

METHOD AND APPARATUS FOR INSTALLING PREFABRICATED VERTICAL DRAIN

1. Field of the Invention

The invention relates to the installation of prefabricated vertical drains into the ground, and more particularly to a method and apparatus for installing prefabricated vertical drains into the ground at a headroom-limited site.

2. Description of the Prior Arts

Prefabricated vertical drain (PV drain) has been used worldwide as an effective means of expediting consolidation settlement in slow-draining soft soil. With reference in Fig. 12, a prefabricated flexible wick drain (90) consisting of a plastic core (91) wrapped in a spun-bond plastic fabric (92), is vertically installed into the ground and the top end of the wick drain (90) is left above the ground. Pore water under the ground flows laterally to the closest PV drain and then be conveyed through the drain to the ground by the pore water pressure, which results in expediting settlement for soft soil.

With reference to Fig. 13, at the bottom end of the mandrel (100), the wick drain (90) is looped through an anchor plate (110). The wick drain (90) can be installed by vibrating or statically pushing a hollow rectangular or rhombic steel mandrel (100) that houses the wick drain (90) into the ground to a desired depth. The anchor plate (110) completely covers the bottom end of the mandrel (100) to prevent soil from entering the mandrel (100). Once the mandrel (100) has been extracted, the anchor plate (110) holds the wick drain (90) securely in place as the mandrel (100) is extracted.

Since PV drains are low-cost, practical and effective, they are widely

used for marine construction, and construction of residential structures, reclaimed land and roadways. However, a heavy installation equipment (120) usually weighting from 70 to hundreds of tons, for inserting wick drain (90) into the ground requires a tall mast (130) for housing the wick drain (90) of a predetermined length that is long enough to reach a desired depth, such as 40 to 60 meters under the ground. Therefore, the application of the existing methods or apparatuses for installing wick drain (90) into the ground has site limitation. Only the site having enough headroom and a ground providing sufficient traction or support for the installation equipment can apply to PV drains installation.

To overcome the shortcomings, the present invention provides a method or an apparatus for installing wick drains into the ground with lower headroom limitation to mitigate or obviate the aforementioned problems.

The main objective of the invention is to provide a method for installing PV drain into the ground that can be exerted in an environment with limited headroom or ground lack of traction and strength for supporting a large heavy PV drain installation equipment.

Accordingly, in one aspect, the present invention provides an apparatus for installing prefabricated vertical drains comprising following steps:

mounting an end of a wick drain through a leading mandrel and at least one connecting mandrel, wherein the leading mandrel has an first end and a second end; the connecting mandrel has a third end and a fourth end; and the end of the wick drain protrudes out the first end of the leading mandrel;

securely attaching the end of the wick drain to an anchor plate covering

the first end of the leading mandrel to prevent soil from entering the leading mandrel;

inserting the first end of the leading mandrel substantially vertically into soil to leave the second end of the leading mandrel above soil;

connecting the third end of the connecting mandrel to the second end of the leading mandrel to form a mandrel assembly;

inserting the mandrel assembly into soil;

sequentially extracting and taking apart the connecting mandrel and the leading mandrel of the mandrel assembly to leave the anchor plate and a portion of the wick drain in soil; and

cutting the wick drain to leave the portion of the wick drain in soil, whereby a prefabricated vertical drain is installed.

In another aspect, the present invention provides an apparatus for installing prefabricated vertical drain comprising a leading mandrel and at least one connecting mandrel.

The leading mandrel has a tube, a tip mouth and a first mounting portion. The tube has a first end, a second end, an outer surface and an outer threaded section. The outer threaded section is formed on the outer surface of the tube at the second end. The tip mouth is hollow, connects to and communicates with the first end of the tube and has an attaching end connecting to the first end of the tube and an intruding end. The first mounting portion is mounted to the second end of the tube and has a gap. The gap of the first mounting portion is defined between the tube and the first mounting portion to allow a wick drain mounting through.

The connecting mandrel has a sleeve, a tube and a second mounting portion.

The sleeve is adapted to be mounted around the second end of the tube of the leading mandrel and has a mounting end, an attaching end, an inner wall, an interior threaded section, an interior reverse threaded section. The attaching end is opposite to the mounting end. The inner wall extends from the mounting end to the attaching end. The interior threaded section is formed on the inner wall at the mounting end and engaging with the outer threaded section of the leading mandrel. The interior reverse threaded section is formed on the inner wall at the attaching end.

