Engineering Geology 233 (2018) 11–22

Contents lists available at ScienceDirect

Engineering Geology

journal homepage: www.elsevier.com/locate/enggeo

Collapse behavior and microstructural alteration of remolded loess under graded wetting tests

Xianxian Shao[a], Huyuan Zhang[a,b,*], Yu Tan[a]

[a] School of Civil Engineering and Mechanics, Lanzhou University, Lanzhou, Gansu 730000, PR China
[b] Key Laboratory of Mechanics on Disaster and Environment in Western China, The Ministry of Education of China, PR China

ARTICLE INFO

Keywords:
Loess
Graded wetting collapse
Critical collapse saturation degree
Critical collapse void ratio
Microstructure

ABSTRACT

In the Loess Plateau of China, there is a long history of loess being remolded and compacted as a method to improve building foundations. However, low density remolded loess has been found to collapse upon wetting due to its metastable structure. This paper investigates the wetting collapse characteristics of remolded loess from an unsaturated state to a saturated condition, and describes the microstructural changes before and after collapse. A graded wetting collapse test was performed on remolded loess specimens with different dry densities to investigate the wetting collapse behavior. Scanning electron microscopy (SEM), laser diffraction (LD) and mercury intrusion porosimetry (MIP) tests were performed to establish a correlation between the microstructural evolutions and the collapse behavior. Results show that the critical saturation degree necessary for wetting collapse increased with increasing initial dry density, while it decreased as the vertical pressure increased. During the process of wetting collapse, the void ratios of remolded loess, with different initial dry densities, decreased exponentially along the same curve with increasing saturation degree. The collapsibility of remolded loess is mainly attributed to its inter-aggregate pore size, and the reduction of inter-aggregate pore size upon loading and wetting. Abundant intra-aggregate pores exist only in remolded loess with a lower dry density, which indirectly indicates that inter-aggregate pores in loess soil are unstable, and liable to collapse.

1. Introduction

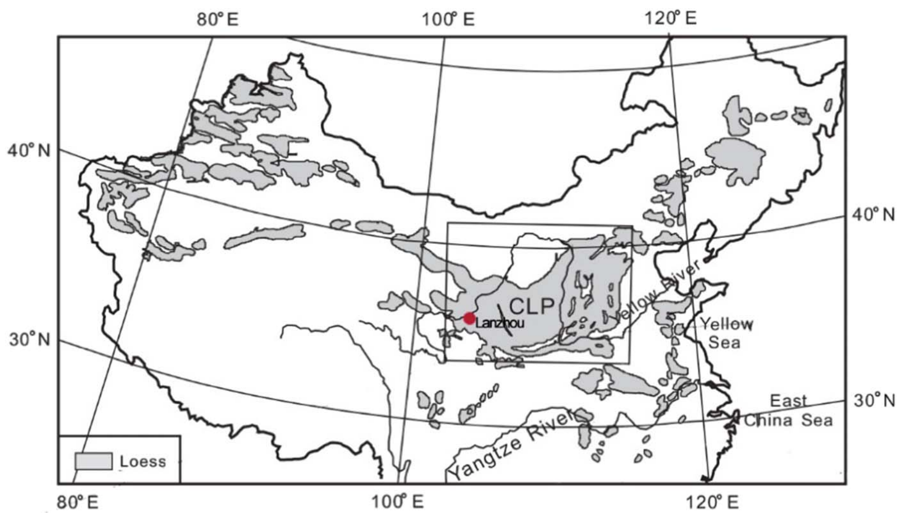
Loess is an aeolian sediment deposited under arid and semi-arid conditions during the Quaternary Period (Karl, 2001; Liu et al., 1999; Pye, 1995; Smalley & Rogers, 1996; Zhang, 1980). It is predominantly composed of silt-sized particles arranged in a meta-stable, high porosity, low plasticity fabric with carbonate cementation bonds (Zhang, 1980). Loess has low compressibility and high shear strength when it is dry. When wet, loess will collapse under its own self-weight or under load, demonstrating high compressibility and low shear strength.

