Experiment investigation of bag-grouting-pile Composite Foundation in Soft Ground Treatment

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Abstract. Bag-grouting-pile is a new technique in reinforcing railway soft foundation. The paper discuss the effect of bag-grouting-pile used in Coastal soft foundation, and test the deep subsidence as well as deep horizontal displacement of bag-grouting-pile composite foundation and high-pressure-jet-grouting pile composite foundation. Through the Contrast of the two ways, it further discusses the reinforcing effect of bag-grouting-pile technique. The research comes to this conclusion: using the method of composite foundation treatment with bag-grouting-pile, the settlement of the upper soil increases with the increase of the load, and the settlement of the upper soil is larger than that of the lower part; the horizontal displacement of the deep soil is small and the horizontal displacement of the surface soil is larger; the maximum displacement and level settlement are located in 1.5-2m below the surface, which indicate that this soil layer disturbance is the largest.

Introduction

With the opening of beijing-tianjin, beijing-shanghai, beijing-guangzhou and beijing-harbin high-speed railway lines, China has entered a new era of high-speed railway. High-speed trains run high speed on the railway, and its track structure and roadbed standard require extremely high requirements, especially for subgrade settlement control. To design speed of 200-250 km of high-speed railway, must strictly control the embankment settlement and uneven settlement, slag roadbed settlement after not more than 15 cm, abutment machine tail transition section roadbed post-construction settlement amount cannot be greater than 8 cm.

In order to solve the problem of foundation settlement of high speed railway, the effective foundation treatment method must be adopted. In fill and dynamic compaction, the prestressed pipe pile, jet grouting pile foundation treatment methods, such as the foundation treatment method is commonly used in railway engineering, widespread applicability is poorer, effect difference big characteristic, and a bag of the grouting pile (hereinafter referred to as the bag pile) is a relatively new soft soil foundation treatment technology, is being more and more attention. Bag pile in soft soil layer grouting technique and geotextiles, integrated application of new technology, with geotextile bags and grout injection forming columnar sclerotium soil compaction reinforcement of soft soil foundation treatment method[1]. By water, triethanolamine, composed of fly ash or sand, cement and other mixed slurry injection advance buried in soft soil foundation in the bag, grouting filling earthwork bag to make it form a diameter of about 30 to 40 cm cylindrical or gourd shape pile, axial compressive strength design value can reach 2.4 MPa. In the formation of grouting, the purpose of strengthening weak soil is finally achieved by compacting the soil and forming a composite foundation. Bag processing foundation, the excess pore water pressure in soil can be free water in the soil along the bag fabric, cloth pile formation of the drainage channels can accelerate the consolidation of soil, increase the bearing capacity of soil[2-4]. The schematic diagram of the soft soil base reinforced by the pile piles is shown in Figure 1.
The cloth bag pile belongs to the vertical reinforced soil body, which can be regarded as semi-rigid pile, which can effectively improve the bearing capacity and composite modulus of weak soil. According to the characteristics of cloth bag pile, it is applicable to soft soil, such as deep silt soil and silty soil, and it will be better to strengthen the soft foundation. According to the guangdong coastal soft soil base condition, mansion deep along the railway foundation belongs to the deep soft soil, high water content, low bearing capacity, high compressibility and its reinforcement engineering mainly adopts dynamic compaction, jet grouting pile, cloth bag, and methods of pipe pile, and the coastal soft soil foundation using bag) (hereinafter referred to as the bag pile grouting pile reinforcement engineering instance is not much and not mature, was still in the stage of research to explore the application of cloth pile. Therefore, it is of practical significance to examine the applicability of the soft soil foundation effect of the cloth bag piles and the technical effects of the soft soil foundation in the pile reinforcement of the pile.

