

FIELD OF THE INVENTION

5 The invention relates to a method for consolidating water-containing ground by extracting and discharging water from the ground.

BACKGROUND OF THE INVENTION

10 Methods are known and applied to consolidate ground in an area where buildings and/or roads are to be constructed. Known methods may apply a load onto the ground by an additional thickness of a (ground) material, such as sand. The additional layer, that can several meters thick applies a vertical force onto the ground, by which the water is pushed out of the ground. Such process can be assisted by providing drains into the ground. It is known to vertically provide prefabricated drains into the ground.

15 Such drains have a relatively small cross-sectional surface. An example is a corrugated plate having a width of about 10 centimeters with corrugations of about 5 millimeters deep, which may surrounded by a cloth-like material that is permeable to water to allow water to be collected into but keep ground substantially out of the corrugations. Ground water is collected within the drains and expelled at their top sides. The prefabricated

20 drains are applied into the ground by a known method for driving a hollow mandrel into the ground. and can be provided into the ground to depths of several tens of meters, for instance, 60 meters. However, it requires rather long time spans in the order of several months or even more than a year to have extracted a sufficient amount of water from the ground such that it has substantially consolidated.

25 In another method drainage trenches are provided in the ground by removing ground material. The drainage trenches are filled with a draining material, like sand, and a pump can be provided at the bottom of the trenches within a surrounding tube like structure. Ground water is collected within the trench and around the pump to be pumped away and expelled at top level. However, such methods require quite some

30 effort and man-hours to make the trenches, supplying sand for filling, ground material from the trenches needs to be taken away or stored on-site, etcetera. A vacuum provided by the pumps within the trenches will assist in collecting water into the trenches, but leakage readily occurs through which vacuum will be lost. This known

method has a limited depth range of only 7 to 8 meters in which it can be applied for consolidating ground. Removal of ground material further requires material to be transported away or to be left on site where it may obstruct or hinder on-site activities.

In another method drains are applied vertically in the ground. The drains are
5 connected at their top sides collectively to a pump for entraining ground water from the drains. This can be done by connecting the vertical channels to a horizontal drain that is connected to a pump or otherwise connect the individual drains to a collective pump. However, leakage of the known drain system easily occurs, which drastically reduces the pumping capacity. The drains and their connections at the top have to be installed
10 individually in the ground in a non-continuous process, which is not efficient and only a limited amount of water can be pumped away.

SUMMARY OF THE INVENTION

It is an object of the invention to provide a method for consolidating ground that
15 efficiently consolidates within a relatively short time span.

It is another or alternative object of the invention to provide a method for consolidating ground that can be provided in a relatively short time.

It is another or alternative object of the invention to provide a method for consolidating ground that requires a minor amount of effort to apply.

20 It is yet another or alternative object of the invention to provide a method for consolidating ground that does not require removing and/or transporting of ground material.

It is yet another or alternative object of the invention to provide a method for consolidating ground that can be applied to depth of several tens of meters, for
25 instance, 60 meters.

It is yet another or alternative object of the invention to provide a method for consolidating ground that allows the consolidated ground to be brought back into its original but still consolidated state.

In a first aspect of the present invention, at least one of these objects is achieved
30 by a method for consolidating water-containing ground, the method comprising
- providing an elongated drain element, the drain element allowing both collection and transport of fluid along a longitudinal direction of the drain element;
- providing a pump to a bottom end of the drain element, the pump being a gas-driven Venturi pump, especially an air-driven Venturi pump;

- providing the drain element with the pump into the ground to be consolidated; and
- driving the pump to discharge collected fluid from the drain element. The drain elements can be applied into the ground by known methods and prove to be very efficient in consolidating ground and also very cost-effective. It allows collection, transport and pumping away of both water and air as fluids from the ground. A vacuum is created within the ground for enhanced consolidation. Since the ground water level is lowered, water flow towards the drains will be assisted by gravity forces.

Advantageously the pump is provided to a bottom end of the drain element, which is effective is very effective in pumping ground water out of the full drain element and providing a vacuum along the drain element to efficiently and effectively provide a vacuum in the ground.

Preferably, the drain element is provided into the ground in a substantially vertical orientation to reach largest depths and not to damage drain element with the pump and its connections.

In a preferred embodiment the pump is a gas-driven Venturi pump, especially an air-driven Venturi pump. Such pump can be made quite small and proves very effective with respect to its size, although an air-driven Venturi pump is generally not considered for pumping away liquid.

In a preferred embodiment the drain element comprises a drain member having a corrugated cross-section transverse to the longitudinal direction of the drain element. Such drain element can be made cost-effectively and with small overall cross-section for easy and efficient application in the ground, while providing very good collection and transport characteristics for water and air. Further, it has shown to be effective in combination with a pump.

