Experimental Study on Anisotropy of Intact Loess under Cyclic Loading

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Abstract. In order to investigate the effects of anisotropy of undisturbed loess on failure strength, dynamic shear modulus and damping ratio under cyclic loading, the dynamic characteristics of undisturbed loess in HaiDong area of Qinghai Province were studied by using the British GDS two-way dynamic triaxial test system. The results show that under the action of equal strain control cyclic load, as the number of cycles increases, the deformation of the sample gradually accumulates, the amplitude of dynamic strain decreases gradually, and the dynamic shear stress decreases. With the increase of dynamic shearing, the strain increases slowly and the strain hardening phenomenon appears. Different sampling angles have an important influence on the failure strength and dynamic shear modulus of undisturbed loess.

1. Introduction
Loess is a Quaternary sediment, accounting for 9.3% of the total land area of the world. China's loess covers an area of about 635,000 km², accounting for about 5% of the total area of the world's loess. Loess has special structures such as vertical development, large void structure and water sensitivity, which seriously affect the construction of infrastructure. In recent years, research on loess has yielded numerous results. Ye Chaoliang et al. [1], Wu Wenju et al. [2] explored the existence of anisotropy of undisturbed loess through a large number of experiments. Deng Longsheng et al. [3] studied the strength characteristics of loess under seismic loading. Wang Zhijie et al [4] carried out dynamic triaxial tests on undisturbed loess in different regions under cyclic loading, and considered that the mechanical properties of undisturbed loess have regional differences.

The regional distribution of loess leads to differences in its mechanical properties. At present, there are many research results, but not systematic. This study intends to use the British GDS two-way dynamic triaxial test system to conduct anisotropy test of undisturbed loess in HaiDong area of Qinghai Province, in order to provide reference for the foundation construction.

2. Test method
The undisturbed loess samples used in this test were taken from a construction site in HaiDong District, Qinghai Province, and were sampled at a depth of 4 m according to the standard [5]. The angles were different from the natural deposition direction according to the test standard [6] (0°, 30°, 45°, 60°, 90°) Preparation of undisturbed loess samples. The basic physical properties of soil samples are shown in Table 1. The test is carried out by means of strain-controlled equivalent cyclic load step-by-step loading. The loading diagram is shown in Figure 1. The confining pressure is 80kPa, 120kPa, 160kPa, the loading frequency is 1 Hz, and the equivalent cycle is 50 times per stage. The sample stops when it reaches the failure standard. In the test, this test considers the overhead structure of undisturbed loess. When there is no obvious yield point, it is considered that the axial strain reaches 5%, which is the soil-like damage
3. Results and Discussion

3.1 Dynamic shear stress relaxation

The relationship between the dynamic shear stress and the number of vibrations under cyclic loading is shown in Fig. 2. As the number of vibrations increases, the initial shear stress decreases rapidly and tends to be stable in the later stage. The original structure of the intact loess has strong shear resistance during the long-term natural deposition process. The strain amplitude of the sample is the largest at the initial stage of loading, and the maximum dynamic shear stress is obtained. Under the action of equal strain control cyclic load. As the number of cycles increases, the deformation of the sample gradually accumulates, the amplitude of the dynamic strain gradually decreases, and the dynamic shear stress decreases.

3.2 Dynamic stress-dynamic strain

Under different confining pressures, at different angles from the natural sedimentary direction, the dynamic shear-strain relationship curve of the undisturbed loess is shown in Fig. 3. As the dynamic shear strain increases, the dynamic shear stress increases rapidly in the early stage and slowly increases. Hardening phenomenon, the strength when the moving strain is 5% is the breaking strength of the original loess [7,8], the breaking strength of the undisturbed loess under different sampling angles is from 0°, 30°/60°, 45°. /90°, in the long-term natural deposition process, the arrangement of the soil
particles under the action of gravity makes them have higher strength in the vertical direction.

![Figure 3 Dynamic stress dynamic strain curve under different sampling angles](image1)

3.3 Dynamic shear modulus

Dynamic shear modulus is the dynamic shear stress required to produce a unit dynamic shear strain. Under cyclic loading, the modulus is the dynamic elastic modulus $E_d = \frac{\sigma_{\text{max}} - \sigma_{\text{min}}}{e_{\text{max}} - e_{\text{min}}}$. However dynamic shear modulus $G_d = \frac{E_d}{2(1 + \mu)}$. According to the actual conditions of the test soil, the dynamic Poisson's ratio of the borrowed soil is 0.3 [9, 10]. The relationship between the dynamic shear modulus and the angle of sample preparation under different confining pressures is shown in Fig. 4. The dynamic shear modulus of undisturbed loess increases with the increase of confining pressure, and the undisturbed soil sample is larger. Under the confining pressure, there is a high constraint around the sample, and the soil particles are in close contact with each other, so that they have a large bite force, a cohesive force and a frictional resistance between each other, and it is necessary to achieve a certain dynamic strain. Dynamic stress. With the increase of the angle of sample preparation, the dynamic shear modulus shows a decreasing variation as a whole, but the dynamic shear modulus of 60° is greater than the dynamic shear modulus of 40°.

![Figure 4 Dynamic shear modulus as a function of sampling angle](image2)

4. Conclusion

Taking the unsaturated undisturbed loess in HaiDong area as the research object, the dynamic shear modulus and damping ratio of the British GDS two-way dynamic triaxial test system were studied. The results are as follows:

1. Under the action of equal strain control cyclic load, as the number of cycles increases, the deformation of the sample gradually accumulates, the amplitude of dynamic strain decreases gradually, and the dynamic shear stress decreases.

2. Different sampling angles have an important influence on the failure strength, dynamic shear
modulus and damping ratio of undisturbed loess. The dynamic shear modulus decreases as the angle of the sample preparation increases.

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