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SPECIFICATION

GROUND IMPROVING METHOD AND APPARATUS USED IN THE METHOD



TECHNICAL FIELD

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The present invention relates to a method of improving ground by providing a pile-shaped portion made of granular materials into the ground, and an apparatus to be used in this method.

BACKGROUND ART

Conventionally, in order to improve soft ground, many sand piles are formed in the soft ground, and a sand compaction pile method (hereinafter, referred to as an SCP method) is used a lot.

In the SCP method, as shown in Fig. 9(a), a casing pipe 21 is injected into subsurface soft ground G, for example, in seabed by utilizing a vibromotive force of a vibrohammer (not shown), and at this time, dry sand 22 is put into the casing pipe 21 while its inside is pressurized (shown by P in the drawing) so that inner pressure and outer pressure of a tip of the casing pipe 21 are balanced. The casing pipe 21 charged with the sand 22 therein is injected to a depth such that its tip reaches foundation ground Ga as shown in Fig. 9(b), and thereafter the casing pipe 21 is pulled out as shown in Fig. 9(c), so that the sand 22 is discharged and a sand pile 22a is

formed in the ground G.

When the above casing pipe 21 is pulled out, the step of reinjecting the casing pipe 21 as shown in Fig. 9(d) and compacting the discharged sand 22 and widens its diameter by means of vibration of the vibrohammer is repeated, so that a sand pile 22 having predetermined outer diameter and the degree of consolidation is formed as shown in Fig. 9(e).

In the prior method, in order to minimize a strength fluctuation of the formed sand pile (22a or 22b), a method which is so-called dry construction for discharging the dry sand 22 put into the casing pipe 21 into the soft ground G by means of air pressure is used.

In the prior ground improving method, however, since the sand put into the casing pipe is forcibly discharged by the air pressure, in the case where a work is done on the soft ground under the water, such as at the seabed or lacustrine bed, when the sand is discharged, ambient mud flies due to the air pressure, and there is a fear of environmental pollution due to water pollution.

In recent years, since high-grade natural sand is difficultly obtained, it is strongly demanded to use a granular material such as slag and coal ash instead of sand for the improvement in the ground from a viewpoint of resource conservation and effective use of waste. Since such a kind of the granular material, however, generally has a fine particle

diameter, and fine particles are mixed therein, when the granular material is discharged by the air pressure similarly to the sand, it flies, thereby arising a problem of more serious water pollution. When such a granular material is tried to be compacted by the vibration of the vibrohammer, it cannot be compacted sufficiently and also flies to a circumference due to the vibration at that time. As a result, the water pollution is aggravated, and there arises a new problem such that quality of the sand pile corresponding material or the like is poor.

The ground improving method and the ground improving apparatus using the air pressure and the vibrohammer cause a big noise and a strong vibration due to the work, a countermeasure should be taken for surroundings, thereby arising a problem such that a worker should bear a great burden on his/her shoulder.

It is an object of the present invention to solve the problems of the above-mentioned prior ground improving method and the apparatus used in the method.

DISCLOSURE OF THE INVENTION

A ground improving method of the present invention, is characterized in that a casing pipe is driven into soft ground, granular materials and water are put into the casing pipe, an ultrasonic wave is emitted to a periphery of the casing pipe in a state in which the granular materials are saturated with

the water so that the granular materials are compacted via the water and frictional resistance between the granular materials and an inner periphery of the casing pipe is reduced, and the casing pipe in this state is pulled out so that the a pile-shaped portion composed of the granular materials is formed in the ground.

Further, an inside of the casing pipe is accessorially pressured by air pressure so that internal pressure of a tip of the casing pipe becomes approximately equal with ground pressure in a depth of the tip of the casing pipe. In such a manner, working efficiency is improved.

In an apparatus of the present invention having a casing pipe with a tip lid and a driving device for driving the casing pipe into ground which is used in a ground improving method for forming a pile-shaped portion composed of granular materials in soft ground, the casing pipe has duplicate peripheral walls at its tip and has a cavity therein, and ultrasonic radiators are provided in the cavity.

