

DESCRIPTION

Title of Invention

REMOVAL METHOD FOR EMBEDDED STRUCTURE

Technical Field

[0001]

The present invention relates to a method of removing an embedded structure.

Technical Field

[0002]

Embedded structures to be embedded under the ground include piles, pipes, earth-retaining members (sheet piles). For example, a pile is driven into the ground as a foundation that bears a structure or the like. The structure is demolished and removed when unnecessary, but the pile under the ground remains under the ground as an existing pile. The existing pile is to be extracted and removed from under the ground when an obstacle under the ground is removed to restore vacant land, or when a newly installed pile, sheet pile, or the like interferes.

[0003]

Known methods for extracting an existing pile include a method of burying a cylindrical casing around the existing pile, extracting the casing, hooking a wire hoop on the tip of the casing, returning the casing under the ground, hooking the wire hoop on the upper part of the existing pile, extracting the casing, and then pulling up the existing pile with the wire while injecting cement milk (see, e.g., Patent Literature 1).

Citation List

Patent Literature

[0004]

1. Japanese Patent No. 6284253

Summary of Invention

Technical Problem

[0005]

However, in the conventional method, the cement milk is injected from on the ground, and thus, the cement milk cannot be injected promptly into a cavity formed upon pulling up the casing. This has created a problem in that the surrounding ground is likely to collapse and entering the cavity, leading to subsidence of the ground.

[0006]

As such, a method similar to that of extraction of a sheet pile can be employed to

install an injection tube along the surface of a pile to extract a pile along with injecting a sealing material from an injection tube. However, in the case of extraction of a pile with a wire, it is difficult to extract a bar pile straight upward, thus having created a problem in that even a slight inclination of the pile causes a breakage of the injection tube or the like and prevents injection of the sealing material.

Solution to Problem

[0007]

In view of the problem described above, the present invention is a method of removing an embedded structure, and provided is a removal method of an embedded structure, comprising:

installing an injection tube at a position with a certain distance or more from the embedded structure,

attaching a string-like member to the embedded structure, and

hoisting the string-like member thereby pulling up the embedded structure, as well as injecting a sealing material from the injection tube into the ground in a flow amount determined corresponding to at least a diameter of the embedded structure.

Advantageous Effects of Invention

[0008]

Employing the method of the present invention allows removal of an embedded structure along with an appropriate injection of a sealing material.

Brief Description of Drawings

[0009]

Fig. 1 shows a flowchart indicating a flow of removal operation for a pile, which is one of embedded structures.

Fig. 2 illustrates an installation position for the injection tube.

Fig. 3 shows a first example of a structure of the injection tube.

Fig. 4 illustrates structures of each member configuring the injection tube.

Fig. 5 shows a configuration example of a plant facility.

Fig. 6 shows a connection example of the injection tube and a supply pump.

Fig. 7 illustrates a casing and a pile extraction machine.

Fig. 8 exemplarily shows aspects from setting of the casing to completion of excavation with the casing.

Fig. 9 exemplarily shows aspects from pull-up of the casing to attachment of a slinging wire.

Fig. 10 exemplarily shows aspects from insertion of the casing to the pull-up of the pile.

Fig. 11 illustrates a structure of the slinging wire and an attachment method thereof.

Fig. 12 exemplarily shows an aspect of cutout of the pile.

Fig. 13 exemplarily shows an attachment position in attaching the injection tube to the casing.

Fig. 14 shows a second example of the injection tube.

Fig. 15 shows a configuration of a switching apparatus.

Description of Embodiments

[0010]

Before describing the removal method of an embedded structure according to the embodiment (hereinafter referred to as the method), a description will be made for a pile as an example of such embedded structures. Here, the embedded structure will be described as a pile, but is not limited to a pile, and may be a pipe, a sheet pile, or the like. In the pile, the inside may take a hollow shape, or the cross section may have a round shape, but not limited thereto, or a polygonal shape such as a triangle or quadrangle, or may have an oval shape, or may have an H-shape, a I-shape, a T-shape, a mountain shape, or the like, as found in a section steel.

[0011]

The pile is a bar body to be driven as a foundation to support a structure primarily in constructing a structure on the soft subsoil. The piles include wooden piles, reinforced concrete piles, PC (Prestressed Concrete) piles, steel pipe piles. The piles also include cast-in-place piles, which are derived by excavating on site, inserting a reinforcing steel bar and pouring concrete, thereby forming a pile on site.

[0012]

To bear a structure such as an apartment, the pile is driven so as to penetrate the soft subsoil and extend with the tip to the bearing stratum. The bearing stratum is a layer involving a 5-m succession of hard layer in which an N-value, used as an index for assessing the ground hardness, is 50.

[0013]

The pile ends its own role by demolition of a structure or the like, and is removed from under the ground when the ground is turned to vacant land, or when interference occurs with a pile, an earth-retaining member, and the like to be newly driven in a new construction after clearing. Here, assuming the pile is a steel pipe pile, description will be made for a method of extracting and remove the steel pipe pile. The steel pipe pile may be a hollow steel pipe, or may be filled with concrete or the like inside.

[0014]

Fig. 1 shows a flowchart indicating a flow of removal operation for a pile. The operation starts from step 100, and at step 101, a preparation is made for an operation of injecting and filling a sealing material into a cavity formed by extraction of the pile

(preparation for cavity filling). In extraction of the pile, for preventing collapse of wall surface of a bore formed in an extraction track, and subsidence of the surrounding structures (houses, existing revetments, or the like), a construction method is employed in which the pile is pulled up along with injection of the sealing material, thereby promptly filling the sealing material into a cavity formed with pull-up of the pile. A preparation therefor is performed here. Examples of the preparation include delivery and assembly of an injection plant including an injection tube.

[0015]

At step 102, the position of a pile head is confirmed. The pile head is the apex of a pile, and if the position of the pile head cannot be confirmed due to earth and sand and the like, the earth and sand and the like is manually dug to expose the pile head. Then, at step 103, a pile extraction machine is delivered and assembled. The body of the pile extraction machine is delivered with a low-deck trailer or the like. A leader, a hydraulic auger, and the like other than the body are serially delivered with a truck or the like after a beginning of assembly.

