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Experimental Study on Static Characteristics of Landslide Loess in Tianshui Region

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Abstract: **The disaster of loess landslide has a characteristics of wide range, great harm and difficult to control. Taking Tianshui landslide as the background, through field investigation and laboratory analysis of the sampling method, study the occurrence mechanism of landslide disaster; qualitative analysis of heavy rainfall and earthquake structure effects of loess, analyzed the relationship of water content on the slope stability, and reveals the physical properties and static properties of landslide soil through the test; by unconfined compressive strength test to undisturbed soil and remolded soil and saturated soil, analysized the undisturbed and remolded soil unconfined compressive strength compared to reflect the soil structure stability, the saturated soil and undisturbed soil unconfined compressive strength compared to reflect the variability of soil structure.**

Keywords: Landslide; Static characteristics; Comprehensive structural potential

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1. Introduction

Chinese northwest loess region where the average annual rainfall is smaller, but more concentrated and in rainy season (from July to September) single rainfall amplitude is bigger, on the slope stability of great harm, often resulting in large area of landslide and collapse geological disasters. Tianshui Panan town is the Loess beam like mountains of Weihe River Valley impact zone elevation 1300 - 1600 meters, mild climate, is a temperate continental climate, the Weihe River from west to east across the town, the total length of 12 km, Jing River flows 68154 cubic meters, Jinchuan River, 40 Pu River, Nan River, Wu Jia He four tributaries, is rich in water resources. Landslide events overview: 2013 July 15, 21 am, Gangu County dump a meteorological records since the biggest rainstorm, six hours rainfall of more than 100 mm, rainstorm and flood disaster resulting in houses collapsed, the collapse of the road, embankment damaged; 22, 7pm points, Dingxi Minxian county and Zhangxian county at the junction of 6.6 earthquake occurred, the earthquake affected Gangu County, disaster again. Damage increased again, multiple occurred landslides, mudslides, landslides and other geological disasters.

2. Analysis of landslide soil

Through field visits, collecting the related regional geological data and the undisturbed loess, according to local raw materials studies, Q2 loess clay content than ordinary loess high, the water absorption performance than Q3 loess is strong, but Q3 loess vertical joints is developed and the wet subsidence is Q2 large, porous, extremely easy to occur in case of water damage. At the time of earthquake, the surface of the slope is brought to the surface of the slope.

3. Indoor soil sample preparation

3.1. Preparation of undisturbed soil samples

Figure1. Landslide region and sampling position.

The soil sample cylinder marked on the direction of placement, and stripped the wax sealing tape, open the soil sample cylinder sample.

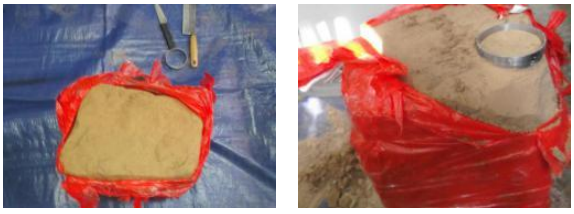

Figure 2. Undisturbed soil sample opening and cutting.

3.2. Preparation of disturbed soil sample

Take soil samples from the soil sample cylinder or

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packing bag removed, and uniformity of soil color, odor, inclusions and soil is described, and the soil samples were cut into pieces, mixing evenly, the representative soil sample determination of moisture content after sample preparation.

Figure 3. Remodeling soil grinding and preparation.

3.3.Saturated sample preparation

For fine grained soils with less than or equal to 10-4cm/s, the vacuum pumping saturation method can be used.

Figure 4. Vacuum saturated soil sample.

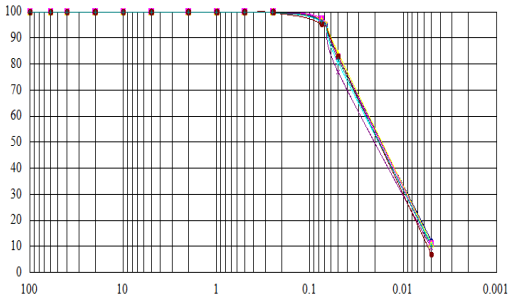


Figure 5. Particle size distribution curve of samples.

4. Physical property test and results

4.1. Particle analysis test

The density meter method for the determination of dry soil in various particle group for percentage of the total mass of the earth, to clear the particle size distribution for soil classification and rough estimation on soil engineering properties and material used.

4.2. Determination of basic physical properties

The following table is the basic physical properties of Panan loess.

Table 1. Basic physical index

Soil sample number	Average density (g/cm^3)	Moisture content	plastic index Ip	Average Specific gravity
1	1.57	23.3	9.1	2.6737
2	1.57	27.4	9.1	2.6737
3	1.57	32.6	9.1	2.6737

5. Static characteristic test and result

5.1. Compression modulus

The compression curves were obtained by using small sized consolidation apparatus according to 25KPa, 50KPa, 100KPa, 200KPa, 400KPa, 800KPa, and the compression e-p curve is as follows.