In yet a further preferred embodiment the drain member has a plate-like configuration having corrugations of the corrugated cross-section in a width direction and having a thickness corresponding a height of the corrugations of the corrugated cross-section. Such drain member proves most efficient in manufacturing, application in the ground and fluid collection and transport properties.

In advantageous embodiments the drain element comprises a fluid-permeable covering that is impermeable to the ground, and wherein the pump is provided inside the covering. Preferably, the drain member is provided inside the covering. Such covering keeps the pump and also corrugation of the drain member free from the

ground and ground particles to not obstruct the pump or the channels formed by the corrugations. Although it may not be expected, the provision of the pump outside of the drain member but inside of the covering proves to work very well.

Preferably, multiple drain elements are provided into the ground, each drain
5 element being provided with a pump in dependence of the permeability and water level in the ground.

Advantageously, the method further comprises

- providing a top end of the drain element at least 0.5 meters below a surface level of the ground; and/or
- 10 - closing a top end of the drain element such as by providing a foil over the top end. This will prevent leakage of the drain element at its top end and thus prevent vacuum loss within the drain element.

In an effective embodiment the method further comprises

- providing a roll of a continuous stretch of drain element without pump(s);
- 15 - determining a required length or lengths of the drain element(s) corresponding to a depth of ground into which the drain element(s) is/are to be provided;
- unrolling parts of the continuous stretch of drain element from the roll corresponding to the determined length(s); and
- providing pumps at positions corresponding to the determined length(s) of the drain
20 element(s). A continuous stretch of drain element without pumps can be effectively provided on such roll. One need not know the required lengths of the actual drain elements at the time of production of the roll with the stretch of drain element. The required length(s) can be determined on-site. On-site the stretch is easily unrolled and the pump(s) added to the required length(s) of drain element(s).

25 In a further effective embodiment the method yet further comprises

- rolling the drain element(s) with pump(s) onto a roll; and
- providing the roll to locations where drain elements are to be provided into the ground. Such roll can be prepared both on-site or off-site, as required, and subsequently provided to the actual location where the drain element(s) are to be provided into the
30 ground for effective handling of the drain element(s).

In another effective embodiment the method further comprises separating the determined length(s) of drain element(s) from the continuous stretch of drain element, to have the required length(s) immediately available.

In a second aspect of the invention there is provided a corresponding drain element for use in a method according to any one of the embodiments as described herein, the drain element having an elongated configuration, allowing both collection and transport of fluid along a longitudinal direction of the drain element, and comprising a pump constructed and arranged to discharge collected fluid from the drain element, the drain element being configured such that the pump is provided at a bottom end of the drain element and being configured to be provided with the pump into the ground to be consolidated, wherein the pump is a gas-driven Venturi pump, especially an air-driven Venturi pump.

10 In an effective embodiment the pump is arranged within the drain element.

In an embodiment the drain element is configured such that the pump is provided at a bottom end of the drain element.

Advantageously, the pump is a gas-driven Venturi pump, especially an air-driven Venturi pump.

15 In a preferred embodiment the drain element comprises a drain member having a corrugated cross-section transverse to the longitudinal direction of the drain element.

In yet a further preferred embodiment the drain member has a plate-like configuration having corrugations of the corrugated cross-section in a width direction and having a thickness corresponding a height of the corrugations of the corrugated cross-section.

20 In yet a further preferred embodiment the drain element comprises a fluid-permeable covering that is impermeable to the ground, and wherein the pump is provided inside the covering.

25 In yet another preferred embodiment the drain member is provided inside the covering.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the invention will further be described with reference to the accompanying drawings, in which like or same reference symbols denote like, same or corresponding parts, and in which

30 Figure 1 schematically shows a drain element according to the invention provided in ground to be consolidated;

Figure 2 shows a detail of a bottom end of the drain element of figure 1, part of a coverage of the drains shown removed;

35 Figure 3 shows a cross-section of the drain element of figures 1 and 2;

Figure 4 schematically shows a pump of the drain element in a detailed view;

Figure 5 shows an installation to provide drain elements into the ground and multiple drain elements provided in the ground; and

Figure 6 shows rolls on which a continuous stretch of drain element according to the invention is provided.

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DETAILED DESCRIPTION OF EMBODIMENTS

A drain element 10 is shown provided in ground G to be consolidated in figure 1. The elongated drain element has a length D of, for instance, 60 meters in its longitudinal vertical direction. A bottom side 10A of the drain element is therefore provided at a depth D of 60 meters below a top level of the ground G. Water present in the ground will be collected by the drain element as is shown by arrows C in the figure. At the bottom end 10A the drain element is provided with a pump 20 having a supply connection 21 and a discharge connection 22. The discharge connection 22 is connected to pump 20 by a corner piece 22A, which prevents the discharge connection from being bend. The supply connection 21 is connected to a control system 25 and the discharge connection 22 discharge water collected into a discharge basin 26 in the embodiment shown.