Project overview and site monitoring

Engineering overview and geological characteristics

The experimental study is based on the project of shantou coastal soft soil subgrade. Fujian xiamen mansion deep high way, way of zhangzhou, fujian province, guangdong chaozhou, shantou, jieyang, shanwei and huizhou, and finally introduced in shenzhen, guangdong province, is China's railway "been horizontal" fast passenger channel of "vertical". The planned mileage is about 550 km, with a design speed of 250 km/h. In order to meet the standard value of the settlement of 250km/h railway embankment and to ensure the smooth and design speed of the train, special measures must be taken in the soft soil area of the deep railway. Under the condition of the soft soil foundation of interlayer, if the bridge is used to strengthen the foundation by using the scheme or the pile, drilling pile and pipe pile, the cost is very high. As the new technology of soft soil foundation, cloth bag pile can be used for foundation reinforcement in the soft ground section of the deep high-speed railway.

The experimental section of subgrade settlement monitoring is located at DK333+640 to DK336+960 section of DK333+640 to DK336+960 in the shenzhen railway. The section is located in the coastal alluvial plain, and the foundation distribution of the soft plastic - flow plastic form is weak soil layer. The treatment segment of the pile grouting pile is medium sand layer, with a thickness of 13.4 m. Below it is fine sand, thick 1.7 m; The underlying silt layer is 11.1 m thick; The bottom of the sand, thick 5m; The bottom is a clay sandstone layer.

The pile length of the cloth bag pile is 15m, which is located in the ground of 13m-28m. Pile diameter 0.4 m, pile spacing 1.2m, pile strength 2.4 MPa, positive triangle layout. The specific layout is shown in Figure 2 [5-8].

Apparatus embedding

Select mansion deep railway DK333+685 - DK333+685 blocks luo river on the west side of the large bridge transition section DK333 + 700 bag test monitoring cross section pile reinforced area of no. 1, in the center of the embankment and slope on the left side of the foot are respectively embedded layered settlement pipe S-1, 2, S-measuring hole depth of 30 m, starting from ground zero m, setting
settlement every 2-3 m copper, on both sides of subgrade slope foot are respectively embedded dip pipe, C-C-1 2, depth of 30 m. The instrument layout is shown in Figure 2.

![Figure 2](image)

**Figure 2** Cloth pile reinforcement area geological columnar and figure of instruments

**Monitoring purposes**

1. Analysis of the rule of change of soft soil foundation settlement over time and load; Under different reinforcement conditions, the subsidence of soft soil was different; The long-term settlement characteristics of soft soil foundation after the disposal of pile piles are studied.

2. The effect of the soft soil foundation treatment method was discussed by analyzing the settlement control effect of the cloth bag pile.

**Monitoring methods and contents**

**Observation of subgrade internal settlement**

Layered settlement monitoring, using the circular type settlement instrument, and calculated, using pipe bottom elevation method that tube has reached the end of bearing layer, the circular settlement is zero, the rest of the circular and settlement with the settlement of soil. The monitoring tube is set at the foot of the slope and the center of the embankment.

The instruments of settlement monitoring include stratified sedimentation tubes, magnetic rings and stratified sedimentation readings. After the settlement of the foundation need to test points with drill holing in according to the geological conditions to determine the decorate good circular and settlement of layered tube, with expansive soil filled hole sealing after put into the tube, the circular embedded with the monitoring of soil and the synchronous settlement, reoccupy layered settlement readout instrument measuring the position of the circular regularly, analyze its settlement value, layer around the calculated settlement\textsuperscript{[9-10]}.

**Observation of horizontal displacement of foundation soil**

Horizontal displacement monitoring using embedded dip pipe on both sides of subgrade and different depth is measured by inclinometer pipe inclination to represent the lateral slope of the subgrade, the calculation of lateral displacement of soil subgrade and its displacement direction.

