, and the rock mass is relatively easy to break. Its residual soil has similar properties to its parent rock and is often encountered in actual engineering. The research on unsaturated strongly weathered sericite schist and its residual soil has become the focus of research by scholars at home and abroad. The engineering properties of unsaturated soils have become one of the main research directions of soil mechanics.

1. Introduction
Kunming belongs to the Yunnan-Guizhou Plateau. The sericite schist particles are relatively uniform and the content of clay particles is low, generally not exceeding 10%. It has fewer fine particles, high porosity, and strong capillary action. Therefore, after encountering water, it easily reacts with water to destroy its structure. Water has a great influence on the stability of sericite schist in deep-buried soft rock tunnels, and its softening in contact with water is one of the main reasons that threaten the safety of tunnel construction and operation. Sericite schist is a kind of extremely soft rock. Soft rock is a general term for a type of rock that has low mechanical strength, large porosity, poor degree of cementation, and is easy to swell, soften and disintegrate in contact with water. These characteristics of soft rock are used in practical engineering. It is easy to cause problems such as landslides, roof falling, and collapse [1-2]. These problems will hinder the progress of the project, affect its progress, and also pose a great threat to the safety of construction workers. Therefore, the research of physical and mechanical properties of soft rock plays an important role in actual engineering.

Many scholars at home and abroad have conducted a lot of theoretical and practical research on the softening characteristics of soft rock in contact with water. Wu Daoxiang et al. [3] in view of the softening and disintegration characteristics of red soft rock in contact with water, the main factors and disintegration mechanism of the disintegration of red soft rock were studied; Su Yonghua et al. [4] observed the changes in the particle level of the fragments during the rock disintegration through laboratory tests and simulated atmospheric conditions in the gradual disintegration test, and concluded that the disintegration process of soft rock is a multifractal process. Kang Tianhe et al. [5] studied the
effect of soft rock surface coating modification through comparative experiments on the disintegration characteristics of two types of soft rocks with mainly stone and montmorillonite content.

2. Materials and physical and mechanical parameters
The experimental materials were taken from the Baishitou tunnel section of the Dalin Railway in Yunnan Province, and some soil samples were collected for testing. The sample is gray, as shown in Figure 1. It belongs to the lower Paleozoic Lancang Group sericite schist, sericite schist intercalated with carbonaceous sericite schist zone. Affected by structure and weathering, the rock is severely broken and the degree of weathering is high. A large amount of residual soil is formed. Sericite schist is weak, fragile, slightly expansive, and easily reacts with water. Adding a small amount of water will reduce the strength of the rock.

The sericite schist was scanned by electron microscope, X-ray diffraction spectrum (Figure 2), and the lithology and mineral composition of the sericite schist were analyzed. The results are shown in Table 1 below.

![Sericite schist residual soil](image1)

![X diffraction spectrum](image2)

Figure 1. Sericite schist residual soil

Figure 2. X diffraction spectrum
Table 1. Soil mineral composition

| Mineral composition | Mineral content (%) |
|---------------------|---------------------|
| Quartz              | 35-45               |
| Mica                | 25-35               |
| Plagioclase         | 1-5                 |
| Kaolinite           | 5-10                |
| Dolomite            | 5-15                |

3. Results
The mineral composition of sericite schist obtained from the test is:

1. The composition of mica mineral is the highest, reaching about 50%, followed by quartz with a content of about 30%, and some feldspar and a small amount of illite and montmorillonite.

2. Mainly exclude soil minerals. Illite has a book-like structure stacked on one side and is a highly hydrophilic mineral. Montmorillonite is a flaky crystal, the color is white gray, or light blue or light red. After absorbing water, it can expand and exceed its original volume several times.

4. Test methods and equipment
The test method is divided into cyclic triaxial test, cyclic torsion shear test, cyclic simple shear test, resonance column test, etc. according to the test equipment; according to the control method during the test, it is divided into stress control type and strain control type.

