Journal of Civil Engineering and Urban Planning (2022)
Clausius Scientific Press, Canada

DOI: 10.23977/jceup.2022.040508
ISSN 2616-3969 Vol. 4 Num. 5

Research Progress of Fly Ash to Improve Expansive Soil on Technology and Discrimination Method

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Keywords: Expansive soil, fly ash, classification of expansive soil, improved expansive soil

Abstract: Expansive soil is a kind of highly plastic clay, and its properties are extremely unstable due to its remarkable swelling and shrinking characteristics, such as repeated water absorption expansion and water loss shrinkage. Therefore, it is necessary to improve the expansive soil. In this paper, the progress of the technology of improving expansive soil with fly ash is summarized, and the research progress of the discrimination method of expansive soil is analyzed and summarized, which can provide some ideas and basis for the treatment of expansive soil engineering.

1. Introduction

Expansive soil has clay minerals such as montmorillonite and illite with highly hydrophilic [1]. It is a hard plastic clay that expands and contracts with the increase and decrease of water content [2,3]. When the soil is immersed in water, the bound water film on the surface of soil particles thickens, which makes the spacing between soil particles widen. When the soil loses water, the bound water film becomes thinner, and the particle spacing shrinks, which leads to the shrinkage of the soil. In the process of dehydration and shrinkage, cracks are easily induced [4], which destroys the original integrity of the soil and changes the engineering properties. It is sensitive to the change of environmental humidity, has multi-crack, strength attenuation, high plasticity and strong expansion and contraction [5,6], and is a typical heterogeneous three-phase medium. Therefore, many scholars in China and abroad have carried out the improvement and discrimination of expansive soil.

2. Research Progress of Fly Ash Improving Expansive Soil Technology

At present, there are many studies on the improvement of expansive soil, and many research results have been obtained. And they are mainly concentrated in these aspects, first, the chemical improvement method; second, the physical improvement method; the third is the biological improvement method [7].

The basic principle of the chemical improvement method is to add hydrated lime and other substances into expansive soil to make it produces a chemical reaction. Common modifiers include cement, alkali waste, water glass and so on. Under the action of various modifiers, the expansion soil can significantly improve the ability of tensile, shear and compressive resistance. A water barrier can be formed by the modifier, thus improving the expansion and contraction performance. Physical

improvement method, that is, mechanical treatment of poor soil layer, so as to change its physical properties to meet the engineering requirements. The addition of biological enzymes is also a common method of biological improvement of expansion soil, but there are major limitations in this method in practice. Reviewing the existing research conclusions in China and abroad, it is found that the chemical improvement method is generally recognized.

Fly ash has obvious advantages as a modifier in the chemical modification method. Fly ash mixed into expansive soil can produce agglomeration function, and at the same time, it can also form cement and fill expansive soil, so as to achieve the purpose of improvement. This method can significantly improve the stability, strength and durability of subgrade and foundation engineering. Fly ash is suitable for all kinds of soil moisture content, and it is suitable for wet weather, which is conducive to saving the cost.

Zha Fusheng [8] used fly ash as an enhancer to improve expansive soils, and his research showed that the incorporation of fly ash can effectively reduce the dilatability of expansive soils. Chen Tao [9] studied the expansive soil of Guangzhou Bypass Expressway, comparing the effects of fly ash, quicklime and cement on the expansion and shrinking properties of expansive soil specimens, and concluded that a quicklime admixture of 6% is the best admixture for medium to high expansive soil. Tests carried out by Wang Chong [10] have shown the improvement of expansive soils when subjected to carbonation, ion exchange and gel clustering of fly ash. After studying the microstructure as well as mineral analysis. Li Dongxu and Sun Guowen [11] concluded after studying the microstructure and mineral analysis that under the action of alkali-activated fly ash, fly ash can quickly form gel-type substances, such as microsilica and calcium aluminate etc., and form a covering effect on the particle surface to form colloids. A. Seco [12] shows how fly ash and lime work to promote the improvement of expansive soils based on ion exchange theory. The study believes that expansive particles adsorb a large number of ions, such as sodium and potassium ions, which are all low-valent, while the magnesium ion and divalent calcium have an adsorptive effect on this, thus reducing the expansibility, hydrophilicity and dispersion of poor soils, While reducing the plasticity index, it promotes the formation and stability of expansive soils, thus increasing early strength. Using three kinds of expansive soils as examples, Akbulut [13] verified the reinforcing effect of adding four kinds of additives and fly ash, lime and cement on expansive soils. The study concluded that the above substances have different effects, with the cement increasing the ion exchange capacity of the swelling soil, while the other two substances create the exact opposite effect. Jose [14] pointed out that the effect of fly ash on expansive soils can reduce the liquid limit and increase the dry density, and correspondingly its compressive strength will also become stronger. Mao Tian-er [15] studied the effect of fly ash on soils from the microstructure and suggested that when fly ash is added to the soil, agglomerated particles are formed, which will damage the hydrophilic structure of expansive soil. Liu Weijing [16] and Gao Chunhua [17] studied fly ash modified expansive soil and pointed out that fly ash is rich in siliceous materials and high-priced metal ions, which will undergo various physicochemical reactions when mixed into the expanded soil, mainly including gelling, carbonation, agglomeration. Fu Naiqiang [18] studied the effect of alkali-excited fly ash and basalt fiber on the improvement of swelling soil, and carried out an unconfined compressive strength test. The type and dosage of alkali exciter, the dosage of fiber and fly ash and the age of maintenance on the strength of improved soil were analyzed. It was found that fly ash could improve the compressive strength of soil. Lan Changyu [19] studied the development and utilization of fly ash. As a treatment method for foundation, fly ash improvement is more and more widely used in the construction of road subgrade.

