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Application of Foam Light Soil in Road Expansion

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Abstract

Foam lightweight soil is a new type of concrete material. In order to reduce the weight of the roadbed, reduce the additional stress of the foundation, and reduce the settlement problem after the foam lightweight soil is filled, the article analyzes the characteristics of the road soft foundation and the reasons for the settlement of the road expansion. The superior performance of foamed lightweight soil is discussed, and the feasibility and advantages of road expansion are analyzed based on the settlement monitoring results of soft foundations in engineering examples. The research believes that foamed lightweight soil has broad application prospects in highway expansion, so as to promote the application of this technology.

Keywords

Foam light soil; Engineering characteristics; Expansion project; Application.

1. Introduction

Since the reform and opening up, the total mileage of my country's construction of highways has increased to 5,198,100 kilometers. However, many roads constructed have reached the designed service life and the pavement is seriously damaged. With the increasing traffic volume and axle load, there is already pressure on road passenger and freight transportation. At present, there are two ways to solve the traffic demand problem: new roads or widening and expanding existing roads. New roads need to requisition land, land is a non-renewable resource, and the cost of requisition is usually greater than the cost of construction, so the expansion of the original road has an absolute advantage. For the expansion project, the settlement of new and old roadbeds is currently the most difficult problem to solve. At present, the methods of dealing with soft soil foundation include pile foundation method, reinforcement method, grouting method, drainage consolidation method and so on. However, these methods have high cost and long construction period, and cannot maintain road operation, and the effect of dealing with differential settlement is not very effective.

Therefore, many scholars choose lightweight materials as a new technical means to reduce the subgrade load and the additional stress of soft soil foundations. Foam light soil has been gradually applied to projects in China with its advantages of lightness, strength adjustability, construction convenience, durability, environmental protection, etc., which solves the serious problems caused by the settlement of new and old roadbeds in traditional soft soil foundation road projects. problem.

2. Soft Soil Roadbed

2.1. Soft Soil Foundation Characteristics

During road construction, the differential settlement of new and old roadbeds is one of the most common and difficult to solve soft soil foundation diseases.

2.1.1 High natural water content

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Soft soil is mainly composed of clay and silt soil particles, and contains a small amount of organic matter. The surface of the clay particles with negative charges can interact with the water and cations of the surrounding medium to form a water film, so the natural water content is relatively high, generally greater than 35%; the natural void ratio is greater than or equal to 1.0, mostly between 1.0 and 2.0.

2.1.2 Poor water permeability

The permeability coefficient of soft soil is generally between 1×10-6~1×10-8 cm/s. The water permeability is poor and the internal seepage conditions are poor, which is unfavorable to the drainage of the foundation, so the consolidation speed under load is very slow.

2.1.3 Low shear strength

The undrained shear strength of soft soils is 5-20 KPa, generally less than 20 KPa; the drained shear strength will increase with the increase of the degree of consolidation.

2.1.4 High compression factor

The compressibility of the soft soil layer in its natural state is about 0.5 to 1.5 MPa, and some are as high as 4.5 MPa.

2.1.5 High sensitivity

The cohesive soil is subjected to the action to cause structural damage and loss of strength. The thixotropy is the nature of the gradual recovery of the intensity of the disturbance action. The thixotropy is expressed by the sensitivity St, which is the ratio of the strength of the undisturbed soil to the strength of the disturbed soil.

2.2. Reasons for Settlement of Soft Soil Foundation

The consolidation degree and strength of the old subgrade are greater than the new subgrade. As far as the consolidation settlement of the old subgrade is basically stable, the consolidation settlement of the new subgrade has just begun. The settlement of the new subgrade is greater than that of the old subgrade, so differential settlement occurs. However, there are many specific factors affecting differential settlement, which can be summarized in the following two aspects.

2.2.1 Insufficient stability

When the roadbed is expanded, the particle size, gradation, and physical and mechanical properties of the roadbed filler cannot be fully controlled, which will easily lead to insufficient strength, stability, corrosion resistance and other properties, which will become unstable under the action of vehicle load and water erosion; construction technology for the junction of new and old roadbeds Complex, difficult to construct, and prone to quality problems; geopolymers (such as geogrids) are not installed at the junction of the new and old roadbeds or the layout quality is poor and cannot play its role; the roadbed drainage facilities are imperfect and poor performance, resulting in surface water The infiltration is relatively serious, which reduces the performance of the roadbed structure, and ultimately results in serious quality problems, which cannot ensure the safe operation of the traffic.