Cyclic triaxial test refers to a test in which an axial cyclic load is applied to one or both ends of a triaxial specimen; a cyclic torsional shear test refers to a dynamic test in which a cyclic torsional shear force is applied to the specimen; a cyclic simple shear test refers to a test in which a cyclic shear force is applied to the sample. The resonance column test refers to the application of torsion shear or axial force on one end of the sample, under which the dynamic load frequency is changed to make the sample resonate to obtain the shear wave velocity of the soil sample or compress the wave speed, and then get the experiment of the dynamic properties of the sample. The stress-controlled cyclic test refers to the cyclic dynamic load applied during the test so that the stress amplitude on the sample remains unchanged. While the strain-controlled cyclic test refers to the cyclic dynamic load applied during the test to make the sample, the strain amplitude remains unchanged in the test. Due to the focus of the research is different, different experimental methods simulate different cyclic vibration forms of soil samples, so the differences or even differences in the experimental results obtained are understandable. Therefore, it is necessary to consider the influence of experimental methods when comparing test results.

5. Dynamic characteristics and influencing factors of soil creep
Dynamic loads include seismic loads, vehicle vibration loads, ocean wave loads, explosion loads and so on. Soil dynamics is a new branch of soil mechanics. It is the product of the combination of soil mechanics, structural mechanics, earthquake engineering, and geotechnical anti-seismic science. The research carried out is relatively systematic. According to the research and the application situation can basically be divided into three aspects: the research and application of soil dynamic response, the research and application of soil dynamic characteristics and soil dynamic test. The dynamic characteristics of soil under dynamic load involve many issues such as sample factors, test methods, conditions and load factors.

6. Cycle history
The history of cyclic loading refers to the cyclic loading experienced by soils in different consolidation states. The history of cyclic loading has a certain impact on the properties of soil. For normally consolidated soils, the pre-shearing effect increases the ability of normally consolidated clays to bear cyclic loads. For over-consolidated soil, the influence of pre-shearing on its strength seems to be inconclusive. Matsui et al. believed that with the dissipation of pore pressure after cyclic shear, the undrained shear strength and deformation modulus were slightly increased, which was similar to that of
normal consolidated soil. But Andersen et al. and Yasuhara et al. found the opposite results for the Dramme clay. The conclusion is that after the cyclic action and with the drainage process, the undrained shear strength will still decrease. That is, the resistance to further undrained cyclic load will be weakened. The reason for this diametrically opposite conclusion may be related to the way of loading and the structure of the soil, especially the size of the over-consolidation ratio. The greater the over-consolidation ratio, the greater the damage to the soil structure caused by repeated shearing. The pore pressure dissipation has little effect on the undrained shear strength during cyclic loading, that is, the performance of the soil after pre-shearing. Attenuation of the intensity. After pre-shearing, the soil shows a weakening of strength.

Ding Zude, Zhang Qingwen, et al. [6] statistically analysed the relationship between peat soil shear wave velocity and soil depth and physical indicators and the dynamic shear of peat soil. According to collecting Kunming peat soil dynamic test data and carrying out peat soil dynamic triaxial test. The changes of shear modulus ratio and damping ratio with shear strain are compared and analysed with cohesive soil. The results show that peat soil is a kind of highly compressible soft soil, and its dynamic characteristics are affected by many factors, such as low dynamic strength and complex dynamic characteristics.

It can be seen that due to the complexity of the dynamic characteristics of soil under dynamic loads, they still lack of a certain degree of system, although there are many existing research results. In addition, some important dynamic characteristics of soil have not yet reached a consistent conclusion. Therefore, it is still necessary to conduct in-depth research on the dynamic characteristics and mechanism of soil removal. At present, the dynamic deformation characteristics of the strongly weathered sericite schist under no dynamic load are combined with the static creep deformation characteristics.

7. Amplitude and frequency

Amplitude refers to the size of the cyclic load, such as cyclic stress level or dynamic strain level, and the number of vibrations refers to the number of cyclic loads or the time of vibration. The influence of cyclic stress level and cycle number on the dynamic properties of soft clay is mainly manifested in the definition of critical cyclic stress ratio and minimum cyclic stress ratio.

With the increase of cyclic stress, the pore pressure and strain develop faster. The size of cyclic stress not only affects the change of pore pressure and strain, but also determines the development mode of pore pressure and strain. Saturated soft clay has a critical cyclic stress ratio. When the cyclic stress ratio is less than the critical cyclic stress ratio, with the increase of the number of cycles, the pore pressure and strain gradually increase, but the increase is slow and the soil will not fail until a higher number of times. When the cyclic stress ratio is greater than the critical cyclic stress ratio, the strain and pore pressure increase rapidly with the increase of the number of cycles. And failure occurs in a smaller number of cycles.