[0016]

At step 104, an injection tube is installed. The position to be installed with the injection tube is a position at a certain distance or more apart from a pile 10 as shown in Fig. 2(a). The installation position of an injection tube 20 is set to a position at a distance X or more from the outer peripheral face of the injection tube to a radial direction of the injection tube 20. This is for preventing the injection tube 20, in excavation using a casing, from being captured with the casing and subjected to entanglement to deform. The distance X is generally set to 0.2 m or more, e.g., 0.2-2 m, though depending on the diameter of the pile 10. Moreover, the injection tube 20 may be installed as only a single around the pile 10, but preferably installed as two or three. If three tubes are installed, one can be used as a spare. Here, this is an example, and the number of the injection tubes 20 to be installed may be four or more. Furthermore, the installation position of the injection tube 20 is not limited to one side such as the left side of the pile 10 as seen from the sheet surface as shown in Fig. 2(a), and may be a position as surrounding the pile 10 or the like.

[0017]

The flow amount of the sealing material to be injected from the injection tube 20 is calculated as a designed injection volume derived by, for example, in the case of the pile 10 having a diameter of 0.8 m, setting a diameter to 1 m with a sufficient margin and using the diameter and a pull-up speed of the pile 10. The pull-up speed of the pile 10 is set to, for example, 0.1-1 m/min. Incidentally, the speed as exemplified here is an example and thus is not limited to the speed within the range.

[0018]

The sealing material can be injected into the ground with repeating an operation of conducting delivery until appearance of leakage onto the ground surface, stopping a pump upon the appearance of leaking onto the ground surface, allowing the sealing material to be

hardened, and then restarting the pump to start the supply. This provides secure, dense filling into a cavity formed by pull-up of the pile, as well as enables filling into other cavities. The other cavities include a cavity present before the injection, and a gap between a box culvert, which is a box-shaped structure, and a sheet pile.

[0019]

The injection tubes 20, as plurally installed, are installed with different lengths as shown in Fig. 2(b). Through these, a deep part receives injection from a first injection tube 20a, which is the longest, and a shallow part receives injection from a second injection tube 20b, which is shorter than the first injection tube 20a. In other words, corresponding to a position of the tip of the pile 10 being pulled up, an injection tube is selected having a shorter distance from an injection inlet of the sealing material to the cavity formed on the tip and having ease for injection, and then injection is conducted from such injection tube, thereby allowing the cavity to be filled promptly. In Fig. 2(b), a spared injection tube 20c is installed as having a length between the length of the first injection tube 20a and the length of the second injection tube 20b.

[0020]

The first injection tube 20a, in flowing out the sealing material downward from the tip, is installed as spacing (floating) with around distance Y upward from the upper face of bearing layer 11, as shown in Fig. 2(b). This is because the bearing layer 11 involves dense packing of earth and sand and the like, making the sealing material difficult to permeate, and therefore the injection inlet on the tip of the first injection tube 20a is spaced at a certain distance from the bearing layer 11, thereby providing appropriate injection of the sealing material. The distance Y is set to, for example, around 0.02-0.1 m. Additionally, if the injection inlet is on the side face of the injection tube, the tip of the injection tube may be adjacent to the bearing layer 11; or if the injection inlet is above the bearing layer 11, the tip of the injection tube may be inserted into the bearing layer 11.

[0021]

Referring to Fig. 3 and Fig. 4, a description will be made for a structure of the injection tube 20. Here, this structure is an example, and the embodiment is not limited to this structure. The injection tube 20 is an excavated built-in injection tube that is to be built into the ground by excavating and inserting into the ground, and includes a swivel 21, a rod 24, and a monitor 27. The swivel 21 connects two pumps that separately supply two liquids (liquid A and liquid B), which compose the sealing material, from pumps and rotatably connects the rod 24. The swivel 21 includes, as shown in Fig. 4(a), for example, a substantially S-shaped pipe 22 to supply the liquid A inside, and a substantially funnel-shaped pipe 23 having an enlarged flow path to supply the liquid B. This allows separate transfer of the liquid A to the central flow path, and of the liquid B to the flow path outside the flow path of the liquid A. The swivel 21 has a separation on route in the longitudinal direction of the injection tube 20, and is configured such that one of the pieces is restricted in movement and the other is rotatable.

[0022]

The rod 24 has a double-pipe structure as shown in Fig. 4(b), and receives the liquid A, which has flowed through a flow path centering the swivel 21, supplied into an inner pipe 25, and the liquid B, which has flowed through a flow path outside the swivel 21, supplied between the inner pipe 25 and an outer pipe 26, and supplies the liquid A and the liquid B separately into the monitor 27.

[0023]

The monitor 27 is disposed at the tip of the injection tube 20, and discharges the sealing material to the lower part of the soil. The monitor 27 includes, as shown in Fig. 4(c), a double-pipe part 28, a mixing part 29, a spherical body (ball) 30, a spring part 31, and a discharge part 32. The double-pipe part 28 is linked to the rod 24, and separately supplies the liquid A and the liquid B to the mixing part 29. The mixing part 29 provides a space for mixing the liquid A and the liquid B. The ball 30 closes a hole disposed below the mixing part 29. In the spring part 31, a spring is contracted as the ball 30 is pushed down with the sealing material, which is mixed and produced in the mixing part 29. This opens the hole below the mixing part 29, which has been closed with the ball 30, and causes the injection material to flow to the discharge part 32 and to be discharged from the discharge part 32 to the upper part of the soil.

[0024]

For installation of the injection tube 20, an injection tube building apparatus is used. The injection tube building apparatus can include a monitor that has a pointed conical tip and is an excavating member with a spiral groove formed thereon; a bar rod to be attached with the monitor; and a grasper to grasp the rod rotatably and ascendably or descendably. These monitor, rod, and the like are different from the rod 24, the monitor 27, and the like of the injection tube 20 as shown in Fig. 3 and Fig. 4. The monitor is not limited to one having a pointed conical tip and a spiral groove formed thereon, and may be a bit having a plurality of blades (chips), which intrudes with cutting the ground, at the tip, or the like.