In another structure, the tip lid is composed of a tip lid case having an approximately conic trapezoid shape whose tip has a widened diameter, a ball valve housed in the tip lid case movable up and down, and a valve seat section which comes in contact with the ball valve so as to bring the tip of the casing pipe into a sealed state, and the tip lid case has duplicated peripheral walls and is formed with a cavity therein,

and ultrasonic radiators are provided in the cavity.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a sectional view showing a tip portion of an apparatus used in a ground improving method according to the embodiment of the present invention; Fig. 2 is a sectional view taken along line A-A of Fig. 1; Fig. 3 is a sectional view showing a state of driving a casing pipe which explains the ground improving method of the present invention; Fig. 4 is a sectional view showing a granular substance discharging state; Fig. 5 is a sectional view showing a main section of the apparatus according to another embodiment of the present invention; Fig. 6 is a conceptual diagram showing a state in which the granular substance is compacted; Fig. 7 is a conceptual diagram showing a state in which a mechanical vibration is given to the granular substance filled with water; Fig. 8 is a conceptual diagram showing a state in which the granular substance is compacted loosely; and Fig. 9 is an explanatory diagram showing a sand pile forming step in a prior method.

THE BEST MODE FOR CARRYING OUT THE INVENTION

The present invention will be explained below in detail with reference to the attached drawings.

Fig. 1 is a sectional view showing a tip portion of an apparatus used in a ground improving method of the present

invention, and Fig. 2 is a sectional view taken along line A-A of Fig. 1. Similarly to the prior sand pile forming device, the apparatus includes a driving device (not shown) such as a vibrohammer and a casing pipe 1 driven into ground by the driving device.

In the apparatus of the present invention, an outer peripheral wall 1b is provided to an outside of the casing pipe 1 so that a cavity is formed around a tip (lower end in Fig. 1) of the casing pipe 1 and the peripheral wall has a duplicate structure, and a plurality of ultrasonic radiators 2 are mounted to an inner peripheral wall 1a in the formed cavity 1c so as to face each other. In the drawing, for easy understanding, the cavity portion is enlarged, but in general, a gap dimension of the cavity 1c (dimension in a radial direction) is within and without 10 cm with respect to the casing pipe with a diameter of about 1.2 m.

A publicly known tip lid of a hinge type or a ball valve type, not shown, is mounted to an upper side of the casing pipe 1 to which the ultrasonic radiators 2 are mounted.

In the apparatus of the present invention having the above structure, similarly to the prior sand pile forming device, the casing pipe 1 is driven by the driving device, not shown, such as the vibrohammer to a predetermined depth while ground soil is prevented from intruding into the tip of the casing pipe 1. A material which is used for forming a portion corresponding

to the prior sand pile is put into the casing pipe 1, but at this time the ground improving method of the present invention can effectively utilize granular materials S_a composed of industrial waste such as slag and coal ash as well as prior sand. The prior method uses the dry method using only dry sand, but the method of the present invention adopts a wet method for putting the granular materials S_a together with water W . Concretely as shown in Fig. 3, a sum of a height H_s of the granular material put into the casing pipe 1, water head H_w and air pressure P accessorially applied to the water surface is made to be equal with pressure received from the soft ground G at the depth of the tip of the casing pipe 1, and the tip lid, not shown, is opened in this state, so that the granular materials S_a saturated with the water are placed at the tip of the casing pipe 1. At this time, the granular materials S_a saturated with water are in a loose state as shown in the conceptual diagrams of Fig. 7 or 8.

In this state, when the ultrasonic radiators 2 provided to the tip of the casing pipe 1 is operated, the vibration of the ultrasonic radiators 2 acts on the granular materials S_a via water W , so that the particles of the granular materials S_a are unconnected by the vibration and the granular materials S_a can move freely. The granular materials S_a which can move freely are influenced by gravitation and are urged to be rearranged in order to reduce gaps so as to be compacted.