As the number of cycles increases, the pore pressure and strain also increase. Saturated soft clay has the lowest cyclic stress ratio. When the cyclic stress ratio is less than this value, as the number of cycles increases, no pore pressure and strain are generated. Matsui et al. also found a similar phenomenon through stress-controlled cyclic triaxial tests. Zhou Jian et al. [8] obtained Hangzhou soft clay the lowest cyclic stress ratio was 0.02 through experiments. Ohara and Matsuda conducted stress-controlled cyclic direct shear tests on Kaolinte saturated clay and found that 0.05% is the lowest cyclic strain value of the clay. Vveetic et al. studied the influence of soil plasticity index P and over-consolidation ratio OCR on the minimum cyclic strain. The results show that the minimum cyclic strain increases as PI and OCR increase.

For the study of soil-water characteristics of unsaturated soils, the joint work of Nuth and Laloui (2008), Masin and Uchaipichat and others showed that the soil-water curve depends on the stress state. In other words, the change of the stress level causes the change of the porosity of the soil, which leads to the change of the water holding capacity of the soil. Brooks-Corey (1964) and Xing (1994), Williams (1982), Burdin and others have established a series of soil-water characteristic models through research. In China, Liu Xiaowen (2009) used the filter paper method to measure the soil-water characteristic curve
of unsaturated red soil, and analysed the relationship between its matrix suction and moisture content and density. Cheng Dongbing (2009) conducted a soil-water characteristic curve test on purple soil in the Three Gorges Reservoir area and fitted its curve model. Chen Hui (2013) et al. [7] established a dynamic model of soil-water characteristic curve based on the theoretical model of porous media thermodynamic mixture.

Liu S (2014) et al. [8] used a separate Hopkinson pressure rod device to study the dynamic mechanical properties of sericite quartz schist under confining pressure. And found that due to the effect of confining pressure, the normal stress on the damage surface of the rock increased accordingly, the bearing capacity of the crack friction exceeds the cohesion of the material. He Yong (2012) et al. [9] conducted tests on the longitudinal and transverse wave velocities of sericite schists and found that the wave velocity decreased significantly when the strongly weathered sericite schist was in a saturated state, and it had a significant time effect. Liu Shi (2011) et al. [10] used a separate Hopkinson pressure bar (SHPB) device to conduct impact dynamic tests on sericite quartz schist and sandstone. And found that the ability of sericite quartz schist to absorb energy was weak; they also used the hydraulic serve pressure testing machine carried out the compression test of sericite quartz schist under different impact loads. The test results showed that the dynamic compressive strength, specific energy absorption and failure morphology of sericite quartz schist all showed significant strain rate correlation. However, the correlation between the elastic modulus and the strain rate is weak.

8. Conclusions
At present, the commonly used definition of soft rock can basically be attributed to the category of geological soft rock. According to geological lithology, geological soft rock refers to low strength, large porosity, poor degree of cementation, and is affected by structural surface cutting and weathering. Loose, soft and weak rock formations that significantly or contain a large amount of expansive clay minerals. Most of these rocks are mudstone, shale, siltstone and argillaceous sandstone with uniaxial compressive strength less than 25 MPa, which are naturally formed complex geological medium.

Sericite schist has a certain degree of plasticity, which is one of the important reasons for large deformation of surrounding rock, and it mainly produced by hydrophilic substances and fragmentation. The weak surrounding rock mass of the tunnel along the line is broken, the structural surface is developed, and the mechanical performance is reduced. Moreover, the tunnel will have engineering problems such as large deformation, collapse, and floor heave due to the rheology of soft rock.

In summary, it is found that most of the research on the deformation and failure mechanism of the strongly weathered sericite schist is based on the saturated state, and the deformation and dynamics research under the unsaturated state is still lacking. Therefore, it is necessary to study the dynamic characteristics of the unsaturated strongly weathered sericite schist residual soil, which has important social and economic significance for improving the stability of the Dalin Railway subgrade.

Acknowledgments
Here, I would like to thank the colleagues of the company for their help and the support of my family, and the support of key R & D plan (Social Development) (2018BC008) of Yunnan Provincial Science and technology department.

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