[0025]

The injection tube building apparatus has a grasper, and thus can grasp an injection tube 20 instead of a rod attached with the monitor for excavation at the tip and then adjust a force for grasping (a force for rotating and pressing) the injection tube 20, thereby lowering and inserting the injection tube 20 at a constant speed, and insertionally installing (building) the injection tube 20 into an introduction bore. Since this is an example, the injection tube building apparatus is not limited as having such a configuration.

[0026]

Then, referring to Fig. 5, a description will be made for a plant facility to supply the liquid A and the liquid B, which compose the sealing material, to the injection tube 20. The description will be provided here as supplying the Liquid A and the Liquid B individually separately to the injection tube 20, mixing them in the injection tube 20 to produce the sealing

material, and injecting the sealing material thus produced into the ground, but the embodiment is not limited thereto. Therefore, a sealing material composed of a single liquid may be supplied to the injection tube 20, and then the sealing material thus supplied may be injected as is into the ground.

[0027]

The plant facility is configured including a supply pump 40 that supplies the liquid A, which is a component of the sealing material, into the injection tube 20 to inject the sealing material; and a supply pump 41 that supplies the liquid B; and mixers 42 and 43 to respectively produce the liquid A and the liquid B; containers 44-47 that respectively contain water, a hardener, an accelerator, and a blast-furnace cement type B to be raw materials for the liquid A and the liquid B; a submersible pump 48; and a generator 49 that supplies a power sources to the pumps 40 and 41, the mixers 42 and 43, and the like.

[0028]

The plant facility is preferably loaded on a vehicle such as a truck, and mobile, because this facilitates transfer of the plant facility to a place of construction, enables an installation operation of the plant facility to be eliminated, and allows a period of construction to be shortened.

[0029]

As the supply pumps 40 and 41, pumps capable of separately supplying two liquids can be employed, such as positive displacement reciprocating pumps. As the positive displacement reciprocating pumps, dual liquid plunger pumps can be employed which easily change an amount of discharge. The dual liquid plunger pump includes two mechanisms of reciprocally moving a rod-shaped piston by a cam, a crank, and the like.

[0030]

Fig. 6 shows a connection example in connecting four dual liquid plunger pumps 50 with each of the rods 24 of the injection tube 20. The dual liquid plunger pump 50 includes a pump that supplies the liquid A and a pump that supplies the liquid B, each of the pumps is connected to the connection pipe 51 and the connection pipe 52.

[0031]

The connection pipe 51 is connected to a rod 24a, which supplies the liquid A, and the connection pipe 52 is connected to a rod 24b, which supplies the liquid B. The liquid A supplied into the connection pipe 51 is passed through the rod 24a and transferred to the monitor 27. The liquid B supplied into the connection pipe 52 is passed through the rod 24b and transferred to the monitor 27. The monitor 27 mixes the liquid A and the liquid B in the mixing part 29, and spouts them from the discharge part 32 to the upper part of the soil.

[0032]

In this regard, a brief description will be made for a chemical liquid injection construction method as a known construction method analogous to the present method. The chemical liquid injection construction method is a construction method in which a chemical

liquid allowing for arbitrary adjustment of a hardening time is injected into the ground to improve strength of the ground. This chemical liquid injection construction method has a requirement that a chemical agent is injected by using an injection rate equal to or less than a limit injection rate, which is an allowable limit of a fracture area to be a permeation face of the chemical liquid for forming a well-integrated, consolidated shape. Thus, the maximum injection rate to be practically used in an on-site injecting operation is set to an injection rate of 20 L/min or less. Therefore, for example, a dual liquid plunger pump capable of supplying the sealing material at an injection rate of about 25 L/min is used as a single.

[0033]

In the present method, since prompt filling is made into a large cavity formed by extraction of a pile having a large diameter, and further from a distant site, an injection rate is required above 20 L/min, e.g., above 50 L/min. The example shown in Fig. 6 is configured to perform injection at an injection rate of about 100 L/min using four of the dual liquid plunger pumps 50 capable of injecting the sealing material at an injection rate of about 25 L/min per pump. However, the embodiment is not limited to this, and two or three or five or more of the supply pumps may be used as long as they can perform injection at a speed of 50 L/min or more. Additionally, in the case of a sealing material composed of a single liquid, the supply pump may be one as long as it can perform supply at 50 L/min or more.

[0034]

Again referring to Fig. 5, an agent contained into the container 45 employs an agent containing an accelerator, and an agent contained into the container 46 employs an agent containing a hardener. The container 47 contains the blast-furnace cement type B.

[0035]

The liquid A is contemplated as a liquid derived by adding and well-kneading the blast-furnace cement type B and an accelerator (with a sedimentation accelerator material) with water, and the liquid B is contemplated as a liquid derived by adding and well-kneading a hardener with water. The liquid A is made by adding an appropriate amount of water from the container 44 by the submersible pump 48, charging appropriate amounts of the blast-furnace cement type B (e.g., 187.5 kg) and the accelerator (with a sedimentation accelerator material) (e.g., 10 kg) from the containers 47 and 45 to the mixer 42, and kneading them. As well, the liquid B is also made by adding an appropriate amount of water from the container 44 by the submersible pump 48, putting an appropriate amount of a hardener (e.g., 35 kg) from the container 46 to the mixer 43, and kneading them. The amounts of water to be added to the liquid A and the liquid B affect kneading-up, thus require a constant accuracy, and are preferably measured using a water meter.

[0036]

The liquid A and the liquid B are separately supplied by the supply pumps 40 and 41 into the injection tube 20, and mixed in injection tube 20, thereby producing the sealing material.

[0037]

The sealing material is preferably a liquid having relatively low viscosity such that after injection from the injection tube 20, without permeating broadly into the soil, it can enter a negatively-pressured cavity formed by extraction of the pile 10, and is also preferably gelatinized quickly. For prevention of permeation, the time until lack of flowability and rapid increase in viscosity of the sealing material (gel time) is preferably around 60 seconds.