In a state in which the ultrasonic wave acts on the granular materials Sa in the casing pipe 1, when the casing pipe 1 is pulled up, the granular materials Sa hardly rub against the inner periphery of the casing pipe 1 due to fine vibration, so that the granular materials Sa are discharged from the tip of the casing pipe 1 easily as shown in Fig. 4.

A pulling-up dimension of the casing pipe 1 at this time is smaller than the height Hs of the above granular materials.

After a predetermined quantity of the granular materials Sa are discharged, the granular materials Sa and the water W, if necessary, are again put into the casing pipe 1 and the abovementioned step is repeated so that a pile-shaped portion S composed of the granular materials Sa is formed into the ground G.

In order to widen a diameter of of the pile-shaped portion S, similarly to the diameter widening work at the time of the prior sand pile forming, after the casing pipe 1 is once pulled up by a certain degree, it is vibrated by the vibrohammer or the like so as to be injected again. In such a manner, the diameter of the discharged granular materials Sa is widened.

In the ground improving method of the present invention, the pile-shaped portion S composed of the granular materials Sa is formed in the soft ground G.

The ground improving method of the present invention does not rely only on high-pressure air unlike the prior dry method

using dry sand, but in the ground improving method of the present invention, the pile-shaped portion S composed of the granular materials Sa is formed into the ground G by the wet method using water and ultrasonic vibration. For this reason, there is no fear that ambient sand and sludge are not erupted by the high-pressure air even in the ground improvement in water such as undersea ground, and the peripheral water pollution due to the work is suppressed minimally, and a big noise due to split-second forcible exhaust is not generated.

Since the slag, coal ash or the like which easily flies and is difficultly compacted is used so as to be capable of forming the pile-shaped portion S having the similar function to that of the prior sand pile, consumption of high-quality sand being in demand is prevented, and effective use of industrial waste to be difficultly discarded is attempted.

Fig. 5 is a sectional view showing the tip portion of the casing pipe 11 according to another embodiment of the present invention. As shown in the drawing, in this case, a ball valve type tip lid is used as the tip lid 12 for preventing intrusion of dirt from the outside. The ball valve type tip lid 12 has the basically same constitution as that whose right is acquired by the applicants of the present invention as Japanese Patent No. 2093345. The tip lid 12 is composed of a tip lid case 13 having an approximately conic trapezoid shape whose tip is widened and opened, a ball valve 15 housed in the tip lid case

13 movably up and down, and a valve seat section 14 which comes in contact with the ball valve 15 so as to bring the inside of the tip of the casing pipe 11 into a sealed state.

A reference number 18 in the drawing designates a cross rib provided on an open portion of the tip. A number 16 designates a fulcrum section for preventing slipping-off of the ball valve 15, and the fulcrum section 16 is provided into a floating state via a reinforcing member 17 attached in the tip lid 12 into an approximately cross shape. Since an action of the ball valve 15 is detailed in Japanese Patent Application Publication No. 8-1060 (1996) corresponding to the above-mentioned patent, its explanation is omitted here.

In the present invention, the tip lid case 13 is extended downward, a drum-shaped inner peripheral wall 13a is provided into the lid case 13 so that a predetermined gap is provided, and a plurality of the ultrasonic radiators 2 are mounted to an outside of the inner peripheral wall 13a in a cavity 13c formed between duplicate peripheral walls 13a, 13b. The ultrasonic radiators 2 are connected with an external power source supply device (not shown) via a power source cable (not shown) provided along an axial direction of the casing pipe 11 by suitable means.

In the ground improving apparatus having the above structure, similarly to the above-mentioned manner, after the granular materials and water are put into the casing pipe 11 driven by the driving device such as the vibrohammer to the

predetermined depth, the casing pipe 11 is pulled up by a predetermined dimension and at this time pressure on the upper side of the ball valve 15 contacting with the valve seat section 14 is raised by buoyance from the ground, so that the ball valve 15a is pushed down and the granular materials wet with the water are dropped into a space formed on the lower portion. The pressure on the upper side of the ball valve 15 is raised in such a manner that the air pressure is accessorially applied to a weight of the put granular materials and water.

