A polymer grouting method for constructing gravel pile for reinforcing the soft and special soil foundation includes steps of: (1) pile-position-pore-forming; (2) installing a grouting pipe; (3) putting grided stones; (4) polymer lifting grouting; and (5) pile-forming. By pile-position-pore-forming, putting graded stones, polymer lifting grouting in the reinforcement site and other steps, the injected two-component expansive polymer material expands rapidly after a chemical reaction, and then is solidified with the graded stones for filling in the pile hole from below to above, the blast hole wall rock-soil is expansive compacted and fully integrating with the surrounding rock-soil, thus forming the polymer gravel pile. The present invention can rapidly reinforce the soft and special soil foundation, thereby providing an advanced, highly efficient, safe and practical method for reinforcing the soft and special soil foundation. It has great economic and social benefits and broad development prospects.
POLYMER GROUTING METHOD FOR CONSTRUCTING GRAVEL PILE

FIELD OF INVENTION

[0001] The present invention relates to a foundation processing technology, and more particularly to a polymer grouting method for constructing gravel pile for reinforcing soft foundation and special soil foundation.

DESCRIPTION OF RELATED ARTS

[0002] Since the 1990s, with the steady and healthy development of the national economic construction, China's highways, high-speed railways and other large-scale foundation engineering facilities construction entered a period of rapid development, and have made remarkable achievements. Due to China's vast territory and complicated variable geological conditions, a large number of highways and high-speed railways pass through the soft soil, the collapsible loess and other adverse geological zones, thus facing very prominent engineering geological problems. The soft soil has physical and mechanical characteristics of large water content, high compressibility, low intensity and small permeability coefficient, when constructing the roadbeds in such area, due to long ground foundation cycle, large post-construction settlement deformation, the long-term stability of the roadbeds is seriously affected. In the collapsible loess, under flooding conditions, the foundation strength of the natural loess is dramatically decreased, and significantly additional settlement is produced, thereby posing a serious threat to the stability of the roadbeds. Therefore, how to effectively deal with the weak foundation and the special foundation, for meeting the requirements of safe and proper use of engineering structures, has become the most important issue that must be solved in the construction of high-speed transport infrastructures.

[0003] In recent 30 years, combined with China's engineering geological features, engineers and technicians have proposed dozens of foundation treatment methods to be widely used in the civil engineering construction. Depending on various reinforcement mechanisms, the existing foundation treatment methods can be generally divided into five major categories of replacement method, drainage consolidation method, chemical reinforcement method, reinforced method and compaction method. The replacement method excavates the surface soft soil to backfill the hard coarse grained materials and tamp for improving the bearing capacity of the foundation, and is mainly adapted for dealing with the shallow weak foundation and uneven foundation with the depth of 2-3 m. The drainage consolidation method adopts the heap load or vacuum preloading to discharge pore water in the soil for improving the soil strength, and partially or totally eliminating the foundation settlement, and is not adapted for the foundation soil with low water content. The chemical reinforcement method adopts the perfusion pressing-in, high-pressure injection, or mechanical stirring to cement the cement or chemical grout with the soil particles together for improving the physical and mechanical properties of the foundation soil, and it has complex construction process, environmental contamination and high cost. The reinforced method lays layer-by-layer the reinforced cushion consisting of earthwork synthetic materials and sand stone as the foundation bearing layer, uses the friction function between the reinforcement and soil to improve the tensile and shear performance of the soil, and is not adapted for dealing with a wide range of deep soft foundation. The compacting method can be divided into two types: one is reduce the void ratio of the soil and improve the bearing capacity thereof by virtue of rolling and dynamic compaction, which is mainly adapted for dealing with the shallow foundations; the other is composite foundation method, in which the flexible pile with higher strength is formed by squeezing the soil into the hole and filling with granular materials, and then the composition foundation is formed by the flexible pile with the surrounding soil to bear the upper load together. According to different filling materials, the flexible pile can be divided into several types of sand pile, gravel pile and cement pile, which are adapted for dealing with different types of deep and shallow soft foundations.