[0038]

Upon mixing the liquid A and the liquid B as described above, gelatinization proceeds in a short time; the gel time can be adjusted by changing their proportion. Because of gelatinization in such a short time, mixing is set to be performed in the injection tube just before flowing out to the soil. Incidentally, since gelatinization does not occur during flowage of the sealing material, a sealing material composed of a single liquid may be supplied into the injection tube and discharged into the ground.

[0039]

Again referring to Fig. 1, at step 105, a pile extractor is installed at a position in the vicinity of the pile 10 to be removed. After the installation of the pile extractor, at step 106, excavation is performed with the casing. The casing is installed so as to surround the pile head, and checked to be installed vertically to the ground with a spirit level, and then rotated with an auger, thereby excavating the ground.

[0040]

Referring to Fig. 7, a description will be made for the casing and the pile extractor. As shown in Fig. 7(a), the pile extractor 60 has a crane 62, as a body, with an expandable and contractible bar member (boom) 61 and includes a rotator (auger) 64 that rotates a frame member (casing) 63 to dig the ground, an elevator (leader) 65 that suspends the auger 64 to allow the auger 64 to ascend and descend, and a reaction bed 66 that receives a reaction force from the ground against the leader 65 in digging of the ground with the casing 63.

[0041]

The pile extractor 60 is assembled by attaching the leader 65 to the body, attaching the auger 64, and finally attaching the casing 63. The auger 64 includes a motor, and ascend and descend along the leader 65, as well as rotates the casing 63 in a constant direction.

[0042]

As shown in Fig. 7(b), the casing 63 is a steel cylindrical hollow frame member, and includes an excavation bit 67, which is a sharp excavating member, at a tip, and a plurality of opening parts 68, which is placed in a line and used as windows for checking, on the side face. The casing 63 has an inner diameter of the hollow larger than the diameter of the pile 10, and digs the ground surrounding the pile 10 and is inserted into the ground.

[0043]

The casing 63 has a hole at the tip for spouting water. This allowed excavation with the casing 63 to be performed along with spouting water. The casing 63 may be a single long

member, but may also be a plurality of members having a connectable configuration that may be connected for every insertion to a predetermined depth. The casing 63 is inserted into the ground by repeating rotation, descent, and connection until reaching the substantially same depth as the tip of the pile 10.

[0044]

Fig. 8 shows aspects from setting of the casing 63 to completion of excavation with the casing 63. Fig. 8(a) shows an aspect of adjusting the center of the casing 63 to the center of the pile 10, and installing the pile extractor 60. The center of the casing 63, which has a ring-shaped cross section, is adjusted to the center of the pile 10, which has a circular cross section, by installing the pile extractor 60 within the range allowing the casing 63 to be arranged directly above the pile 10, rotating the body and moving the boom 61 back and forth, and the like.

[0045]

Fig. 8(b) shows an aspect of excavating an outer periphery of the pile 10 along with spouting water from the tip of the casing 63 and loosening soil of the ground. The casing 63 is arranged so as to surround the outer periphery of the exposed pile head, rotated with an auger 64, and lowered along the leader 65, thereby excavating the outer periphery of the pile 10. At that time, spout of water from the tip makes the soil muddy and easy to adhere to the casing 63, but facilitates excavation. The water thus spouted turns into muddy water, but the muddy water can be appropriately drawn using the submersible pump or the like, subjected to removal of floating matters, mud, and the like, treated with pH adjustment and the like, and then released to a river.

[0046]

Fig. 8(c) shows an aspect of inserting the casing 63 to a predetermined depth, and completing excavation with the casing 63. Once the casing 63 is inserted to the predetermined depth, the periphery of the pile 10 is made covered with the casing 63.

[0047]

Again referring to Fig. 1, at step 107, the pile 10 is bordered with checking self-sinking and rotation of the inner pile 10 from the opening parts 68 disposed on the side face of the casing 63.

[0048]

The pile 10 closely contacts with the surrounding soil. Once the periphery of the pile 10 is excavated with the casing 63 and completely bordered from the surrounding soil, the pile 10 is no longer retained with the surrounding soil; and sinks by itself due to deadweight because of the periphery of the pile 10 becoming muddy and soft; and further rotates with casing 63 because of presence of the muddy soil filling between the casing 63 and the pile 10. Consequently, completion of the bordering is determined by checking self-sinking or co-rotation.

[0049]

Upon completion of the bordering, the flow proceeds to step 108, and the casing 63 is pulled up along with rotating at a low speed. The casing 63 is rotated in the same direction as that of the pull-up and the excavation. In the case of a plurality members being connected, rotation is stopped at a phase of the connected part being pulled up to about 1 m from the ground surface, and a casing connected to the top is removed. The operations at step 103 and step 105-step 108 may be performed concurrently with an operation at step 104.

[0050]

After completion of the pull-up of the casing 63, at step 109, preparation is performed for filling the sealing material. The preparation for filling the sealing material is production of the liquid A and the liquid B described above, and the like. At step 110, the casing 63 is attached with a slinging wire 70, which is a string-like member. The operation at step 109 may be performed concurrently with the operation at step 110.

[0051]

Fig. 9 shows aspects from pull-up of the casing 63 to attachment of the slinging wire 70. Fig. 9(a) shows an aspect of pulling up the casing 63 along with rotating in the same direction as excavation. The casing 63 is difficult to pull up as is due to the surrounding muddy soil occurring resistance, and thus is pulled up along with rotating. The rotating direction is set to the same direction as that of excavation in order to perform the rotation of the casing 63 smoothly. At that time, the pile 10 becomes inserted into a bore 69 excavated with a casing 63.

[0052]

When a jamming phenomenon occurs and clamps the casing 63 inside the ground to make it unrotatable, the casing 63 can also be pulled up with rotating forcedly. However, since the surrounding ground is likely to collapse, the casing 63 is preferably improved in slip, reduced in clamping, and pulled up along with rotating. For improving slip of the casing 63, a lubricant such as oil can be used; but since this pollutes the soil, an agent made from a plant-based material is desirable.

[0053]

The present method found that in an operation of slope-face plant splaying, a bond is desirable which is used for adhesion of plant and made from a plant-based material. The bond is injected along an outer surface of the casing 63, thereby improving slip of the casing 63, reducing clamping inside the ground, facilitating rotation of the casing 63, and pulling up as well as rotating the casing 63.