2.2.2 Inconsistent deformation

The consolidation settlement of the old roadbed has basically been completed and the mechanical properties have been improved. Under the load of the new embankment, the new roadbed will have a large secondary consolidation settlement and shear damage caused by lateral extrusion deformation, which will cause the old roadbed top surface to be damaged. Coordinated deformation leads to cracking of the old road surface; widening roadbed works will change the drainage status of the foundation, resulting in settlement of the old foundation, and in severe cases, it will cause roadbed cracks and other diseases; insufficient compaction of the fill will increase the compression and deformation of the roadbed itself, which will cause the driving load When the plastic deformation of the roadbed increases, and the compression

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deformation of the roadbed under good local conditions is dominant, the uncoordinated deformation of the new and old roadbed will damage the expanded road surface.

2.3. Commonly Used Soft Soil Foundation Treatment Methods

Rolling and compaction (including mechanical rolling, vibration compaction, heavy hammer compaction, dynamic compaction, etc.), soil replacement cushion method (sand gravel cushion, plain soil cushion, lime-soil cushion, slag cushion), Drainage consolidation (sand well preloading method, plastic drainage board preloading method, precipitation preloading method, vacuum preloading method, etc.), vibrating method and compaction method (lime soil compaction pile method, compacted sand pile method, blasting Method, etc.), displacement mixing (deep mixing method, high-pressure jet grouting method, vibratory displacement method, etc.), geopolymer (geomembrane, geotextile, geogrid, etc.).

These traditional treatment methods only increase the bearing capacity of the foundation, and do not consider reducing the load of the fill. Different geological conditions and construction environments in different regions make it difficult to choose a suitable foundation treatment method. When the soft foundation is at a certain depth and the roadbed is at a certain height, the commonly used soft foundation treatment methods cannot completely solve the settlement problem, affect the construction quality, and have the risks of high cost and long construction period, which will eventually lead to road cracks and even subsidence.

3. Foam Light Soil

3.1. Definition

The foam is prepared from the foaming agent aqueous solution by physical methods, mixed with cement slurry (additives can be added if necessary) in a certain proportion to form a fluid, and finally solidified and shaped by physical and chemical effects. The main agent is commonly used pozzolan cement, ordinary Portland cement and other cements, which have the effect of consolidating and strengthening the soil skeleton. As the auxiliary agent, auxiliary materials such as gypsum powder and silica fume are used to achieve catalysis, early setting and reduce cost. The purpose of the raw material soil is generally engineering waste soil, sandy soil, cohesive soil, and its particle diameter should be less than 5 mm to ensure the fluidity of foamed lightweight soil; foaming agents include resin, protein, and interface activity Materials, etc. The preparation process of foamed lightweight soil is shown in Figure 1, and the bubble preparation process is shown in Figure 2.

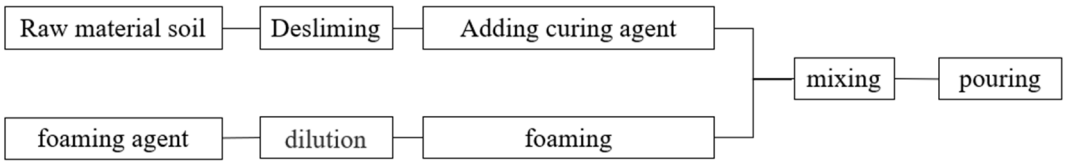

Figure 1. Preparation process of foamed lightweight soil

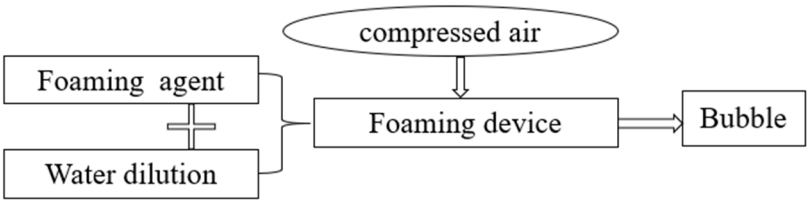

Figure 2. Bubble preparation process

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3.2. Engineering Characteristics

3.2.1 Lightness and strength adjustability

There are many closed and independent tiny colloidal bubbles in the foam light soil, and the bubbles are not communicated with each other. Therefore, the bulk density and strength of the foamed light soil can be changed by adjusting the mixing amount of raw material soil, foaming agent, cement, etc., so that the bulk density of the foamed lightweight soil changes within the range of 5-12 KN/m3, and the strength changes within the range of 0.3-1.5 MPa. The bulk density comparison of main civil construction materials is shown in Table 1.