[0004] In recent years, the composite foundation reinforcement method based on the compaction and filling principle is widely used in the highway and high-speed railway soft foundation and special soil foundation treatment. Specially, the gravel pile method is favored by engineers and technicians because of its economical materials, relatively simple construction process and so on.

[0005] The existing gravel pile reinforcement technology generally uses the vibrating sinking pipe, the hammer sinking pipe or the impact holing method to form the pile hole, and then fills in the gravel while tapping, and finally forms the pile body. Due to the compressibility of the gravel pile less than that of the soft soil, the additional stress basically transferred to the foundation is gradually concentrated on the pile body with the deformation of the foundation, simultaneously, the pile body produces the lateral deformation to compress the soil between piles for transferring the stress to the soil between piles, a composite stress system is formed by the interaction between the pile body and the soil between piles, thus improving the bearing capability and reducing the settlement of the foundation.

[0006] Although the gravel pile reinforcement method has the outstanding advantages, and is increasingly widely used, it still has some deficiencies for the demand of the foundation treatment engineering which are mainly manifested in: (1) adopting the high-pressure water punching cutting pile technology in the vibro flotation process, which is not adapted for the foundation treatment engineering with higher sensitivity to water; (2) more complex construction process and difficult to control the construction quality; (3) greater disturbances to the foundation in the construction process and polluting the environment due to produced large amounts of liquid waste; (4) large construction equipment, high energy consumption, poor applicability and high requirements on the construction site; (5) the vertical bearing capacity of the pile largely depending on the binding force of the surrounding soil to the gravel pile, wherein if the surrounding soil is soft, the binding force of the surrounding soil to the gravel pile is poor, the vertical bearing capacity of the pile body is restricted; (6) the pile body consisting of granular mixture materials, wherein almost no cohesive force exists between the particles, so that the horizontal bearing capacity of the pile body is poor, the composite foundation is invalid due to the sheared gravel pile while withstanding the horizontal loads under special circumstances.

[0007] In conclusion, China's transportation infrastructure construction faces a lot of foundation treatment problems, how to according to the deficiencies of the existing foundation treatment technology, develop new materials, technologies and equipments for the foundation treatment is signifi-
cant for improving China's foundation treatment technical level, guaranteeing the quality and the operational safety of the transportation infrastructure.

The polymer grouting technology is a foundation quick reinforcement technology developed in 1970s. It injects the polymer materials to the foundation for filling the pores and compacting the soil, making use of the characteristics that the volume of the polymer material is rapidly expanded and solidified after the chemical reaction. Currently, the polymer grouting technology is mainly applied to foundation reinforcement and road maintenance of the industrial and civil buildings. No polymer grouting method for constructing gravel pile is reported.

SUMMARY OF THE PRESENT INVENTION

An object of the present invention is to provide a fast, safe and high-strength and environmentally-friendly polymer grouting method for constructing gravel pile, aiming at the deficiencies of the existing foundation treatment technologies, and especially, the maladjustment of the grouting technology with water reaction for the collapsible loess or water expansion soil. The present invention can rapidly reinforce the soft foundation and special soil foundation, thereby providing an advanced, highly efficient, safe and practical method for reinforcing the soft foundation and special soil foundation.

Accordingly, in order to accomplish the above object, the technical solution adopted by the present invention is as below.