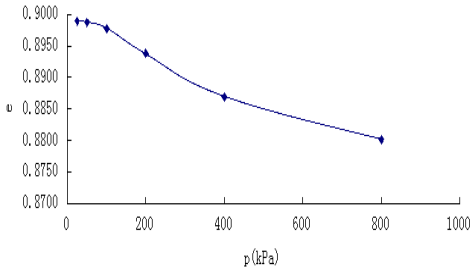
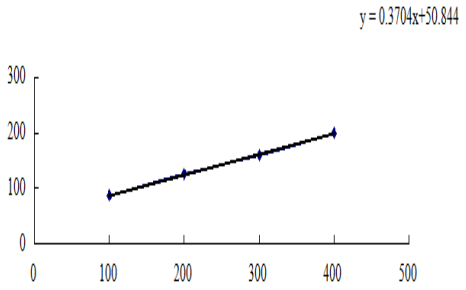


Figure 6. E-p compression curve of undisturbed soil.



Figue 7. Relationship curve of shear strength and vertical pressure.

5.2. Direct shear test

The relationship between shear strength and vertical pressure of undisturbed soil under natural state was obtained by using the direct shear strain controlled

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direct shear apparatus.

5.3. Compaction test

The relationship between dry density and water content of the real test was tested by light hammer.

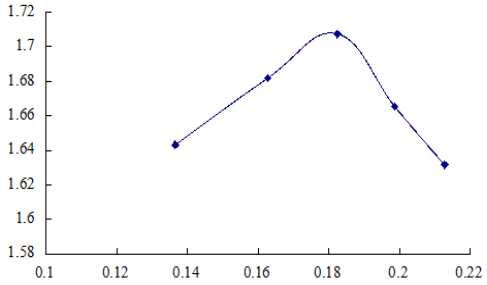

Figure 8. Dry density and water content of the compaction test.

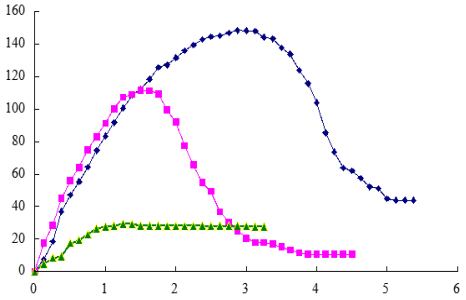

Figure 9. Relationship between axial stress and axial strain.

5.4. Penetration test

The permeability coefficient of cohesive soil was determined by the indoor South 55 type.

Table 2. Permeability coefficient index

Soil sample type	Permeability coefficient (cm/s)	Density (g/cm^3)	Dry density (g/cm^3)
Undisturbed soil	1.6× 10-5	1.57	1.40
Reconstituted soil1	1.44× 10-5	1.5	1.33
Reconstituted soil2	0.97× 10-5	1.58	1.410
Reconstituted soil3	0.29× 10-5	1.66	1.48

6. Structural analysis

The structural strength of loess is the ultimate strength of the specimen under the condition of no lateral pressure. From can reflect soil structural shear effect and convenient testing angle of follow the comprehensive structure potential theory, through undisturbed soil and remolded soil and saturated soil without side limit compression strength test, by undisturbed soil and remolded soil without side limit compression strength reflecting soil structure stability, by saturated soil and undisturbed soil without side limit compression strength reflect the variability of soil structure defined following structure index:

$$m_u = \frac{m_1}{m_2} = \frac{(q_u)_0/(q_u)_r}{(q_u)_s/(q_u)_0} = \frac{(q_u)_0^{\,2}}{(q_u)_r(q_u)_s} \qquad (1)$$

The structure of loess is an important physical property index, which influences the mechanical properties of the soil together with the grain size, density and humidity of the soil. The structure index of the loess is defined by the unconfined compressive strength of the soil. Through unconfined uniaxial compression test of loess, the uniaxial compressive stress-strain curves of natural moisture content undisturbed soil, reconstituted soil and saturated undisturbed soil are tested and analyzed.

According to the analysis of test results can be seen, the saturated soil sample strain with stress increases slowly increased, but the stress reaches a certain value, the soil sample in the creep condition, at this time has reached liquefaction, structural loss, loess slope prone to landslides or flow slide damage.

7. Conclusion and suggestion

In view of the heavy rains and earthquakes invasion combined effects of Gangu Panan town due to the road damage, large area landslide disasters in the field investigation, especially soil laboratory test shows that, without considering the dynamic pore water pressure influence analysis of the slip zone loess physical properties and static characteristics, the root according to the analysis of the loess collapsibility deformation mechanism and potential soil pressure, the slope landslide mechanism provides a theoretical basis and data support.

Through the research shows that the rainstorm and earthquake induced geological disasters affecting a wide range, the destructive power is strong, the slope water rates have skyrocketed due to heavy rainfall early, resulting in Loess shear strength reduction, seismic pore water pressure accumulated evoked whole sliding even for loess liquefaction occurs flowslide failure.

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