The tube has an attaching end, a connecting end, an outer surface, an outer reverse threaded section and an outer threaded section. The attaching end is attached to the attaching end of the sleeve. The connecting end is opposite to the attaching end. The outer surface extends from the connecting end to the attaching end. The outer reverse threaded section is formed on the outer surface of the tube at the attaching end and engages with the interior reverse threaded section of the sleeve. The outer threaded section is formed on the outer surface of the tube at the connecting end.

The second mounting portion has a gap. The gap of the second mounting portion is defined between the tube and the second mounting portion of the connecting mandrel to allow the wick drain mounting through.

Based on the structure of the apparatus in accordance with the present invention, the leading mandrel and the connecting mandrel can be used and assembled sequentially and house and insert a wick drain into the ground.

Therefore, the method and apparatus as described above is useful for installing PV drain in an environment with limited headroom.

Other objectives, advantages and novel features of the invention will become more apparent from the following detailed description when taken in conjunction with the accompanying drawings.

IN THE DRAWINGS:

Fig. 1 is a first general view illustrating that an apparatus in accordance with the present invention is installing a prefabricated vertical drain;

Fig. 2 is a second general view illustrating that the apparatus in Fig. 1 is installing a prefabricated vertical drain;

Fig. 3 is a third general view illustrating that the apparatus in Fig. 1 is installing a prefabricated vertical drain;

Fig. 4 is a fourth general view illustrating that the apparatus in Fig. 1 is installing a prefabricated vertical drain;

Fig. 5 is a fifth general view illustrating that the apparatus in Fig. 1 is extracting a leading mandrel;

Fig. 6 is a sixth general view illustrating that the apparatus in Fig. 1 with an extracted leading mandrel when finishing an installation of prefabricated vertical drain;

Fig. 7 is an illustrative side view in partial section of a leading mandrel in accordance with the present invention mounted with a wick drain and a anchor plate in soil;

Fig. 8 is an enlarged, side view in partial section of a first mounting portion and a tube of the leading mandrel in accordance with the present

invention;

Fig. 9 is an enlarged, exploded perspective view of a leading mandrel and a connecting mandrel;

Fig. 10 is an enlarged, side view in partial section of a combination of two connecting mandrel;

Fig. 11 is a top view of a leading mandrel in accordance with the present invention;

Fig. 12 is a perspective view of a wick drain in accordance with the prior art; and

Fig. 13 is an operational side view illustrating that a installation equipment for inserting wick drain in accordance with the prior art is installing a prefabricated vertical drain into the ground.

A method for installing prefabricated vertical drain in accordance with the present invention comprises following steps.

With reference in Fig. 1, in the step of mounting a wick drain (50), an end of the wick drain (50) is mounted through a leading mandrel (10) and one connecting mandrel (20). The leading mandrel (10) has a first end and a second end. The connecting mandrel (20) has a third end and a fourth end. The end of the wick drain (50) protrudes out the first end of the leading mandrel (10).

In the step of attaching the wick drain (50), the end of the wick drain (50) is attached securely to an anchor plate (60) covering the first end of the leading mandrel (10) to prevent soil from entering the leading mandrel (10).

With reference to Fig. 7, in the step of inserting the leading mandrel (10), the first end of the leading mandrel (10) is inserted substantially vertically

into soil to leave the second end of the leading mandrel (10) above soil.

With reference to Fig. 2, in the step of connecting the connecting mandrel (20), the third end of the connecting mandrel (20) is connected to the second end of the leading mandrel (10) to form the mandrel assembly.

With reference to Fig. 3, in the step of inserting the mandrel assembly, the connecting mandrel (20) of the mandrel assembly is inserted into soil.

With reference to Fig. 5, in the step of extracting and taking apart of the connecting mandrel and the leading mandrel of the mandrel assembly, the connecting mandrel (20) and the leading mandrel (10) of the mandrel assembly are sequentially extracted out of soil and taken apart to leave the anchor plate (60) and a lower portion of the wick drain (50) in soil.

With reference to Fig. 6, in the step of cutting the wick drain (50), an upper portion of the wick drain (50) is cut to leave the lower portion of the wick drain (50) in soil.

With reference to Fig. 4, When multiple connecting mandrels (20) are used, in the step of inserting the mandrel assembly into soil further comprises following steps.

Multiple connecting mandrels (20) are inserted in to soil in sequence. When former connecting mandrel (20) is inserted into soil, the fourth end of the former connecting mandrel (20) is left above soil. Then a later connecting mandrel (20) adjacent to the former connecting mandrel (20) is connected to the fourth end of the former connecting mandrel (20).