The horizontal inclinometer includes the bevel probe, signal cable and reading meter. The sedimentation tube is a special PVC pipe with a guide slot in it. Level of the design principle of inclinometer is vertical embedded in the soil under test grooved dip tube, when the catheter with soil deformation, horizontal displacement value of the test tube to reflect the horizontal displacement value of the soil. Survey probes generally is about 0.5 m long, at both ends is equipped with guide roller, the probe center installation precision accelerometer, when settlement instrument idler pulley moves along the dip tube guide groove, the probe of the accelerometer gravity vector on the vertical axis of components were determined, in order to determine the probe and the vertical axis Angle, inclination Angle and the length of the probe of the product is the difference of horizontal displacement at the ends of the probe. Instrument adopts wire drawing subsidence along the pipe wall.
on to the next move, keep records, the tilt Angle at various points from each Angle value, after calculation and analysis can be concluded that the wall horizontal displacement value of each point, which reflects the soil horizontal displacement value \([11-12]\).

**Site monitoring and data analysis**

During the 175 days of monitoring, the monitoring records of stratification settlement and measurement are monitored regularly, and the monitoring components are basically normal in this process. The soil filling and other construction segments of the pile reinforced area are synchronized with other construction segments, the initial filling rate is relatively slow, the soil rate is fast and the maximum filling height is 4.2 meters. The time-load diagram is shown in Figure 3.

![Figure 3 Time-load diagram](image)

**Horizontal displacement test results and analysis**

According to the actual settlement data, the lateral displacement graph is drawn, as shown in Figure 4 and Figure 5. The curve is used to analyze the variation of soil horizontal displacement with depth.

![Figure 4 Side displacement diagram of left side](image)  
![Figure 5 Side displacement diagram of right side](image)

In the above image, the horizontal displacement of the deep soil in the soft soil foundation after the reinforcement of the bag piles is small, while the horizontal displacement of the surface near earth is relatively large. This is mainly due to the deep soft soil under vertical bag pile in composite foundation of lateral restraint, effectively reduce the horizontal displacement of deep foundation, so as to enhance the overall stability of the foundation. The trend of the two graphs is basically the same. This is due to the increase of upper load and the lateral extrusion of weak soil. Due to the increase of the lower settlement amount, the soil has the horizontal displacement of the subgrade. The maximum horizontal positive displacement is located at the depth of 1.5 m-2m below the surface, and the
maximum positive displacement is 3.15mm and 3.8mm respectively. The maximum horizontal negative displacement is located at 13.5 m below the ground, which is due to the high volume of soil compression due to the weak lower lying layer. The lateral displacement of the following side of 13.5 m decreases rapidly, and the cloth bag pile plays the lateral restraint, effectively reducing the horizontal displacement of the soil.

**Results and analysis of stratified settlement monitoring**

The stratified sedimentation pipes are buried in the center of the foundation and the slope of the left side of the foundation. According to the measured magnetic ring settlement data, the trend chart of each magnetic ring settlement with time is shown in Figure 6.

![Figure 6](image)

Figure 6  The slope of the slope at the left slope of the roadbed

As can be seen from FIG. 6, the settlement of subgrade increases with load, and the settlement volume of upper soil is larger than that of lower settlement. Subgrade on the left side of the reinforced area in figure 6 for a bag of pile settlement observation points, each point subsidence trend and inclinometer Figure 5 curve fit very well, the maximum horizontal displacement and maximum sedimentation occurred in 1.5-2 m below the surface, this suggests that the more reliable measurement data.

**Conclusion**

1) The foundation of soft soil can be effectively controlled by using cloth bag grouting piles.

2) Reinforcement of soil body by using cloth bag pile reinforcement method, the settlement of foundation increases with the increase of load, and the settlement volume of upper soil body is larger than that of lower settlement. The horizontal displacement of deep soil is small, and the horizontal displacement of surface soil is larger. It has been proved that cloth bag piles can be used for soft soil treatment, and it is used for the treatment of deep soft soil in coastal areas to form a composite foundation, which has good treatment effect.

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**References**