Table 1. Bulk density of main civil construction materials

material	Cement concrete	Concrete pavement	Subgrade fill	Fly ash	Civil foam	Foam light soil
Weight KN/m3	25	21-22	19-20	12-16	0.2-0.35	3-12

3.2.2 High liquidity

Foam light soil can be transported long-distance by mixing station and pipeline due to its high fluidity. It also has the characteristics of self-leveling and self-hardening, without rolling and vibrating. After pouring is completed, it usually solidifies in about 4 hours, and there is no pressure on the retaining structure after solidification.

3.2.3 Durability and environmental protection

Foam light soil is a cement material, and its oil resistance, durability, and heat resistance are all higher than those of polymer materials. The bubble volume content exceeds 40% to 70%, and the thermal conductivity is relatively low, which ensures good thermal insulation performance, improves the freeze-thaw resistance of the foamed lightweight soil, and enhances the durability of the roadbed. In road construction, the foamed lightweight soil, which is an inorganic material, uses waste soil from the project on-site, which does not pollute the natural environment.

3.2.4 Constructability

During construction, the foamed lightweight soil can be poured on-site and backfilled in a narrow space. With high fluidity, it can be pumped by pipelines. The maximum transmission distance can reach 1500 meters, and the maximum pumping height can reach 30 meters; no mechanical rolling or vibration is required. The construction efficiency is improved, vertical filling can be realized, the construction period is short, and the traffic does not need to be closed when the road is expanded.

4. Principles of Subgrade Settlement Treatment by Foam Light Soil

Road expansion projects mostly adopt the method of splicing and widening on both sides of the roadbed. The engineering example shows that the splicing on the soft soil foundation will cause the original roadbed to produce an inverted basin-shaped distribution of additional settlement increments and settlement differences in the form of side load, causing the new and old roads to crack. Foam light soil has low weight and high strength. It can be used to fill the roadbed to reduce the weight of the roadbed, reduce the additional pressure of the foundation, and effectively control the settlement after construction; due to the high fluidity of the foam light soil, it avoids the defect of insufficient conventional filling; it can be vertical Filling, reducing the land area, making the strength of the filled subgrade greater than that of the conventional subgrade; the foam light soil embankment is in an over-consolidated state, which greatly inhibits the settlement of the soft soil foundation and improves the stability of the embankment. As shown in Figure 3.

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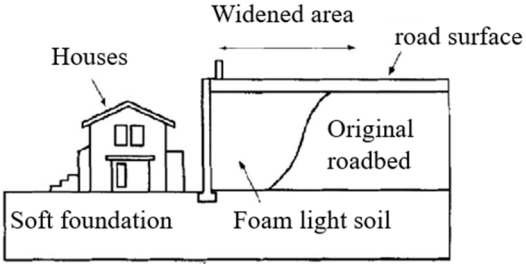

Figure 3. Schematic diagram of road widening

5. Project Overview

Located in the Hangjia Lake water network area, it belongs to the Lianhang section of the Shenjiahuhang Expressway in coastal deposits, with a total length of 50.938Km and a soft soil foundation (high water content, high compressibility, low strength) section of about 35 Km. The project is to achieve the goal of normal opening to traffic before the Spring Festival in 2010 and to ensure the quality of the project. Among them, special sections such as bridge heads treated by vacuum preloading, transition sections with different soft foundation treatments, sections with large roadbed settlements, etc. are replaced with foamed lightweight soil to reduce the additional stress of soft foundation embankments and roadbed settlement. The specific distribution is shown in Table 2.