[0054]

Fig. 9(b) shows an aspect of completing pull-up of the casing 63. The casing 63 thus pull-up has mud adhered thereon, and the adhered mud is washed out with a high-pressure washer or the like. Fig. 9 (c) shows an aspect of attaching the slinging wire 70 to the casing 63. A hoop in the wire formed the hoop is put on the tip of the casing 63 after wash-out of mud, i.e., at the end of a part disposed with the excavation bit.

[0055]

Again referring to Fig. 1, after the slinging wire 70 is attached to the tip of the casing 63, the flow proceeds to step 111; injection of the sealing material is started and extraction of the pile 10 is started. In the extraction of the pile 10, the sealing material is injected from the injection tube 20 inserted, thus filling promptly the sealing material into a cavity formed with the extraction. The sealing material is produced by activating the supply pumps 40 and 41 shown in Fig. 5, supplying the liquid A and the liquid B separately into the injection tube 20, and mixing them in the injection tube 20, and then spouted from the injection inlet.

[0056]

Fig. 10 shows aspects from insertion of the casing 63 to pull-up of the pile 10. Fig. 10(a) shows an aspect of inserting again the casing 63, which is attached with the slinging wire 70, up to the predetermined depth in the ground without rotating the casing 63. The casing 63 is inserted without rotation because when the casing 63 is inserted along with rotating the casing 63, the slinging wire 70 attached to the casing 63 will come off.

[0057]

Fig. 10(b) shows an aspect of attaching the slinging wire 70 to the pile 10, and checking fixation of the slinging wire 70 to the pile 10, followed by pulling up the casing 63. The slinging wire 70 is tensely attached to the casing 63, and the tension is released in pull-up. At that state, only the casing 63 is pulled up. Then, the slinging wire 70 is tensed again, and the slinging wire 70 is attached to the pile 10.

[0058]

Fig. 10(c) shows an aspect of pulling up the slinging wire 70 gradually to extract the pile 10. After the slinging wire 70 is fixed to the pile 10 as shown in Fig. 10(b), the other end of the slinging wire 70 is attached to the tip of the boom 61 and pulled up upward, thereby pulling up the pile 10.

[0059]

The slinging wire 70 is created as shown in Fig. 11, by making a small hoop 71 at one end, passing the other end through the small hoop 71, thereby making a large hoop 72 to be put around the casing 63, the pile 10, or the like. The small hoop 71 may be a hook used for a safety belt or the like. In attachment around the casing 63, the casing 63 is passed through the large hoop 72, which is then put around the casing 63, and the other end of the slinging wire 70 is pulled in a direction away from the casing 63, thereby forming close contact around the casing 63.

[0060]

In changing a member to be tied from the casing 63 to the pile 10, pulling the other end of the slinging wire 70 is stopped to release the tense, thereby providing a loosen state and pulling up the casing 63. The hoop 72 in the slinging wire 70 is released from the close contact with the casing 63, and thus even when the casing 63 is pulled up, only the casing 63 is pulled up and the hoop part of the slinging wire 70 remains at the position of the depth as is

into the ground. At that time, an arrangement is formed so as to surround the pile 10.

[0061]

Therefore, pulling again the other end of the slinging wire 70 provides fixation with close contact around the pile 10. As such, the slinging wire 70 is fixed to the pile 10, and the pile 10 can thus be extracted by pulling up the slinging wire 70.

[0062]

Extraction of the pile 10 is performed by injecting the sealing material from the injection tube 20 into the ground in at least a flow amount determined corresponding to a diameter of the pile 10. For example, for a diameter of about 1 m, a designed injection volume can be 50-200 L/min. Injection of the sealing material is performed with pumping pressure of the supply pumps 40 and 41, earth pressure, and negative pressure generated by extraction of the pile 10.

[0063]

In the extraction operation for the pile 10, every time the pile 10 is pulled up by a certain height, a check can be made whether a certain volume of the sealing material has been injected. In pulling up the pile 10 by the certain height and simultaneously injecting the sealing material, whether the sealing material has been injected into a cavity formed by the pull-up by the certain height can be checked by confirming whether after completion of the injection into the cavity, the sealing material come to leak onto the ground through a gap or the like surrounding the pile 10 formed by the excavation with the casing 63. Incidentally, the extraction operation for the pile 10 can also be performed by continuously pulling up the pile 10, and also continuously injecting the sealing material.

[0064]

By setting the designed injection volume to more injection volume relative to a common construction method of chemical liquid injection, as well as employing a liquid form with relatively low viscosity as the sealing material, filling can be instantly made into a cavity formed by the pull-up of the pile 10 even when the injection tube 20 is installed at a position apart from the pile 10. The sealing material, upon spouting into the soil, has low viscosity and is thus likely to flow so as to spread in the soil, which is relatively soft and has large gaps between soil particles, above the bearing layer 11; however, once the pull-up of the pile 10 forms a cavity, a flow path toward the cavity is formed due to negative pressure of the cavity, thus leading to intensive flow to the cavity.

[0065]

The present method employs use of a low-viscosity liquid sealing material, higher injection rate of the sealing material, and larger injection volume, and thus a cavity, upon forming, can be filled instantly therinto with the sealing material. Moreover, even when the ground has another cavity, the sealing material can also be injected into such other cavity. Therefore, it can be securely prevented that the surrounding ground collapses toward the cavity and enters into the cavity, causing subsidence of the ground.

[0066]

Again referring to Fig. 1, at step 112, whether the pile 10 is to be cut off is determined. The determination at step 112 can be performed in checking an injection volume of the sealing material every time the pile 10 is pulled up by a certain height. Whether the pile 10 is to be cut off is determined by confirming whether the pile 10 has a length of 7 m or more. In the case of the pile 10 with a length of less than 7 m, the pile 10 is extracted without cutting-off. By contrast, in the case of the pile 10 with a length of 7 m or more, the flow proceeds to step 113, in which the injection of the sealing material is suspended and the pile 10 is cut off using a cutter such as a pipe cutter.