According to the present invention, the inserting of the first end of the leading mandrel (10) and the connecting mandrel (20) respectively includes

following steps. The second end of the leading mandrel (10) and the fourth end of the connecting mandrel (20) is vibrated or statically pushed into soil by an installation equipment (40).

In an preferred embodiment of the present invention, the step of mounting an end of a wick drain through a leading mandrel and at least one connecting mandrel includes mounting the end of the wick drain through a sleeve between the leading mandrel and the connecting mandrel; and the step of connecting the third end of the connecting mandrel (20) to the second end of the leading mandrel (10) to form a mandrel assembly includes: respectively engaging two ends of the sleeve (21) with the second end of the leading mandrel (10) and third end of the connecting mandrel (20) to form the mandrel assembly.

In an preferred embodiment of the present invention, the step of mounting an end of a wick drain through a leading mandrel and one connecting mandrels further includes mounting the end of the wick drain through other connecting mandrels and sleeves, wherein the sleeves are respectively mounted between the leading mandrel and the connecting mandrel and each two of adjacent connecting mandrels; and the step of connecting the fourth end of the later connecting mandrel (10) to the third end of the former connecting mandrel (20) to form the mandrel assembly includes: respectively engaging the two ends of the sleeve with the fourth end of former connecting mandrel (20) and the third end of the later connecting mandrel (20) to form the mandrel assembly.

In another preferred embodiment of the present invention, the installation equipment (40) is an excavator with a vibrator having a weight

ranging from 18 to 30 tons.

With reference to Figs. 1, 7 and 8, an apparatus for installing prefabricated vertical drain in accordance with the present invention comprises a leading mandrel (10), at least one connecting mandrel (20) and an installation equipment (40).

The leading mandrel (10) is tubular and has a tube (11), a tip mouth (12) and a first mounting portion (13).

The tube (11) may be 5 to 10 meters in length and has a first end, a second end (111), an outer surface and an outer threaded section (112). The outer threaded section (112) is formed on the outer surface of the tube (11) at the second end (111).

The tip mouth (12) is tubular, connects to and communicates with the first end of the tube (11) and has an attaching end, an intruding end (121). The attaching end connects to the first end of the tube (11). The intruding end (121) may be rectangular in cross section. A caliber of the intruding end (121) is smaller than a caliber of the attaching end.

With further reference to Figs. 7 and 8, the first mounting portion (13) is mounted to the second end (111) of the tube (11) and has a shaft (131), multiple legs (132) and a gap (133). The shaft (131) may be 40 to 50 centimeters in length, protrudes out the second end (111) of the tube (11) and has two ends and a rough surface (1311). One of the two ends protrudes out the second end (111) of the tube (11). The other of the two ends is mounted in the tube (11). The rough surface (1311) is formed around the one of the two ends and is adapted for being hold by a installation equipment (40), such as a crane

(or excavator) with driving gear such as a roller chain, cable activated by rotatory winches and linear hydraulic rams, and a vibrator. The legs (132) are mounted between and connect the shaft (131) and the tube (11). As shown in Fig. 11, the gap (133) may be arch in cross section and is defined between the tube (11), the shaft (131) and the legs (132) to allow a wick drain (50) with a width of 10 centimeters mounting through.

With further reference to Figs. 9 and 10, the connecting mandrel (20) is tubular and has a sleeve (21), a tube (22), a second mounting portion (23) and at least one optional O-ring (24).

The sleeve (21) is adapted to be mounted around the second end (111) of tube (11) of the leading mandrel (10) and has a mounting end (211), an attaching end (212), an inner wall (213), an interior threaded section (214), an interior reverse threaded section (215), two side surfaces and at least one optional groove (216). The attaching end (212) is opposite to the mounting end (211). The inner wall (213) extends from the mounting end (211) to the attaching end (212) and defines a hole penetrating the sleeve (21). The interior threaded section (214) is formed on the inner wall (213) at the mounting end (211) and engages with the outer threaded section (112) of the leading mandrel (10). The interior reverse threaded section is formed on the inner wall (213) at the attaching end (212). The two side surfaces are annular and formed at the mounting end (211) and attaching end (212) and opposite to each other. The groove (216) is annular and formed in the corresponding side surface.