Table 2. Replacement of foam light soil in Lianhang section

Road section	pile	length /m	width /m	thickness /m	Engineering Amount /m3	Replacement site
L1	K2+423.8-K2+476	52.2	23.5	1~2.5	1806	Bridgehead roadbed (vacuum preloading section)
L2	K3+315-K3+335	20.0	23.5	1.0~1.5	1160	General roadbed (transition section of plastic set pile and plastic drainage board)
	K3+440-K3+460	20.0				
L3	K9+660-K9+710.9	50.9	23.5	1.0~2.0	8699	General roadbed (subgrade settlement over a large section)
	K9+728.3-K9+815	86.7		1.0~2.4		
	K10+328-K10+456	128.0		1.0~2.0		
L6	K28+388-K28+494	106.0	23.5	1.2~2.5	4333	Plastic drainage board treatment section (due to the impact of policy treatment, the preload period cannot be met)
L8	AK0+429-AK0+453	24.0	23.5	1.2~2.5	944	The treatment depth of the shotcrete pile cannot be satisfied
L10	RCK22+404-RCK22+500	96.0	7.95-8.30	3.7~4.2	6115	Widening the road around the city (difficult to construct due to land restrictions)
	RCK22+250-RCK22+356	106.0	7.9-8.0	4.3~4.5		
total		689.8			23057	

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5.1. Scheme Design

(1) Wet bulk density: ≤6KN/m3 within 80 cm of the top layer, ≤5.5KN/m3 for the part below 80 cm. Mixing ratio strength: 28 d strength within 80 cm of the top layer is ≥0.8 MPa, and 28 d strength of the part below 80 cm is ≥0.8 MPa. Flow value: 160 mm~200 mm.

(2) When mixing and making foamed lightweight soil cement slurry, the mixing time should not be less than 2 min, and the stopping time of cement slurry or foamed lightweight soil in the discharging equipment should not exceed 2 h. It also needs to be cured, and the temperature needs to be above 5°C.

(3) Maintain hard shoulders, soil shoulders and side slopes during construction.

(4)The lateral drainage slope of the subgrade, with a step transition, shall be treated according to the slope of 1:5.

(5) The thickness of single-layer pouring for foamed lightweight soil is controlled within the range of 0.3-0.8 m, and a horizontal construction joint is set every 10 m in the longitudinal direction. Immediately stop pouring in case of heavy rain, and take rain-proof measures for the foamy light soil that has not finally set.

(6) The top layer of foam light soil is not allowed to be constructed by machinery within 7 days, and must be cured after 7 days.

5.2. Settlement Monitoring Results

(1) Before replacement, the monthly settlement of the construction section is between 14-18 mm, and the settlement rate is between 0.4-0.7 mm/d, and the settlement rate is not converging or converging slowly.

(2) After replacement, the settlement speed of the roadbed is faster. The monthly settlement of most sections varies between 2 and 4 mm, and the settlement rate varies between 0.01 and 0.14 mm/d, all reaching the settlement stability standard.

(3) In the construction section where the deep soft soil layer, pavement base layer and subbase layer are paved at one time, the monthly settlement will be reduced to less than 5 mm after two months. Currently sedimentation rate was stable at 2 mm / month.

6. Summary

(1) The result of soft soil foundation treatment directly affects the quality of subgrade engineering. At present, traditional soft foundation treatment measures are difficult to solve the problem of post-construction settlement. It is also accompanied by problems such as poor overall stability, high cost, and long construction period that are difficult to control. Disasters such as side slip, road subsidence and cracking.

(2) The engineering example fully proves the light-weight strength adjustability of the foamed lightweight soil. The 7d compressive strength can be adjusted from 0.6 to 0.8 MPa. The construction is convenient and efficient, does not affect the traffic and the construction period is short, and it can be reduced after construction and filling. The self-weight of the subgrade effectively reduces the additional stress of the foundation, greatly reduces the overall settlement, differential settlement and side slippage, and can use engineering waste soil on site, which has good economic and social benefits.

(3) As a new type of lightweight filling material, foamed lightweight soil has proved its feasibility and economy through a large number of studies and engineering applications. In the past 20 years, it has been widely used in the filling of abutment backs and embankments on soft foundations. Filling, road widening, etc., can solve the problems of bridge head jumping, settlement difference between new and old roadbed, and soft soil roadbed settlement, and achieve good results. As the most effective method of soft foundation treatment today, foamed

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lightweight soil has a wide application prospect, and this technology can be promoted vigorously.

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