[0067]

After cutting off, and for preventing a pile below the cut plane from falling down to an excavate hole, the pile 10 is wound with an anti-drop wire rope 73, and tightly bound to a sheet pile 74, a work scaffold, or the like, thereby making temporal fixation, as shown in Fig. 12.

[0068]

In addition to filling the formed cavity, the sealing material passes through a gap that is excavated with the casing 63 and surrounds the pile 10, and flows out onto the ground. The operations such as the cut-off of the pile or the attachment of the anti-drop wire rope 73 as described above are operations in the periphery of the pile 10, and thus cannot be performed until the sealing material is hardened to have a certain degree of strength.

[0069]

However, since the sealing material used in the present method has a short gel time and promptly exerts a predetermined strength, the operation described above can be performed promptly. This allows a period of construction to be shortened and working efficiency to be improved.

[0070]

The slinging wire 70 is removed from the cut-off pile 10a, and the flow returns to step 110 to repeat the operations of making an attachment to a pile 10b, which is temporarily fixed and located below the cut plane; again pulling up the slinging wire 70 along with injecting the sealing material; and determining whether the pile is to be cut off as well.

[0071]

If determined not to cut off the pile 10 at step 112, the flow proceeds to step 114 to determine whether the extraction has completed. If not completed, the flow returns to step 111 to pull up the slinging wire 70 along with injecting the sealing material.

[0072]

After completion of the extraction of the pile 10 at step 114, the injection tube 20 is extracted at step 115, and the presence of any other pile 10 to be extracted is checked at step 116. If present, the injection tube 20 is extracted, followed by the flow returning to step 104.

[0073]

By contrast, if any other pile to be extracted is absent at step 116, the flow proceeds to step 117; the injection plant is disassembled, loaded on a truck or the like and delivered out, and as well, the pile extractor 60 is also disassembled, and delivered out by loading the body on a low-deck trailer and loading others such as a leader, an auger, and the like on a truck. Then, the operation is finished at step 118.

[0074]

The present method employs a sealing material having a short gel time as the sealing material, and thus allows performing promptly also an operation on the ground, where the pile 10 is formerly present, after removal of the pile 10, thereby enabling installation of an injection tube building apparatus on such ground and extraction of the injection tube 20.

[0075]

In addition to use of the injection tube building apparatus as described above, the injection tube 20 can also be installed in the ground using a vibratory hammer hung with a crane. The vibratory hammer is a machine that has a chuck part to capture the pile, adds vibration force to the pile, reduces peripheral friction force, resistance force, and the like of the pile and inserts it into the ground.

[0076]

The injection tube 20 may also be attached to the outer periphery of the casing 63 by welding or the like, and inserted simultaneously with insertion of the casing 63. In insertion into the ground, the casing 63 is inserted along with spouting water and excavating the ground with an excavation bit disposed at the tip. Therefore, a pipe 80, which supplies water, is also attached to the outer periphery of the casing 63 by welding or the like, as shown in Fig. 13(a). The pipe 80 is disposed as at least two, in order to supply a constant amount of water.

[0077]

In attachment to the casing 63, the injection tube 90 can be attached to at least one of the pipes 80 disposed as at least two, so as to be adjacent to the pipe 80 in the rear side of the rotation direction shown by an arrow C. In the example shown in Fig. 13(a), two pipes 80 are attached, and two injection tubes 90 are each attached in the back side on the rotation direction of the two of the pipes 80.

[0078]

The injection tube 20 and the pipe 80 are attached and extend along a longitudinal direction of the outer face of the casing 63, as shown in Fig. 13(b). The injection inlets of the injection tube 20 and the pipe 80 are located on a part projecting from the tip of the casing 63 and is configured for allowing to spout toward inside of the casing 63.

[0079]

In use with attachment of injection tube 20 to the casing 63, the slinging wire 70 is attached to the pile 10, and then excavation is performed by the casing 63 along with spouting water from the pipe 80, thereby rendering the periphery of the pile 10 covered with the casing 63. Then, along with injecting the sealing material from the injection tube 20, the pile 10 is

gradually extracted together with the casing 63.

[0080]

The pile 10 and the casing 63 can be extracted by repeating of: pulling up them e.g., by 50 cm, stopping temporarily at that level, then injecting a predetermined injection volume, and again pulling up them by 50 cm upon completion of the injection; or can also be extracted by continuously supplying the sealing material corresponding to an extraction speed of the pile 10.

[0081]

In the pile 10 and the casing 63 with long lengths, the pile 10 and the casing 63 are cut off in the middle, and the slinging wire 70 is reattached, thereby allowing pulling up the residual portions of the pile 10 and the casing 63. At that time, the pipe 80 and the injection tube 20 attached to the casing 63 can be cut off together.

[0082]

The injection volume of the sealing material can be an amount corresponding to the volume of a cavity formed by pull-up of the pile 10 and the casing 63.

[0083]

In the example shown in Fig. 13, the injection tube 20 is attached on the outer periphery of the casing 63 to prevent the pile 10 from bumping and breaking the injection tube 20 in extraction of the pile 10 located inside, but the embodiment is not limited thereto. Accordingly, the injection tube 20 may be attached inside the casing 63, as long as a gap is disposed sufficient to avoid collision with the pile 10 in the extraction. Attaching the injection tube 20 inside the casing 63 allows more rapid filling of an extraction track of the pile 10. Incidentally, in attachment of the injection tube 20 inside the casing 63, the injection tube 20 is preferably attached so as to arrange the injection inlet in a part not projecting from the tip of the casing 63. This is because, due to the presence of the casing 63 so as to cover the outside of the injection tube 20, the discharged sealing material no longer moves to the outside, thus allowing more rapid filling of an extraction track of the pile 10 located inside.

[0084]

Furthermore, in attachment of the outer periphery of the casing 63, the injection inlet at the tip of the injection tube 20 may direct upward as shown in Fig. 13(b), but may also be one treated with processing such as bending so as to direct toward the inside where the pile 10 is present. Directing the injection inlet at the tip of the injection tube 20 toward the inside allows more rapid filling of an extraction track of the casing 63 and the inner extraction track of the pile 10.

