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## Study on K<sub>0</sub> Characteristics of Unsaturated Loess Under Isotropic Stress Path

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# Study on K<sub>0</sub> Characteristics of Unsaturated Loess Under Isotropic Stress Path

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**Abstract.** Loess mainly distributes in arid and semi-arid regions of central and Western China. It is a typical structural soil with special structure and special sensitivity to water. Based on the analysis and summary of previous studies on the mechanical properties of loess, the quantitative and qualitative effects of various factors, especially consolidation conditions, on the mechanical properties of loess are compared and analyzed. The structural change characteristics of loess under isostatic stress ratio compression test were studied. The results show that the strength and deformation characteristics of the soil are not only related to the stress state, but also affected by factors such as the generation mode and the stress path.

## 1. Introduction

Natural soils may experience different stress paths during geotechnical engineering construction and operation, and the stress paths have a significant impact on the soil stress-strain relationship [1]. Based on various experiments of structural loess, the modified Cambridge model is used as the theoretical basis, and structural parameters with clear physical meaning are introduced to establish K<sub>0</sub> [2]. Due to the enormous difficulty in quantifying the structural structure of soil. The influence of soil structure has always been implied in the soil parameters. Only the results of micromorphology and chemical analysis can make some qualitative explanations for the changes of soil laws, but the requirements for solving practical problems of engineering are far from the same [3]. The results show that the pore pressure increases with the axial strain (compression or extrusion) under two types of equal stress ratio stress paths when the minimum negative pore pressure produced by the passive compression stress path at the beginning of the smaller confining pressure is neglected [4]. It increases rapidly at first and then changes slowly, and all of them are positive. Because the collapsible deformation of loess is catastrophic, discontinuous and irreversible, which causes serious harm to the project, it has always been a key technical problem in the construction of collapsible loess area. Some achievements have been made in the study of unsaturated loess structure and its elastic-plastic constitutive model at home and abroad [5]. The results show that the development characteristics of pore water pressure in soils are affected by stress path, consolidation state and stress level to varying degrees.

Generally speaking, soil has its unique structural characteristics, especially natural sedimentary soil. After a long period of consolidation in a specific environment, the particle characteristics, arrangement



characteristics and connection characteristics of soil vary greatly, which leads to the different strength and deformation characteristics [6]. Under undrained condition, pore water pressure behavior of soil is a basic problem. Skempton et al. based on elastic theory, the pore water pressure equation is widely used in geotechnical calculation. But the parameters are not a simple constant, but a variable related to the stress-strain characteristics of soils. The soil mechanics method is the most appropriate method to study the soil structure and its application. It divides the structural characteristics of soil into two aspects: the arrangement and connection characteristics of soil particles, and combines these two factors that affect the structural properties of soil. The standard of structural strength [7]. When the consolidation stress conditions are the same, the stress path has a great influence on the pore pressure development characteristics. For an axially loaded and radially unloaded type of equal stress ratio stress path, the pore pressure increases with increasing load stress ratio; for axially unloaded and radially loaded types of equal stress ratio stress paths, the pore pressure is the load stress ratio increases and decreases. Many geotechnical experts in China have devoted themselves to research in this area, and their results are quite rich.

