Research on Construction Technology of Unsaturated Soil Highway Subgrade

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Abstract: With the rapid development of the transportation industry, many highway constructions have been gradually extended to arid and semi-arid areas, and the roadbed works on unsaturated soils have gradually increased. However, the unique moisture sensitivity and suction variability of unsaturated soils bring complex challenges to roadbed construction. For this reason, in order to effectively improve the bearing capacity and stability of unsaturated soil roadbase, this paper researches and optimizes the construction technology of unsaturated soil highway roadbase from the perspectives of filler selection, layered compaction, strong tamping reinforcement, drainage design, etc., which is of great practical significance to ensure the long-term stability and safety of unsaturated soil roadbase.

Keywords: Unsaturated soil; Highway; Roadbed; Compacted reinforcement

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With the rapid development of the transportation industry, the demand for highway construction is growing, while many new road sections often cross arid and semi-arid regions, where foundations are mostly unsaturated soils. In these areas, the special properties of unsaturated soils, such as susceptibility to moisture changes, suction instability and other problems, pose serious technical challenges to roadbed construction. In recent years, the engineering properties of unsaturated soils have gradually received extensive attention from the academic and engineering communities. According to statistics, the area of unsaturated soil in arid and semi-arid regions accounts for more than 30% of the total global land area. If this kind of soil is not properly handled in construction, it is very easy to have problems such as settlement, cracking and insufficient strength, which affects the long-term stability of the roadbed. Therefore, it is crucial to study and improve the construction technology of unsaturated soil roadbeds, and to formulate scientific fill selection, layered compaction, strong tamping reinforcement, drainage and quality control programs to ensure the durability and safety of highways.

1. Characteristics of Unsaturated Soil Roadbeds

Unsaturated soils are soils in which both water and air are present in the soil pores, i.e., soils with a saturation between 0 and 100 percent. Unsaturated soils are widely found in nature, especially in arid and semi-arid areas, where there are a large number of expansive soils, loess, and other special soils, and a certain amount of suction usually exists within these soils, which affects the engineering characteristics. Unsaturated soil roadbed is a road base structure composed of unsaturated soil, and its main characteristics include:

(1) Sensitive to changes in water content: The water content of unsaturated soil roadbeds is susceptible to rainfall, evaporation and other environmental factors, leading to changes in the moisture content of the roadbed, thus affecting its mechanical properties.

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(2) Complex strength and deformation characteristics: due to the existence of suction, the strength and deformation characteristics of unsaturated soil roadbed are different from saturated soil. Changes in suction will cause changes in the volume and strength of the soil body, affecting the stability of the roadbed.

(3) Affecting permeability: The permeability of unsaturated soils is affected by water content and suction, and the complexity of water migration characteristics may lead to redistribution of water within the roadbed, affecting the performance of the roadbed.

(4) Influence on the environment: the performance of unsaturated soil roadbeds is significantly influenced by environmental factors such as climatic conditions and changes in the water table, which need to be fully considered in the design and construction of these factors.

2. Research on Construction Technology of Highway Foundation on Unsaturated Soil

(1) Roadbed fill selection

In the construction of unsaturated soil roadbed, the selection of filler is an important step to ensure the stability and durability of the roadbed, and the selection of suitable filler can not only improve the strength of the roadbed, but also effectively reduce the settlement. First of all, give priority to the selection of well-graded coarse-grained soil as the roadbed filler, which has high strength and good shear resistance, and can maintain stability under different climatic conditions. In order to ensure the construction quality, it is necessary to control the grain size of the filler, and the maximum grain size of the filler should not be more than 2/3 of the thickness of the fill layer, for example, in a fill layer of 30 centimeters, the grain size should be controlled within 20 centimeters, so as to ensure that the crushing is uniform and the compactness reaches the standard. In the construction process, the thickness of the loose fill layer should be controlled within 50 centimeters, and the over-thickness of the fill layer will easily lead to insufficient compaction and affect the strength of the roadbed. In the part of the roadbed elevation below 1.5 meters, stone filling is the ideal choice, which can enhance the bearing capacity and stability of the underlying roadbed, and help the roadbed better resist the adverse effects of moisture changes. When selecting stone materials, attention should be paid to the strength and durability of the stone, and the use of appropriate particle size, strong and durable stone, so as to maintain a good compaction effect during construction, but also to prevent soil erosion and enhance the overall strength of the roadbed.

(2) Layered filling and compaction

Layer filling and compaction is a key construction step in the construction of unsaturated soil roadbed, which directly affects the stability and bearing capacity of the roadbed. In the process of layered filling, the thickness of each layer should be controlled in strict accordance with the design requirements, and usually kept between 30 and 50 centimeters, which can ensure the best compaction effect, and it is not easy to have uneven compaction and other problems. Compaction, the selection of suitable vibratory roller, the model should be selected according to the size of the roadbed and soil properties, to ensure the compaction effect. Specific operation sequence needs to follow the "first fast and then slow" principle of rolling, that is, the initial stage can be appropriate to accelerate the speed of rolling, so that the filler is initially dense, to be stabilized, gradually slow down the speed of deeper compaction, to achieve the required degree of compaction. In addition, the path of rolling is also a good idea, it should be advanced from both sides of the roadbed to the center, so as to effectively avoid "bulging" or "sinking" on both sides of the roadbed, and to ensure the uniformity and compactness of the entire roadbed.