A polymer grouting method for constructing gravel pile comprises steps of:

(1) pile-position-pore-forming: according to the design requirements, constructing a pile hole at a pile position by a drilling tool, whose depth reaches a design depth;

(2) installing a grouting pipe: installing a grouting pipe in the pile hole, wherein the grouting pipe is located in a middle of the pile hole, and a grouting outlet of the grouting pipe is close to a bottom of the pile hole;

(3) putting graded stones: according to different geological conditions, putting graded stones into the pile hole;

(4) polymer lifting grouting: putting a polymer lifting grouting control equipment on a hole of the grouting pipe; placing the grouting pipe into a pipe fixing device of the polymer lifting grouting control equipment; injecting two-component expansive polymer material to the pile hole via the grouting pipe by a polymer grouting system, and simultaneously opening the lifting grouting control equipment; and

(5) pile-forming: upwardly lifting the grouting pipe according to the set rate, the injected two-component expansive polymer material expanding rapidly after a chemical reaction, and solidifying with the graded stones for filling in the pile hole from below to above, expansion compacting a blast hole wall rock-soil and fully integrating with a surrounding rock-soil, thus forming a polymer gravel pile.

According to the foundation processing requirements, by pile-position-pore-forming, putting graded stones and polymer lifting grouting in the reinforcement site, the pile body and the soil around the pile of the present invention are further compacted, thus forming the composite foundation consisting of the polymer grouting gravel pile, the modified soil around the pile and the soil between piles.

Compared with the traditional foundation processing methods, the present invention has some advantages as below.

(1) The formed polymer gravel pile of the present invention and the soil around the pile form the composite foundation, which has the replacement, vertical enhancement, drainage, exhausting, cementation, compaction, filling and other mechanisms;

(2) The present invention is non-water reacted and strong applicability. The non-water reacted polymer material is not shrunk, and has strong tensile performance and vibration and crack resistance performances, large volume expansion ratio. The pile body has full form, is capable of filling the pile hole, is adapted for not only general geotechnical environment, but also the soft foundation reinforcement of collapsible loess or water expansion soil for which the cement-based materials are not adapted;

(3) The present invention has high strength. The polymer grouting material is fully integrated with the surrounding rock and soil to form the root-like cementation structure with strong adhesive force. Compared with the cement material under the same circumstance, the anchoring force is increased by nearly one time;

(4) The present invention has fast construction without need to be cured. The drilling and lifting grouting continuous operates, and the construction is fast. About 90% strength is formed after the reaction of material for 15 minutes without need to be cured;

(5) The present invention has convenient construction. The polymer grouting serial equipment is adapted for different sites, easy to approach, and has small construction electricity consumption;

(6) The present invention has good durability. The polymer grouting material has stable performance, no pollution, good flexibility and small permeability coefficient, and is closely bonded with the rock and soil and compatible deformed. It has good chemical solvent corrosion resistance and impermeability performance.

Therefore, the polymer grouting method for constructing gravel pile developed in the present invention has many advantages in the soft foundation rehabilitation project. Compared with the existing foundation processing technology, the polymer grouting method for constructing gravel pile is a new technology and mainly manifested in the following aspects:

(1) Piling materials and piling concept: based on the concept of the flexible pile, the polymer grouting method for constructing gravel pile uses the new grouting material of non-water reacted polymer, so it has safety and environmental protection, lightweight durability, high expansion rate, good impermeability, and early strength. The constructed polymer gravel pile is a flexible body, closely bonded with the soil, compatibly deformed, and has good impermeability and crack resistance.

(2) Reinforcement mechanism: the polymer grouting method for constructing gravel pile uses the expansive force after the polymer material reacting to fill the pile hole, expensively compact the hole wall rock and soil, and fully integrate with the surrounding rock and soil, the polymer material is solidified with the stone together during the expansion process, and then forms the composite foundation with the surrounding soil, thus rapidly reinforcing the soft foundation.
(3) Construction mode: by drilling, putting stones, polymer grouting pile-forming, the present invention has convenient construction. The present invention uses the polymer lifting grouting technology to rapidly and stably reinforce the soft foundation.

(0029) In summary, either from the piling material, the piling concept, the reinforcement mechanism or the construction mode, the present invention is obviously different from the existing foundation processing method, has strong applicability, fastness, high toughness, good durability and other advantages, and has great economic and social benefits and broad prospects for the development and application.