[0085]

In building of the injection tube 20 with attachment to the casing 63, since the casing 63 has the injection tube 20 attached in advance, a pre-attached injection tube 90 is to be used. A structural example of the pre-attached injection tube 90 is shown in Fig. 14. Here, the example shown in Fig. 14 is an example, and the embodiment is not limited to this structure.

[0086]

The injection tube 90 as shown in Fig. 14 includes rods 91 and 92, which are two cylindrical pipes disposed parallelly. The rods 91 and 92 are formed flow paths for supplying the liquid A and the liquid B separately. In supplying a single liquid, a single rod may be used. The rods 91 and 92 can be made to be longitudinally dividable into plural numbers as required, and can be linked by longitudinally plugging in using a connecting member.

[0087]

On the top of the injection tube 90, an introduction member 93 is disposed including each introduction inlet for connecting each of the rods 91 and 92 with each of connection pipes 51 and 52. Link of the introduction member 93 to each of the connection pipes 51 and 52 is made by longitudinally plugging in or the like.

[0088]

The injection tube 90 also include a tip member 94 to be connected to the upper end of the rod 91 and 92. The tip member 94 has introduction inlets 95 and 96 for the liquid A and the liquid B, a space (a mixing chamber 97) following the introduction inlets 95 and 96 and being for mixing each liquid and producing the sealing material, and an injection inlet 98 to connect the mixing chamber 97 with the outer ground.

[0089]

The injection inlet 98 radially extends from the mixing chamber 97 located in a central part of a cross section of the injection tube 90 to an outer side face injection tube 90, and has a check valve 99 disposed inside for prevent backflow from the outside. The check valve 99 may be arranged at any position such as in the vicinity the ground, in the vicinity of the mixing chamber, or in the center, as long as it is located inside the injection inlet 98. The check valve 99 is a valve that operates so as to cause back pressure of the sealing material inside mixing chamber 97 to prevent backflow by a valve body, and is classified into a lift type, a swing type, and the like corresponding to models of valve bodies. The lift type is a type that opens and closes by moving a valve body vertically, and the swing type is a type that opens and closes by rotating a valve body with a hinge as a fulcrum like a door.

[0090]

At that time, since a gap is generated between the injection inlet 98 and the check valve 99, a sealing member (sealant) is disposed for filling the gap, and fixing the check valve 99 to prevent it from being pushed by the sealing material and protruding outside. The sealant can be, for example, a cylindrical hollow shape composed of silicone, and can be engaged into the injection inlet 98 and used. The sealant generates friction resistance to the injection inlet 98, and resists extrusion of the check valve 99 by the sealing material. In supply pressure of the sealing material, the sealant can be fixed the check valve 99 sufficiently.

[0091]

Nevertheless, upon receiving a pressure several-fold to several dozen-fold larger than the supply pressure of the sealing material, the sealant will be pushed outside together with

the check valve 99. Thus, in cleaning inside the injection tube 90, such high-pressure water is supplied to push the check valve 99 and the sealant outside, thereby providing cleaning from the inside of the mixing chamber 97 to the injection inlet 98 with ease and in a short time. The check valve 99 and the sealant can be easily attached only by inserting them into the injection inlet 98 after cleaning and drying.

[0092]

In the example shown in Fig. 14, the injection inlet 98 is disposed on both right and left sides as seen from the sheet so as to allow the sealing material to be spouted both rightward and leftward, but may also be disposed only one side where the cavity is present and configured to spout toward only one side. Moreover, the injection inlet 98 may be disposed at a tip of the injection tube 90 directed to a deep part, and configured to spout from the tip to a deep part.

[0093]

In use with attachment of the injection tube 90, shown in Fig. 14, to the casing 63, the top of the injection tube 90 is connected with pipes (hoses) for supplying individually the liquid A and the liquid B, which compose the sealing material, via a swivel as a connecting member. The swivel here used is fixed and thus will not rotate.

[0094]

The injection tube 90, in attachment to the casing 63, is pulled up together with pile 10, and the sealing material enters promptly into a ring-shaped extraction track of the casing 63 forms by the pull-up (cavity 1), and as well, the sealing material filled in the cavity 1 flows toward an extraction track of the pile 10 formed in the center (cavity 2) from the periphery of the cavity 2, and fills the cavity 2. Furthermore, the injection inlet 98 of the injection tube 90 moves along with pull-up of the casing 63, causing a constant presence of the injection inlet 98 close to the cavity 2. Therefore, even using the injection tube 90 as a single, the cavities 1 and 2 can be filled promptly with the sealing material.

[0095]

Meanwhile, in the excavated built-in injection tube 20 shown in Fig. 3, the discharge part 32 do not change its position even in the pile 10 being pulled up, thus gradually increasing a distance from the discharge part 32 to a cavity formed by the pull-up of the pile 10, and making it difficult to fill promptly the cavity with the sealing material. For this reason, at least two of the injection tubes 20 having different lengths are installed.

[0096]

In installation of the injection tubes 20 having different length as such, at the beginning of pull-up of the pile 10, the sealing material will be injected from a longer one of the injection tubes 20, and then halfway, the sealing material will be injected from a shorter one of the injection tubes 20. Thus, the two pipes to supply respective liquids can be at first, connected to a longer one of the injection tubes 20 to inject the sealing material, and then halfway, reconnected to a shorter one of the injection tubes 20 to inject the sealing material

from the shorted one of the injection tubes 20.

[0097]

However, such reconnection takes much time and labor. Thus, use of a switching apparatus 110 shown in Fig. 15(a) can facilitate switching. The switching apparatus 110 include two three-way valves 111 and 112, which have outlets/inlets for fluids in three directions. The three-way valves 111 and 112 have an inlet and two outlets. The one inlet of the three-way valve 111 is connected to, for example, a pipe (hose) 118 to supply the liquid A, and the two outlets are connected respectively to swivels 114 and 115, which are connected to two of the injection tubes 20 having different lengths, via hoses 116 and 117.

[0098]

As well, in the three-way valve 112, the one inlet is connected to, for example, to the hose 113 to supply the liquid B, and the two outlets are connected respectively to the swivels 114 and 115, which are connected to the two of the injection tube 20 having different lengths, via hoses 119 and 120. Since the three-way valves 111 and 112 have the same structure, description will be provided only for the three-way valve 111, with omission of description for the three-way valve 112.