(3) Ramming reinforcement

In the construction of roadbeds on unsaturated soils, in order to enhance the bearing capacity and stability of the foundations, the strong ramming reinforcement method can be used. During construction, a crawler crane of 20

tons or more is equipped to carry and handle heavy rammers. Rammer generally choose the weight of 10 tons, the diameter of 1.8 to 2 meters between the steel hammer head, this specification of the rammer can produce enough impact force, effective reinforcement of soil. Specific operation, in accordance with the "layered filling, layer by layer ramming" principle, every 3 meters of height filling, you need to carry out a comprehensive ramming treatment, to ensure that the entire roadbed in different depths have reached the ideal degree of compaction. In ramming construction, the hammer height is generally set between 10 and 12 meters, which can provide enough compaction energy for the soil body, so that the void inside the soil body is fully compressed. In addition, the spacing of the tamping point and the number of times of tamping is also a key technical parameter, usually, the spacing of the tamping point is controlled at 2-2.5 meters, and each tamping point needs to be repeated tamping 3 to 5 times, after tamping, the use of sand filling method or nuclear density meter to test the degree of compactness, to ensure that the reinforced soil compactness to meet the design standards. In the whole tamping process, according to the soil condition and tamping effect, need to flexibly adjust the tamping strength and number of times, so that the unsaturated soil roadbed to maintain a good bearing capacity.

(4) Drainage measures

In the construction of unsaturated soil roadbed, due to its extreme sensitivity to moisture changes, setting up a perfect drainage system can ensure the stability of the roadbed under various climatic conditions. First of all, the design of the side ditch should be scientific and reasonable, and the side ditch is usually set along both sides of the roadbed to ensure that the rainwater can be quickly discharged and not be retained in the vicinity of the roadbed. The depth of the side ditch is usually 0.5 to 1 meter, the width is adjusted according to the demand of drainage, and the bottom should be set up with a certain slope, so as to facilitate the natural drainage of water. Infiltration trenches are placed at the bottom or sides of the roadbed to retain groundwater or seepage water. Soakaways are usually filled with gravel, and it is recommended to use a layer of gravel with a grain size of 20-40 mm and a water-filtering geotextile to prevent the loss of fine-grained soil and clogging. Drainage bedding is suitable for use in areas with high precipitation or high water table. The bedding layer is usually 30-50 cm thick and consists of crushed stone or gravel with good water permeability, which promotes rapid water infiltration and drainage. In addition, drainage blind tubes can be installed at the bottom and sides of the roadbed, which are filled with materials with good permeability to further improve the drainage effect. In order to ensure the effective operation of the entire drainage system, drainage facilities should be regularly inspected and cleaned, focusing on side ditches and soakaways, to avoid siltation and clogging, and to maintain smooth drainage. Through the combined use of side ditches, infiltration trenches and drainage matting, the internal moisture of the roadbed can be effectively controlled, preventing the settlement and strength reduction caused by moisture aggregation.

(5) Construction monitoring and quality control

In the construction process of unsaturated soil roadbed, good construction monitoring and quality control can not only ensure that the roadbed meets the design requirements, but also effectively prevent quality hazards. First of all, the compaction needs to be monitored in real time, which can be detected by nuclear density meter or sand filling method, and the compactness of each layer of filling must meet the design standard, which is generally required to be above 95%. Moisture content control is equally critical, because too high or too low moisture will affect the compaction effect of the soil. The moisture content can be measured periodically using the drying method or a portable moisture meter to stay within ±2% of the optimum moisture content. In addition to compaction and moisture content, settlement monitoring is also a necessary means to ensure the stability of the roadbed. Settlement observation points are set up at key locations, and the amount of settlement is regularly measured using a level meter. Settlement is required to be within a controllable range, so as to avoid large settlements of the preserved roadbed in the course of use. In order to further improve the construction quality, a detailed construction program should be formulated at the early stage of the project to clarify the process and standards of filling, compaction and

monitoring. In case of special circumstances such as rainfall or changes in foundation level during construction, the construction program and quality control measures should be adjusted in time to ensure that the final roadbed has good stability and durability.

3. Conclusion

In summary, for the construction technology of unsaturated soil roadbeds, systematic improvement and optimization can significantly enhance the stability and durability of roadbeds, from fill selection to drainage design. However, the special characteristics of unsaturated soils determine that the construction may still face some unforeseen challenges. In the future research and practice, the dynamic characteristics of unsaturated soils should be continuously paid attention to, the construction monitoring means should be improved, and the construction strategy should be adjusted in time in order to further guarantee the safety and reliability of the roadbase.

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