China has the largest loess distribution in the world, covering some 631,000 km^2 of its mainland or 6.6% of its total area (Fig. 1a). The loess is generally thicker than 100 m over large areas of the Loess Plateau, with the maximum recorded thickness of 335 m near the city of Lanzhou in Gansu Province (Fig. 1b and c) (Derbyshire et al., 1995; Ding et al., 1998; Liu, 1965; Liu et al., 1980). In the Loess Plateau, the widespread availability and the local economy make the use of loess attractive as compacted fills in high-filled foundations, deep compacted highway embankments, artificial slopes and backfills (Hilf, 1991; Jing et al., 2005; Li et al., 2014; Zhang et al., 1998). Some research has shown that remolded loess with lower compactness still possessed collapsibility, even though its natural structure was broken (Sha & Chen, 2006; Wang et al., 2013; Wang et al., 2016). Problems associated with the collapse of remolded loess in compacted fills include differential settlement, cracks, structural damage and slope failure, which all pose a considerable threat to infrastructure and construction (Bowders et al., 2000; Derbyshire, 2001; Lawton et al., 1992; Wang et al., 2011).

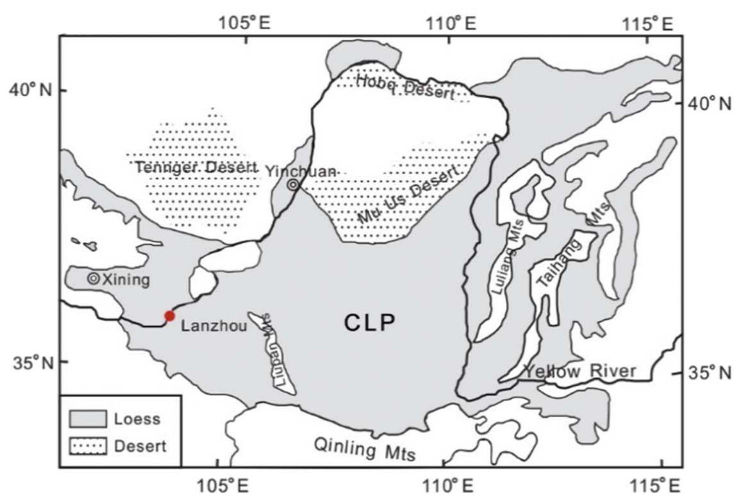
Single and double oedometer tests are conventional methods commonly used in the laboratory to evaluate the collapsibility of loess wetted to a fully saturated condition under loading. However, *in situ*, loess is often wetted to a specific water content, short of becoming fully saturated. Thus, the collapsible deformation of loess predicted from laboratory testing is often higher than for *in situ* conditions. The unsaturated collapse behavior of artificial structural loess, studied by Jiang et al. (Jiang et al., 2012), showed that the strain changes depending on different water content increments when subject to a confining pressure. For remolded loess, few investigations have studied the collapse behavior during the process of water content increasing before reaching saturation. In this study, a series of graded wetting collapse tests were conducted on remolded loess with different dry densities, to

* Corresponding author at: School of Civil Engineering and Mechanics, Lanzhou University, Lanzhou, Gansu 730000, PR China.
E-mail address: zhanghuyuan@lzu.edu.cn (H. Zhang).

https://doi.org/10.1016/j.enggeo.2017.11.025
Received 2 September 2016; Received in revised form 19 November 2017; Accepted 29 November 2017
Available online 05 December 2017
0013-7952/



(a) Distribution of Chinese Loess Plateau (CLP) in China



(b) Map of the Chinese Loess Plateau (CLP)

(c) Sampling site in Lanzhou, Loess plateau of China

Fig. 1. Location map showing loess distribution in China and the sampling site (Dijkstra, 2001; Hao et al., 2010). (a) Distribution of Chinese Loess Plateau (CLP) in China, (b) Map of the Chinese Loess Plateau (CLP), (c) Sampling site in Lanzhou, Loess plateau of China.