## 2. Methodology

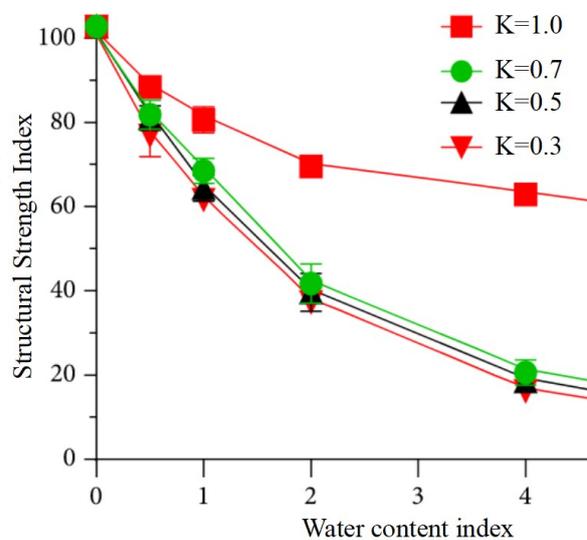
The special structure of loess makes it different from other kinds of soil in engineering properties. In the construction of Loess area, there are more and more problems related to the strength and stability of loess [8]. Therefore, the structural study of soil has attracted wide attention of scholars at home and abroad. Previous research objects are mostly soft soil and normal consolidated soil, but there is little research on pore pressure characteristics of loess under different stress paths. The proposed soil structural parameters based on this criterion are not only concise, reliable and practical, but also can fully reflect the geometric and mechanical characteristics of soil structural properties, and are closely and regularly related to the deformation and strength characteristics of soil [9]. On the effective ball stress and deviatoric stress coordinate system, there is approximately a unique effective stress path under various stress-stress paths of the axially loaded and radial unloading type. It is generally believed that the deposition of loess is the first to operate the wind, forming part of the native loess, and the secondary loess is formed by water. However, in the axial unloading and radial loading types, the various equal stress ratio stress paths have different effective stress paths, and as the load stress ratio increases, the effective stress paths are clockwise from right to left. Arrange [10]. Exploring new engineering techniques and new techniques applicable to the treatment and construction of loess layer foundation, and exploring the organic integration of structural research and constitutive model research to guide the design and construction of loess area engineering is the development trend of research.

**Table 1.** Structural strength of undisturbed loess under different initial water content.

Structural strength			p/kPa			
Stress ratio K			0.3	0.5	0.7	1.0
Water content	3.0	Intensity index	70	80	90	100
	6.0		50	60	70	80
	9.0		25	55	65	55
	12.0		10	20	45	30

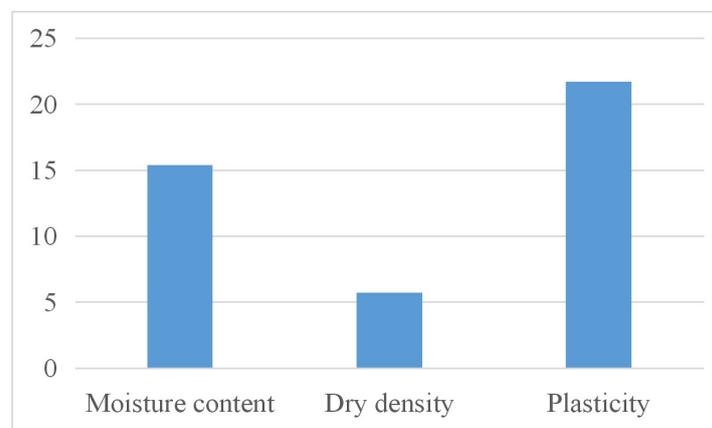
The structural nature of soil is the mechanical effect of the spatial arrangement of soil particles and the coupling between particles. Its importance has long been pointed out by Taishaji. Shen Zhujiang once pointed out that the study of soil structure is the core of soil mechanics in the 20th century problem. Under different stress paths, the pore pressure is caused by the combination of the average normal stress increment and the shear stress increment. The pore pressure caused by the average normal stress increment is independent of the nonlinear deformation characteristics of the soil. There is a significant nonlinear relationship between pore pressure and shear stress caused by shear stress. The

physical and mechanical properties of loess show some differences with the diagenetic areas of the diagenetic areas. The stratum is relatively thin, and its loess has high density, high strength, low compressibility, no collapsibility, and low water permeability. Previous studies have shown that the pore water pressure development characteristics of soils are affected to varying degrees by stress path, consolidation state and stress level. Loess is a sediment in arid and semi-arid areas. Its main characteristics are low water content, high porosity and high carbonate content. Because of its collapsibility and collapse in water, this unique structure directly affects the mechanical properties and engineering properties of loess. In this paper, Yangling saturated undisturbed loess is taken as the research object, and the influence of consolidation stress ratio on pore pressure development of saturated undisturbed loess under different stress paths is discussed through triaxial tests of consolidation undrained stress path under uniform pressure consolidation and  $K_0$  consolidation conditions.