The tube (22) has an attaching end (221), a connecting end (222), an outer surface (223), an outer reverse threaded section (224), and an outer

threaded section (225). The attaching end (221) is attached to the attaching end (212) of the sleeve (21). The connecting end (222) is opposite to the attaching end (221). The outer surface (223) extends from the attaching end (221) to the connecting end (222). The outer reverse threaded section (224) is formed on the outer surface (223) at the attaching end (221) and engages with the interior reverse threaded section (215) of the sleeve (21). The outer threaded section (225) is formed on the outer surface (223) of the tube (22) at the connecting end (222) and engages with a mounting end (211) of the sleeve (21) of another connecting mandrel (20).

The second mounting portion (23) has a shaft (231), multiple legs (232) and a gap (233). The shaft (231) protrudes out the connecting end (222) of the tube (22) and has two ends and a rough surface (2311). One of the two ends protrudes out the connecting end (222) of the tube (22). The other of the two ends is mounted in the tube (22). The rough surface (2311) is formed around the one of the two ends and is adapted for being hold by the installation equipment. The legs (232) are mounted between and connect the shaft (231) and the tube (22). The gap (233) may be arch in cross section and is defined between the tube (22), the shaft (231) and the legs (132) of the second mounting portion (23) to allow the wick drain (50) mounting through.

The O-ring (24) is mounted in the corresponding groove between the sleeve (21) of the connecting mandrel (20) and the leading mandrel (10), and the sleeve (21) of the connecting mandrel (20) and another connecting mandrel (20) to air-tightly seal conjunctions between the leading mandrel (10) and connecting mandrel (20). It prevents soil from entering the leading mandrel (10)

and the connecting mandrel (20) while the leading mandrel (10) and the connecting mandrel (20) are inserting into soil.

The installation equipment (40) is adapted for driving the leading mandrel (10) or the connecting mandrel (20) into or out of soil and selectively attaches to and holds the first mounting portion (13) of the leading mandrel (10) or the second mounting portion (23) of the connecting mandrel (20). The installation equipment (40) may consist of a crane (or excavator) with driving gear such as a roller chain, cable activated by rotatory winches, and linear hydraulic rams, and vibrator, which is adapted to holding the shaft (131) of the first mounting portion (13) the leading mandrel (10) and the shaft (231) of the second mounting portion (23) of the connecting mandrel (20), whereby the leading mandrel (10) and the connecting mandrels (20) can be inserted or extracted by the installation equipment (30) as shown in Figs. 1 to 6.

Even though numerous characteristics and advantages of the present invention have been set forth in the foregoing description, together with details of the structure and features of the invention, the disclosure is illustrative only. Changes may be made in the details, especially in matters of shape, size, and arrangement of parts within the principles of the invention to the full extent indicated by the broad general meaning of the terms in which the appended claims are expressed.

CLAIM(S):

1. A method for installing prefabricated vertical drain, comprising:
 - mounting an end of a wick drain (50) through a leading mandrel (10) and one connecting mandrel (20), wherein the leading mandrel (10) has a first end and a second end, and the connecting mandrel (20) has a third end and a fourth end, the end of the wick drain (50) protruding out the first end of the leading mandrel (10);
 - securely attaching the end of the wick drain (50) to an anchor plate (60) covering the first end of the leading mandrel (10) to prevent soil from entering the leading mandrel (10);
 - inserting the first end of the leading mandrel (10) substantially vertically into soil to leave the second end of the leading mandrel (10) above soil;
 - connecting the third end of the connecting mandrel (20) to the second end of the leading mandrel (10) to form a mandrel assembly;
 - inserting the mandrel assembly into soil;
 - sequentially extracting and taking apart the connecting mandrel (20) and the leading mandrel (10) of the mandrel assembly to leave the anchor plate (60) and a lower portion of the wick drain (50) in soil; and
 - cutting an upper portion of the wick drain (50) to leave the lower portion of the wick drain (50) in soil, whereby a prefabricated vertical drain is installed.
2. The method for installing prefabricated vertical drain of claim 1, wherein

the step of mounting an end of a wick drain (50) through a leading mandrel (10) and one connecting mandrel (20) includes mounting the end of the wick drain (50) through the leading mandrel (10) and multiple connecting mandrel (20);

the step of inserting the mandrel assembly into soil includes: inserting the mandrel assembly into soil to leave the fourth end of a former connecting mandrel (20) above soil; and connecting a later connecting mandrel (20) adjacent to the former connecting mandrel (20) to the fourth end of the former connecting mandrel (20) to form the mandrel assembly.

3. The method for installing prefabricated vertical drain of claim 1, wherein the inserting of the first end of the leading mandrel (10) includes vibrating or statically pushing the first end of the leading mandrel (10) into soil by an installation equipment (40).

