Study on Treatment Method of Wet and Soft Loess Foundation

QingYing Liu
Xi’an Peihua University, Xi’an, Shaaxi, 710125, China
Corresponding author’s e-mail: 569567056@qq.com

Abstract. In this paper, the mechanical characteristics of wet and soft loess foundation are analyzed. According to the past treatment methods of wet and soft loess foundation and some engineering practice experience, this paper outlines and enumerates some main methods for the treatment of wet and soft loess foundation.

1. Introduction
Loess is Quaternary sediment. It is widely distributed on all continents of the world. The total area is about 13 million square kilometers. It accounts for 9.3% of the total land area. The distribution area of loess in China is about 640,000 square kilometers, accounting for 6.7% of the total land area. The wet soft loess mainly refers to the Loess with a certain degree of saturation. Loess is softened by the accumulation and immersion of groundwater. Its physical state is plastic, soft and even fluid loess.

Roadbed construction technology in loess area is the main technical problem encountered in the construction of high-grade highway, and it has become one of the keys to the success of the project. Therefore, seeking economic, effective and reliable treatment measures of wet and soft loess foundation is related to the safety, function and investment benefit of the project. It is of great practical significance to study the treatment methods of wet and soft loess foundation.

2. The mechanical characteristics of wet and soft loess
Many experiments show that: When the water content of loess is less than 22% and the saturation is less than 60%, it will have obvious collapsibility. When the water content is more than 22% and the saturation is more than 60%, the collapsibility decreases or basically disappears. It has high compressibility, low strength and obvious wet and soft characteristics.

2.1. Low strength
The unconfined compressive strength is 15-34 kPa. The internal friction angle is less than 20°. The cohesion is generally less than 20 kPa.

2.2. High compressibility
When some collapsible loess is immersed in water, its collapsibility disappears and becomes wet and soft loess. Its compressibility is high, and its compressibility coefficient increases with the increase of liquid limit and natural water content of loess. Generally speaking, wet and soft loess foundation not only has a large amount of compression deformation, but also lasts a long time. Its compressive modulus is small. Generally, its compressive modulus is less than 15 MPa.
2.3. Low bearing capacity
The number of hits in standard penetration test of wet and soft loess is mostly 2-3 hits and 7-8 hits locally. The bearing capacity of foundation is generally 60-90 kPa.

2.4. No collapsibility or less collapsibility
The collapsibility of wet and soft loess has disappeared or decreased significantly after being immersed in water.

2.5. Thixotropic sensitivity
Once the wet and soft loess is agitated by vibration, its structure is damaged, the strength of the soil decreases obviously, even shows a flow state, stops disturbing, and the strength of the soil increases gradually after a period of time.

3. Treatment Method of Wet and Soft Loess Foundation
At present, the treatment of wet and soft loess foundation mainly refers to the treatment of soft soil foundation. This paper summarizes the treatment methods of wet and soft loess foundation in the past and some engineering practice experience. There are mainly the following treatment methods of wet and soft loess foundation.

3.1. Replacement method
Replacement method refers to the replacement of shallow and inferior soil layers under the foundation with hard, stable and high strength fillings. When the soft soil layer is thinner, it can be completely replaced. At the same time, the soil layer is compacted to achieve the required compactness and form a good artificial foundation. The main replacement materials for wet and soft loess foundation are sand, gravel, pebble, plain soil, lime soil, cinder, slag and other hard, high strength, stable performance and good corrosion resistance materials. The mechanism of replacement method is simple, it is easy to take materials locally and to construct conveniently, but the thickness of soil layer treated by replacement method is limited, which is mainly suitable for the treatment of wet and soft loess foundation with soil layer less than 3 m.

3.2. Powder jet pile method
Powder jet pile method refers to using cement, lime and other materials as the main solidifying agent, mixing soft soil and solidifying agent by special mixing machine in situ, and using a series of physical-chemical reactions between solidifying agent and soft soil to form a consolidated pile with integrity, water stability and certain strength, and forming a composite foundation with vertical bearing capacity with the original soil. This method is effective and reliable for improving the bearing capacity of soft soil foundation, reducing foundation settlement, preventing sand liquefaction and piping. The reinforcement depth of this method can reach 20-30 meters, but this method should not be used when the moisture content of wet and soft loess is too large.