**Figure 1.** The Curve of Relation between Structural Strength and Water Content

The stress-controlled triaxial apparatus is used in the test. The pressure is supplied by the air compressor. The force required is adjusted by a constant. The volume strain and the axial strain under different pressure levels can be measured in the test. The moisture content, dry density and plasticity of loess samples with a specific gravity of 3.0 are shown in Fig. 2.



**Figure 2.** Physical and Mechanical Index of Loess

### 3. Result Analysis and Discussion

The structural essence of soil is a display of the physical state of soil, a natural historical product of soil formation conditions and environment. The critical state model of structural loess can describe the two main characteristics of initial anisotropy and structurality of  $K_0$ -consolidated loess. Therefore, the study of the structural and changing laws of loess has important theoretical significance and application value. However, the subjects studied in the past are mostly soft soils and normal consolidated soils. There are few pore pressure characteristics of loess under different stress paths. Under undrained condition, pore water pressure behavior of soil is a basic problem. Skempton's pore water pressure equation based on elastic theory is widely used in geotechnical calculation, but its parameters are not a simple constant, but variables related to stress-strain characteristics of soil. The main body of the loess stratum is composed of loess, paleosol and calcareous nodule layers, which have high density, low compressibility and permeability. It is a good bearing stratum for the foundation. Through the loading test of equal stress ratio, the stress state of loess in practical engineering can be better simulated. Nevertheless, the study of the structural constitutive model of loess is restricted by the instrumentation of unsaturated soils, and there are still some defects in the micro-test. At present, there is no good constitutive model that can accurately and reasonably describe the stress-strain characteristics of structural loess under the combined action of force and water.

Soil structure is the mechanical effect of spatial arrangement of soil particles and intergranular bonding. Through disturbance and water saturation, the arrangement and bonding structure characteristics of undisturbed loess particles can be changed, and the structural potential of undisturbed loess can be fully released. The more prominent problems, such as leakage and deformation of irrigation channels, cracking and collapse of tunnels, post-construction settlement of high-grade highway foundations and instability of Loess slope, are related to loess's special structural characteristics, which need to be studied and solved urgently. Before structural strength failure, the smaller the stress ratio, the smaller the corresponding structural parameters under the same spherical stress, which reflects that the soil particles are in an unstable state and the unstable potential is larger under the condition of small stress ratio. The pore pressure of soft clay and clay is always negative with the increase of axial strain, which indicates that the pore pressure development is not only affected by the stress path, but also closely related to the physical properties and structural state of the soil. The stronger the original joint of the soil, the greater the strength loss after the disturbance remodeling, the greater the body strain that occurs under the force, and the larger the structural parameters of the soil. Under the same stress increment, no large mutations are caused, and after compression by different equal stress ratios, the undisturbed loess is finally compressed to the same compacted state. It reflects that after the structural strength is destroyed, the structural effect of the stress ratio on the soil is getting smaller and smaller.

### 4. Conclusion

The  $p$ - $\varepsilon_v$  curve of undisturbed loess and remolded loess is significantly different. The structure of  $p$ - $\varepsilon_v$  curve of undisturbed loess shows approximate elastic deformation stage, approximate plastic stage and deformation stability stage, while remolded loess exhibits compaction and deformation stability. 2 stages. It is better suited to normal consolidation or weakly overconsolidated saturated structural soils with initial  $K_0$  consolidation state, reflecting the initial stress anisotropy caused by  $K_0$  consolidation. The stress path has a great influence on the pore pressure development characteristics of saturated undisturbed loess under uniform pressure consolidation and  $K_0$  consolidation, but the influence of stress path on pore pressure characteristics during pressure consolidation is significantly different from that of  $K_0$  consolidation. On the one hand, the structural parameters defined reflect the force effect of the arrangement and connection characteristics of soil particles. On the other hand, it also reflects the size of certain structural potential of soil under certain stress state. The larger the structural parameters, the greater the structural potential of soil, and the less easy it is to destroy. When the consolidation stress conditions are the same, the stress path has a great influence on the pore pressure development characteristics of  $K_0$  consolidated saturated undisturbed loess. However, under different stress paths

with equal stress ratio, the effect of the change of loading stress ratio on pore pressure development is different. In order to simulate all kinds of stress process and natural state of soil in the actual construction process, stress path test method has been paid more and more attention by many scholars.

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