A review of researches on fiber-reinforced solidified soil

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Abstract: At present, fiber-reinforced solidified soil is a research hotspot in the civil engineering field, but there are few related researches. Researches mainly focus on solidified soil and fiber-reinforced soil. Based on this, the research status of solidified soil and fiber reinforced soil is comprehensively analyzed in this paper. It is found that there is still a great lack of research on the strengthening mechanism of solidified soil. The research on the mechanism is still in the stage of qualitative description, and the related technical problems need to be further studied. Similarly, there are still great limitations in the research of fiber reinforced soil. These are reflected in the limited types of soil studied, more laboratory mechanical properties tests, but less research on fiber toughening mechanism.

1. Introduction

At present, the more feasible soil reinforcement treatment method is to reinforce the local soil on site in the fields of transportation engineering, geotechnical engineering, water conservancy engineering and agricultural engineering. The materials used to strengthen soil have gradually developed from the traditional single inorganic materials such as cement, lime and fly ash to the new curing agent composed of a mixture of various materials. However, there are still many basic problems in the application of soil curing agent in practical engineering. For example, the curing agent has limited performance and only works on specific soil. Soil curing agent can’t take into account the improvement of soil bearing capacity, durability and freeze-thaw resistance and the water stability of solidified soil is poor. In order to solve these problems, adding fiber to soil has been gradually applied and popularized in engineering. Based on this, the research results of solidified soil and fiber reinforced soil at home and abroad are analyzed in this paper.

2. Research status of solidified soil

Mechanical property tests of solidified soil mainly include compressive, tensile, flexural and shear tests[1], among which compressive strength is the most basic and representative index of solidified soil materials. Compressive strength is not only the main basis of engineering design, but also closely related to other properties of solidified soil. Generally speaking, the main factors affecting the mechanical properties of solidified soil are soil quality, the amount of soil curing agent, age, density, moisture content and curing conditions. Therefore, one of the main research directions of soil curing agent is to select soil curing agent with strong compatibility for different soils[1-3].

D. T. Eriktius et al.[4]found that with the increase of cement content, the liquid plastic limit of
solidified soil decreased, but the unconfined compressive strength and shear strength of solidified soil significantly increased. Based on Abram law, S. Horpibulsuk et al. obtained the development law of soil-cement strength at different ratios and ages. S. Olias et al. used fly ash and cement to solidify fine clay, and found that with the increase of solidified materials, the plasticity of solidified soil decreases, compressive strength increases and modulus increases. M et al. used a mixture curing agent to strengthen the local clay. The study showed that the mechanical properties and durability of the clay after curing, including tensile and compressive strength, elastic modulus, California load ratio (CBR), water resistance and shrinkage properties were improved. R.G. Kochetkova et al. studied the mechanical properties and changes of relevant parameters of clay after being strengthened by three curing agents SAA, Roadbond and Status, and discussed its mechanism of action. ZHENG D.M et al. found that Conaid, a sulfide ion curing agent, can effectively reduce the combination of soil and free water and reduce the volume of soil. P.t. et al. studied the characteristics of the new soil curing agent Q2, elaborated the curing mechanism of the soil curing agent, built the field test road and tested the bearing capacity and freeze-thaw resistance of the solidified soil road. Wang et al. studied the microstructure and strength characteristics of the soil cured by ion hardener through chemical analysis, SEM scanning electron microscopy analysis, unconfined compressive strength test and other tests. Xu found that the strength of solidified soil increased in the form of power function as the content of curing agent increased. Zhang et al. conducted compaction, infiltration and direct shear tests on the loess before and after the addition of SSA soil stabilizer, respectively, and suggested that the optimal content of the stabilizer should be 1%. Shi et al. compared and analyzed the reinforcement effect of soil stabilizer and traditional inorganic binder such as cement and lime by carrying out tests of resilience modulus, CBR, bending and sinking. Shen analyzed the strength characteristics of solidified sulphuric acid saline soil and discussed the mechanism of solidified sulphuric acid saline soil by ground polymer cementite materials.

Although a great deal of research has been carried out on the mechanical properties of solidified soil materials, and many years of experience has been gained, but there is still a lack of research on the strengthening mechanism of soil curing agent on the properties of solidified soil. The existing research is still at the level of revealing the influence of curing agent materials on curing effect. The research on mechanism is still at the stage of qualitative description, and the related technical problems need to be further studied.

3. Research status of fiber reinforced soil

Fiber reinforced soil technology is a new method of soil improvement. Through laboratory and field tests, Santoni et al. found that the optimal content of polypropylene fiber was 1%, and the addition of 51mm long monofilament polypropylene fiber significantly enhanced the carrying capacity of the airport runway. Kumar et al. found that unconfined compressive strength increases with the increase of fiber content, and the enhancement effect of fiber on tensile strength is better than unconfined compressive strength. Estabragh A.R. et al. found that the addition of fibers improved the compressive strength and axial rupture strain of the sample, and caused the failure of the sample to transform from brittleness to ductility. Divya.P.V. et al. found that fiber improved the stress-strain characteristics of soil and enhanced the toughness of engineering soil. Y Wang et al. found that jute fiber with a content of 0.6% and a length of 6mm could effectively enhance the performance of expansive soil.

Shi et al. conducted experimental studies on the compressive strength of samples with different fiber content, lime content and age. The interaction and mechanical transfer between polypropylene fiber and soil contact surface are analyzed, and it is concluded that the reinforcing effect of the fiber depends on the shear strength of the interface of soil. Shi et al. found that fiber had a good improvement effect on the strength and deformation characteristics of lime soil. Wang et al. studied the shear strength characteristics of polypropylene fiber reinforced unsaturated cohesive soil under different moisture content and dry density, and the results showed that the addition of fiber effectively improved the shear strength. Tang et al. studied the influence law of fiber content, dry density and water content on the tensile strength of fiber reinforced soil, and the results showed that the addition of
fiber could significantly improve the tensile strength and failure effect of samples. Yang et al.[27] studied the mechanical properties of modified polypropylene fiber and cement-reinforced loess under different fiber content, cement content, curing age and fiber length. Lei et al.[28] found that the interaction modes between fiber and soil are mainly binding and fiber network.

In conclusion, the practice of fiber reinforced soil engineering develops rapidly and has been widely used in soil reinforcement engineering[22, 23]. However, the theory of fiber reinforced soil is far behind the practice and the relevant theoretical research is not sufficient. Meanwhile, most of the soil types studied are sandy soil and cohesive soil, while experimental studies on special soils such as collapsible loess are rarely reported. Moreover, most of the experiments are still in the stage of mechanical properties research, and there are few researches on the toughening mechanism of materials. Therefore, it is necessary to carry out basic experimental research and theoretical analysis from various aspects to promote the development of fiber reinforced soil technology.

4. Conclusions

The research status of solidified soil and fiber reinforced soil is comprehensively analyzed in this paper. It is found that there is still a great lack of research on the strengthening mechanism of solidified soil. The research on the mechanism is still in the stage of qualitative description, and the related technical problems need to be further studied. Similarly, there are still great limitations in the research of fiber reinforced soil. These are reflected in the limited types of soil studied, more laboratory mechanical properties tests, but less research on fiber toughening mechanism.

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