The research on the improvement of expansive soil with fly ash has been relatively mature, but there are various evaluation methods for evaluating the improvement effect of expansive soil before and after improvement.

3. Current Status of Expansive Soil Discrimination

In the process of discriminating and classifying expansive soils, there are various methods of discriminating, the main ones being the following.

The national standard code methods of differentiation are in accordance with (1) The *Technical Code for Construction in Expansive Soil Areas*. It is proposed that the basis for determining whether a soil is expansive or not: first, the amount of cation exchange; second, montmorillonite content; third, free expansion rate. (2) *Specification for Design of Highway Road Base*. In which two bases of discrimination are proposed: one is the standard moisture absorption rate; the other is the free swelling rate. (3) In accordance with the *Rules for Geological Expansive Soil Survey of Railway Projects*, the relevant discrimination basis is put forward as in the first specification above, the difference is that the relevant regulations are more detailed.

The mineralogical method: which is based on the principle of determining the clay mineral composition and content of expanded clays, has three main methods: XRD, EDX and SEM. Such methods usually use the index of montmorillonite content when judging the performance of expansive soil.

Multi-index comprehensive classification and discriminant method. When classifying expansive soil, the classification method is mainly based on the indicators that can represent the properties of expansive soil, such as total expansion rate, plasticity index and cohesive particle content. However, if it is a single index discriminant method, the comprehensiveness of its judgment results cannot be guaranteed, because it is based on only one index. In addition, methods such as air-dry moisture content method and plastic graph discrimination method can achieve more accurate identification of expansion and shrinkage performance. But each of these approaches has its own advantages and disadvantages. In China, a criterion - based classification method for expansive soil has been formed.

Ke Zunjing [20] believes that the classification can be developed around the maximum expansion and contraction index; In the *Technical Code for Building in Expansive Soil Area* (GBJ112- 87), the method based on the above index is also put forward. Vander Merwe [21] proposed that in terms of discriminating and classifying expansive soils, three factors can be used to construct a viscous expansion potential discriminant classification diagram for analysis: the first is clay activity; the second is the content of particles smaller than 2 μm; the third is plasticity index; Li Shenglin [22] specially established a plasticity diagram, in which the vertical axis is the plastic index and the horizontal axis is the liquid limit. The following indicators are mainly used in the discrimination method proposed by Holtz [23]: first, the expansion body; the second is the shrinkage limit; the third is plastic index; fourth, the glue content; Yang Shiji put forward the following evaluation indexes: one is the expansion amount of CBR; the other is suction; the third is the total rate of expansion and contraction; the fourth is plasticity index; The fifth is the liquid limit [24], and specifically proposed three levels; Tan Luorong [25] believed that the air-drying water content identification method could be used. During this period, some scholars used the multi-index mathematical method in the identification of expansive soil [26], the *Code for Design of Highway Subgrade* proposes that the plastic index and standard hygroscopic water content could be used as the criteria in the classification. The *Expansive Soil Survey Rules for Railway Engineering Geology* proposes that the initial judgment can be made by analyzing macro characteristics, such as natural geological phenomenon, structure, site appearance, color, etc. If the liquid limit and free expansion rate are greater than 40%, which are explained as expansive soil. In terms of detailed judgment, the following three indexes can be used for analysis: first, the cation exchange capacity; the second is the content of montmorillonite; the third is the free expansion rate. In addition, the existing multi-index combined analysis method has been well applied, such as grey correlation analysis, fuzzy mathematics and so on.

4. Conclusion

The above classification methods also have corresponding problems. Due to the different geographical climate in different regions, the objective environmental changes affecting expansive soil index will lead to inaccurate classification of expansive soil grade. Some discrimination methods choose indexes too simple, there may be a big error in distinguishing expansion grade of expansive soil. For the multi-index discriminant method, it is still to be discussed whether all the selected indexes reflect the soil state and the correlation is primary and secondary, or whether some indexes affecting the expansibility are omitted. For multi-index discriminations, which ones can be used as the discrimination indexes for the expansion grade of expansive soil and the correlation between these indexes and the expansion grade still need to be discussed in detail. Therefore, a lot of work needs to be done to classify the expansion grade of expansive soil.

Acknowledgements

This paper was supported by the College Students' Innovation and Entrepreneurship Project of Jilin Province (grant number S202210191022), the Key Science and Technology Research Project of Jilin Provincial Education Department (grant number JJKH20230345KJ).

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