In such a manner, the ultrasonic radiators 2 arranged on the circumference of the tip lid case 13 are operated so as to apply vibration to the granular materials dropped into the lower half space of the tip lid case 13 via the water, and the rearrangement is induced so that the gaps between the particles are narrowed, thereby compacting the granular materials. The vibration at this time functions so as to reduce friction between the inner peripheral wall 13a of the tip lid case 13 and the granular materials, so that the the granular materials, which are compacted into a pillar shape according to the pulling-up of the casing pipe 11, easily drop into the space formed on the lower portion so as to be discharged from the casing pipe 11.

Thereafter, when the above operation is repeated similarly, the granular materials discharged from the casing pipe 11 are compacted so that the pile-shaped portion is formed

in the soft ground.

Similarly to the above case, in this case, after the casing pipe 11 is once pulled up to a certain degree, the vibration is applied to the casing pipe 11 by the vibrohammer or the like and the casing pipe 11 is again injected, so that the diameter of the formed pile-shaped portion can be widened.

The embodiments shown in the drawings explain the example in which the plural ultrasonic radiators 2 are provided into the cavities 1c, 13c provided at the tip of the casing pipe 1 or the tip lid case 13 so as to face each other and three sets of them are arranged in up-down direction, but the ultrasonic radiators 2 may be mounted so as to transmit the ultrasonic vibration to the inside of the casing pipe 1 via the casing pipe 1 or the inner peripheral walls 1a, 13a of the tip lid case 13, and thus mounting positions and a number of them are arbitrary.

INDUSTRIAL APPLICABILITY

As mentioned above, in the ground improving method of the present invention, the ultrasonic wave is emitted to the granular materials filled with water so that the granular materials are compacted, and sand is discharged only by air pressure. For this reason, noise and vibration at the time of the work are less than the prior method in which a big noise is generated due to the split-second forcible exhaust, and high-pressure air is not erupted. As a result, there is no fear

that ambient dirt and sand fly and that water are polluted greatly like the prior method, thereby reducing an influence on the environment. Since the granular substances such as slag and coal ash, which are difficultly used in such ground improvement in the prior method, can be used, good-quality sand which is in demand can be left, and the effective use of industrial waste to be difficultly treated can be attempted.

The apparatus to be used in the ground improving method of the present invention can be easily formed by fabricating prior casing pipe and tip lid, and the driving device such as the vibrohammer having the prior structure can be used in its original state. The apparatus can, therefore, cope with lowering of cost, and thus the use of this method is improved.

CLAIMS

1. A ground improving method, characterized in that a casing pipe is driven into soft ground, granular materials and water are put into the casing pipe, an ultrasonic wave is emitted to a periphery of the casing pipe in a state in which the granular materials are saturated with the water so that the granular materials are compacted via the water and frictional resistance between the granular materials and an inner periphery of the casing pipe is reduced, and the casing pipe in this state is pulled out so that the a pile-shaped portion composed of the granular materials is formed in the ground.

2. The ground improving method according to claim 1, characterized in that an inside of the casing pipe is accessorily pressured by air pressure so that internal pressure of a tip of the casing pipe becomes approximately equal with ground pressure in a depth of the tip of the casing pipe.

3. An apparatus having a casing pipe with a tip lid and a driving device for driving the casing pipe into ground which is used in a ground improving method for forming a pile-shaped portion composed of granular materials in soft ground, characterized in that the casing pipe has duplicate peripheral walls at its tip and has a cavity therein, and ultrasonic radiators are provided in the cavity.

4. An apparatus having a casing pipe with a tip lid and a driving device for driving the casing pipe into ground which

is used in a ground improving method for forming a pile-shaped portion composed of granular materials in soft ground, characterized in that the tip lid is composed of a tip lid case having an approximately conic trapezoid shape whose tip has a widened diameter, a ball valve housed in the tip lid case movable up and down, and a valve seat section which comes in contact with the ball valve so as to bring the tip of the casing pipe into a sealed state, and the tip lid case has duplicated peripheral walls and is formed with a cavity therein, and ultrasonic radiators are provided in the cavity.