3.3. stone column method
The gravel pile method refers to the method of squeezing the pile pipe into the stratum with vibration or impact load, forming holes in the soft foundation, then putting the gravel into the pile pipe from the entrance port of the pile pipe, then compacting and pulling out the pile pipe at the edge, forming a compact gravel pile, and forming a composite foundation with the soil around the pile. This method is mainly applicable to the treatment of wet and soft loess foundation with a thickness of 4-15 meters. After gravel pile construction, the pile body about 1 meter in length at the top of the pile is loose and its compactness is small. It should be excavated or compacted by rolling or tamping. Finally, the cushion should be laid. The thickness of the cushion should be 200-500 mm. It should not be too thick. The cushion should be layered and compacted. The material can be chosen as medium, coarse sand or mixture of sand and gravel.
3.4. Lime-soil compaction pile
Lime-soil compaction pile refers to the use of hammering steel pipe into the soil, so as to make lateral compaction into holes, after the pipe is pulled out, in the pile hole layer by layer backfill 2:8 or 3:7 lime soil compaction. Limestone has certain cementing strength and water stability. Limestone compaction piles and soil between piles form composite foundation to bear the upper load. This method belongs to transversely compacted soil layer. In the process of pore-forming, the compactness of the soil layer around the pile is improved by forced lateral compression by vibration. The compaction influence range can generally reach 1.5-2 times of the diameter of the pile.

3.5. Geotextile matting
Geotextile paving is to lay geotextiles in soft soil foundation or slope as reinforcement to form elastic composite soil, which plays the role of drainage, filter, isolation, reinforcement and reinforcement, so as to improve the bearing capacity of soil, reduce settlement and increase the stability of foundation. Geotextiles are characterized by soft texture, light weight and good continuity; convenient construction, high tensile strength, and basically the same strength in all directions; good elasticity, wear resistance, corrosion resistance, durability and microbial erosion resistance, capillary effect, good permeability and good dredging effect, and can discharge water. This method is suitable for strengthening soft soil foundation to accelerate the consolidation of soil and improve the strength of soil. It can be used for strengthening layers of highway and railway subgrade to prevent subgrade frosting and sinking.

4. Summary
The wet and soft loess has high water content, low strength and high compressibility. Therefore, only by effectively controlling drainage consolidation and preventing infiltration can the soil maintain high strength and good stability under the action of external factors. If the foundation is not treated or improperly handled, it will cause foundation instability and uneven settlement. When choosing the method of foundation treatment, the reasonable method of foundation treatment should be selected on the basis of comprehensive consideration of safety, ecology and economy. This paper summarizes several methods of treating wet and soft loess foundation, which should be used separately or jointly according to the actual situation in the actual process.

Acknowledgments
This work was supported by the special research project of Education Department of Shaanxi Province. (NO.18JK1079)

References
[1] Lv, A. (2007) On the Treatment of Soft-earth Foundation and Special Foundation. Friends of Science, 05:41-43.
[2] Zhao, Y. (2003) Treatment of Soft Ground and Collapsible Loess Ground. Sci-Tech Information Development & Economy, 13:323-324.
[3] Gao, H. (2012) Analyses for Mechanical and Engineering Characteristics of Saturated Soft Loess. Journal of Water Resources and Architecture Engineering, 10:38-42.
[4] Wang, X. (2011) Analysis on Special Soil Foundation Treatment Measures of Expressway. Transport Standardization,11:22-25.
[5] Wang, Y. (2009) Treatment Method and Practice of Highway Soft Soil Foundation. Transpoworld, 11:96-97.
[6] Zhang, L. (2018) Effective treatment strategy of soft soil subgrade in road engineering construction. Shanxi Architecture, 44:121-122.