4. The method for installing prefabricated vertical drain of claim 2, wherein the inserting of the first end of the leading mandrel (10) includes vibrating or statically pushing the first end of the leading mandrel (10) into soil by an installation equipment (40).

5. The method for installing prefabricated vertical drain of claim 1, wherein the inserting of the mandrel assembly into soil includes: vibrating or statically pushing the fourth end of the one connecting mandrel (20) in the mandrel assembly into soil by an installation equipment (40).

6. The method for installing prefabricated vertical drain of claim 1, wherein

the step of mounting an end of a wick drain (50) through a leading

mandrel (10) and one connecting mandrel (20) includes: mounting the end of the wick drain (50) through a sleeve (21) between the leading mandrel (10) and the connecting mandrel (20); and

the step of connecting the third end of the connecting mandrel (20) to the second end of the leading mandrel (10) to form a mandrel assembly includes: respectively engaging two ends of the sleeve (21) with the second end of the leading mandrel (10) and third end of the connecting mandrel (20) to form the mandrel assembly.

7. An apparatus for installing prefabricated vertical drain, comprising:

a leading mandrel (10) having

a tube (11) having

a first end;

a second end (111);

an outer surface ; and

an outer threaded section (112) formed on the outer surface of the tube (11) at the second end (111);

a tip mouth (12) being tubular, connecting to and communicating with the first end of the tube (11) and having

an attaching end connecting to the first end of the tube (11);

and

an intruding end (121); and

a first mounting portion (13) mounted to the second end (111) of the tube (11) and having

a gap (133) defined between the tube (11) and the first

mounting portion (13) to allow a wick drain (50) mounting through; and

at least one connecting mandrel (20) having

a sleeve (21) adapted to be mounted around the second end (111) of the tube (11) of the leading mandrel (10) and having

a mounting end (211);

an attaching end (212) opposite to the mounting end (211); and

an inner wall (213) extending from the mounting end (211) to the attaching end (212);

an interior threaded section (214) formed on the inner wall (213) at the mounting end (211) and engaging with the outer threaded section (112) of the leading mandrel (10);

an interior reverse threaded section (215) formed on the inner wall (213) at the attaching end (212); and

a tube (22) having

an attaching end (221) attached to the attaching end (212) of the sleeve (21);

a connecting end (222) opposite to the attaching end (221);

an outer surface (223) extending from the connecting end (222) to the attaching end (221);

an outer reverse threaded section (224) formed on the outer surface (223) of the tube (22) at the attaching end (221) and engaging with the interior reverse threaded section (215) of the sleeve (21); and

an outer threaded section (225) formed on the outer surface (223) of the tube (22) at the connecting end (222);

a second mounting portion (23) having
a gap (233) defined between the tube (22) and the second
mounting portion (23) to allow the wick drain (50) mounting through.

8. The apparatus for installing prefabricated vertical drain of claim 7,
further comprising:

an installation equipment (40) adapted for driving the leading mandrel
(10) or the connecting mandrel (20) into or out of soil and selectively attaching
to the first mounting portion (13) of the leading mandrel (10) or the second
mounting portion (23) of the connecting mandrel (20).

9. The apparatus for installing prefabricated vertical drain of claim 7,
wherein the first mounting portion (13) has

a shaft (131) protruding out the second end (111) of the tube (11) and
having

two ends; and

a rough surface (1311) formed around one of the two ends of the
shaft (131); and

multiple legs (132) mounted between and connecting the shaft (131)
and the tube (11) of the leading mandrel (10).

10. The apparatus for installing prefabricated vertical drain of claim 7,
wherein the second mounting portion (23) has

a shaft (231) protruding out the connecting end (222) of the tube (22)
of the connecting mandrel (20) and having

two ends; and

a rough surface (2311) formed around one of the two ends; and

multiple legs (232) mounted between and connecting the shaft (23) and the tube (22) of the connecting mandrel (20).

11. The apparatus for installing prefabricated vertical drain of claim 7, wherein the intruding end (121) of the tip mouth (12) of the leading mandrel (10) is rectangular in cross section; and a caliber of the intruding end (121) of the tip mouth (12) is smaller than a caliber of the attaching end of the tip mouth (12).

12. The apparatus for installing prefabricated vertical drain of claim 7, wherein the sleeve (21) further has

two side surfaces being annular, respectively formed at the mounting end (211) and attaching end (212); and

at least one groove (216) being annular and formed in a corresponding side surface; and

at least one O-rings (24) mounted in the corresponding groove (216) to air-tightly seal conjunctions between the leading mandrel (10) and connecting mandrel (20).