(0030) These and other objectives, features, and advantages of the present invention will become apparent from the following detailed description, the accompanying drawings, and the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

(0031) FIG. 1 is a schematic view of a polymer gravel pile pile-position-pore-forming according to a preferred embodiment of the present invention.

(0032) FIG. 2 shows a grouting pipe is installed in the pile hole.

(0033) FIG. 3 shows the graded stones are put into the pile hole.

(0034) FIG. 4 is a schematic view of the polymer lifting grouting.

(0035) FIG. 5 is a sectional view of the polymer gravel pile.

(0036) FIG. 6 is a top view of the polymer gravel pile.

(0037) [Figure Drawings, 1: drilling tool; 2: pile hole; 3: grouting pipe; 4: graded stones; 5: polymer lifting control equipment; 6: polymer material; 7: polymer gravel pile.]

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

(0038) The present invention is further explained in detail with the accompanying drawings.

(0039) A polymer gravel pile grouting method comprises steps of:

(0040) (1) pile-position-pore-forming: according to design requirements, constructing a pile hole at a pile position by a drilling tool 1, whose depth reaches a design depth, as shown in FIG. 1;

(0041) (2) installing a grouting pipe: installing a grouting pipe 3 in the pile hole 2, wherein the grouting pipe 3 is located in a middle of the pile hole, and a grouting outlet of the grouting pipe 3 is close to a bottom of the pile hole 2, as shown in FIG. 2;

(0042) (3) putting graded stones: according to different geological conditions, putting graded stones 4 into the pile hole, as shown in FIG. 3;

(0043) (4) polymer lifting grouting: putting a polymer lifting grouting control equipment 5 on a hole of the grouting pipe 3: placing the grouting pipe 3 into a pipe fixing device of the polymer lifting grouting control equipment 5; injecting two-component expansive polymer material 6 to the pile hole via the grouting pipe by a polymer grouting system, and simultaneously opening the lifting grouting control equipment 5, as shown in FIG. 4; and

(0044) (5) pile-forming: upwardly lifting the grouting pipe according to the set rate, the injected two-component expansive polymer material expanding rapidly after a chemical reaction, and solidifying with the graded stones for filling in the pile hole from below to above, expansion compacting a blast hole wall rock-soil and fully integrating with surrounding rock-soil, thus forming a polymer gravel pile 7, as shown in FIGS. 5 and 6.

(0045) One skilled in the art will understand that the embodiment of the present invention as shown in the drawings and described above is exemplary only and not intended to be limiting.

(0046) It will thus be seen that the objects of the present invention have been fully and effectively accomplished. Its embodiments have been shown and described for the purposes of illustrating the functional and structural principles of the present invention and is subject to change without departure from such principles. Therefore, this invention includes all modifications encompassed within the spirit and scope of the following claims.

What is claimed is:

1. A polymer grouting method for constructing gravel pile, comprising steps of:

(1) pile-position-pore-forming: according to design requirements, constructing a pile hole at a pile position by a drilling tool, whose depth reaches a design depth;

(2) installing a grouting pipe: installing a grouting pipe in the pile hole, wherein the grouting pipe is located in a middle of the pile hole, and a grouting outlet of the grouting pipe is close to a bottom of the pile hole;

(3) putting graded stones: according to different geological conditions, putting graded stones into the pile hole;

(4) polymer lifting grouting: putting a polymer lifting grouting control equipment on a hole of the grouting pipe; placing the grouting pipe into a pipe fixing device of the polymer lifting grouting control equipment; injecting two-component expansive polymer material to the pile hole via the grouting pipe by a polymer grouting system, and simultaneously opening the lifting grouting control equipment; and

(5) pile-forming: upwardly lifting the grouting pipe according to the set rate, the injected two-component expansive polymer material expanding rapidly after a chemical reaction, and solidifying with the graded stones for filling in the pile hole from below to above, expansion compacting a blast hole wall rock-soil and fully integrating with a surrounding rock-soil, thus forming a polymer gravel pile.

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