[0099]

The three-way valve 111 has a lever 111a capable of rotating at substantially 90°, the inside of which, for example, has a cylindrical hollow 121, three communicating paths 122-124 that join the hollow 121 to each outlet/inlet, and an L-shaped path 125 that rotates along with rotation of the lever 111a, as shown in Fig. 15(b).

[0100]

As shown in Fig. 15(c), when the lever 111a is located at a position D, i.e., when the lever 111a, which rotates with centering one end, places the other end at the position D, the L-shaped path 125 joins the communicating path 122, which is connected with the hose 118, to communicating path 123, which is connected with the hose 116, and flows the liquid A, which has flowed through the hose 118, to the hose 116 and supplies it to the swivel 114.

[0101]

Once the lever 111a is rotated by bringing the other end of the lever 111a to the direction of an arrow line E, the L-shaped path 125, which is located inside, also rotates along with the rotation of the lever 111a. Once the other end of the lever 111a reaches a position F, the path 125 takes a form that joins the communicating path 122, which is connected to the hose 118, to the communicating path 124, which is connected to the hose 117. This allows the liquid A, which has flowed through the hose 118, to be flowed to the hose 117 and to be supplied to the swivel 115.

[0102]

The switching has been described with reference only to the liquid A, but in switching the liquid A, the liquid B is also switched simultaneously. Upon the switching, the liquid A and the liquid B are no longer supplied to the swivel 114; thus, removing the hoses

116 and 117 from the swivel 114 and then connecting the hoses 116 and 117 to another swivel, during supply of the liquid A and the liquid B to the swivel 115, allows further switching from the swivel 114 to the other swivel. In installation of three or more of the injection tubes 20 having different lengths, reconnection to another swivel for every switching in this manner allows continuous injection of the sealing material from each of the injection tubes 20.

[0103]

As described above, employment of the method allows removing an embedded structure along with appropriately injecting a sealing material. Therefore, even in the presence of a structure in the vicinity, an embedded structure can be removed along with preventing subsidence of the structure.

[0104]

The method of removing an embedded structure according to the present invention has been described in detail with reference to the embodiment illustrating in the drawings so far, but the present invention is not limited to the embodiment mentioned above, and can be modified with another embodiment, addition, modification, deletion and the like, within the range that can be contemplated by those skilled in the art, and any aspect falls within the range of present invention as long as it provides an action or effect of the present invention.

Description of Signs and Numerals

[0105]

10, 10a, 10b-pile,
 11-bearing layer,
 20, 20a -20c, 90-injection tube,
 21, 114, 115-swivel,
 22, 23, 80-pipe,
 24, 24a, 24b, 91, 92-rod,
 25-inner pipe,
 26-outer pipe,
 27-monitor,
 28-double-pipe part,
 29-mixing part,
 30-ball,
 31-spring part,
 32-discharge part,
 40, 41-supply pump,
 42, 43-mixer,
 44-47-container,
 48-submergible pump,
 49-generator,

50-dual liquid plunger pump,
51, 52-connection pipe,
60-pile extractor,
61-boom,
62-crane,
63-casing,
64-auger,
65-leader,
66-reaction bed,
67-excavation bit,
68-opening part,
70-slinging wire,
71, 72-hoop,
73-anti-drop wire rope,
74-sheet pile,
93-introduction member,
94-tip member,
95, 96-introduction inlet,
97-mixing chamber,
98-injection inlet,
99-check valve,
110-switching apparatus,
111, 112-three-way valve,
111a-lever,
113, 116-119-hose,
121-hollow,
122-124-communicating path,
125-path.

CLAIMS

Claim 1

A method of removing an embedded structure comprising:
installing an injection tube at a position with a certain distance or more from the embedded structure,
attaching a string-like member to the embedded structure, and
hoisting the string-like member thereby pulling up the embedded structure, as well as injecting a sealing material from the injection tube into the ground in a flow amount determined corresponding to at least a diameter of the embedded structure.

Claim 2

The method of removing an embedded structure according to claim 1, wherein the installing the injection tube comprises forming at least two bores having different depths at a substantially predetermined distance from the embedded structure in a circumferential direction of the embedded structure, and installing at least two injection tubes having different lengths.

Claim 3

The method of removing an embedded structure according to claim 2, wherein the injecting the sealing material comprises selecting one of the at least two injection tubes corresponding to the position of the embedded structure, and injecting the sealing material from the selected injection tube.

Claim 4

The method of removing an embedded structure according to claim 2 or 3, wherein the injecting the sealing material comprises switching by a switching apparatus an injection tube to supply the sealing material.

Claim 5

The method of removing an embedded structure according to any one of claims 1-4, wherein the flow amount of the sealing material is determined based on a pull-up speed of the embedded structure and the diameter of an embedded structure.

Claim 6

The method of removing an embedded structure according to any one of claims 1-5, wherein the sealing material comprises water, a hardener, an accelerator, blast-furnace cement type B.

Claim 7

The method of removing an embedded structure according to any one of claims 1-6, wherein the injection tube is installed at least 0.2 m or more from the embedded structure.

Claim 8

The method of removing an embedded structure according to any one of claims 1-7, the method comprising:

- inserting a hollow frame member into the ground so as to surround the embedded structure,

- pulling up the frame member inserted from the ground,

- attaching the string-like member to the frame member, and

- inserting the frame member attached with the string-like member, into the ground so as to surround the embedded structure.

Claim 9

The method of removing an embedded structure according to claim 9, wherein the pulling up the frame member comprises injecting a bond along the out surface of the frame member, wherein the bond is used for adhesion of plants.

Claim 10

A method of removing an embedded structure comprising:

- attaching a string-like member to the embedded structure,

- injecting a hollow frame member attached with an injection tube for injecting a sealing material, so as to surround the embedded structure, thereby installing the injection tube at a position with a certain distance or more from the embedded structure, and

- hoisting the string-like member thereby pulling up the embedded structure, as well as along with pulling up the frame member, injecting a sealing material from the injection tube into the ground in a flow amount determined corresponding to at least a diameter of the embedded structure.