Figures 2 and 3 shows the drain element 10 in more detail. Figure 2 shows the bottom end 10A of the drain element and figure 3 shows a cross-section. The drain element 10 comprises a plate-like drain member 11 that is corrugated in a cross-section transverse to the longitudinal direction. The drain member 11 has a width W of, for example, 10 centimeters in a direction transverse to the longitudinal direction. The corrugations 11A of the corrugated cross-section have a height H of, for instance 3 to 5 millimeters in a direction transverse to both the width direction and the longitudinal direction. A corrugation has a width W1 of, for instance, also 3 to 5 millimeters. The corrugations 11A provide channels 11B in the longitudinal direction.

The drain element 11 further comprises a covering 12 of cloth-like material, which geotextile or geotextile-like materials are known as such, that is permeable to water and air but substantially not permeable to ground or ground particles. Water and air contained in the ground can thus enter into the channels 11B of the drain element through the covering while ground particles are blocked. The covering is provided such that it keeps the channels 11B formed by the corrugations 11A open for transport of water and air along the channels in the longitudinal direction.

The pump 20 is provided at the bottom end 10A of the drain element. The pump is an air-driven Venturi pump, which is shown in more detail in figure 4. Compressed air is supplied in the direction of arrow Ai through supply line 21 from a known control system 25 shown in figure 1. The compressed air enters the pump through a nozzle 21A in the direction of an outlet 20A of the pump. The pump action is in the direction of arrow Ap. An underpressure or vacuum is created at entrance 20A of the pump by the action of compressed air leaving the nozzle. As a result water and air at the bottom of the drain element 10 is pumped through the inlet 20A of the pump towards its outlet 20B and into the discharge connection 22. Subsequently, the water and air is transported upwards through discharge connection 22, shown by arrow Ao, towards and out into the basin 26. Air will enter into the atmosphere but the water will be collected in the basin. The discharged water may be provided elsewhere as well when leaving the discharge connection 22.

Water and air will be supplied to the pump 20 through the channels formed by the corrugations 11A of the drain member 11. Since air is pumped away by the pump a vacuum will be created within the channels 11B, which will cause a level of vacuum within the ground. A vacuum in the ground causes a preload or surcharge to the ground, which assists in urging water out of the ground. The water will be collected in the channels of the drain element and discharged through discharge line 22 by the pump 20. A top side 11b of the drain element is provided more than 0.5 meters below the surface level of the ground G, for instance, by 2 meters, so that the channels 11B are closed at their tops ends by a layer of ground. Alternatively, the top ends of the drain elements can be closed-off by, for instance, applying a foil, or in any other suitable fashion, when sticking out above or ending close to the surface level of the ground. Loss of vacuum at the top end of the drain elements is therefore prevented in an easy manner. Would any leakage occur for one drain element. It will not affect any other drain element.

Figure 5 shows multiple drain elements 10 provided in the ground G. A pump 20 and supply and discharge connections 21 and 22 are not shown in figure 5. A crane 50 with a mast 51 is used to bring the drain elements into the ground by a driving method which is known as such. The drain elements are provided on a roll, as shown in figure 6, to the crane. At the location where the drain elements are to be provided into the ground a drain element is taken from the roll, provided into the crane and

subsequently applied into the ground.

A continuous stretch of prefabricated drain element yet without pump is initially provided on a roll 61 as shown in figure 6. A length D of the continuous stretch is taken from the roll. The length D corresponds to the length of a drain element to be provided into the ground as shown in figure 1. The covering 12 of the continuous stretch is opened at the top and bottom sides of that length D. A pump 20 with supply and discharge connections 21, 22 is provided to the length D of drain element within the covering such that the pump is at the bottom side and the connections 21, 22 exit the drain element at the top side. Subsequently the continuous stretch of drain element is provided on another roll 62. Alternatively, the length D of drain element is completely separated from the continuous stretch and provided onto roll 62. In yet another alternative embodiment, separated lengths of drain elements with pumps are collected in another manner and provided to the locations where the drain elements are to be provided into the ground. This can all be carried out under controlled circumstances, like in a separate building or container on the project location. A continuous stretch of drain element is easily provided on a roll, and such roll and pumps and connections are easily provided to the area of which the ground is to be consolidated for preparation of drain elements with pumps on the spot. The roll 62 with prepared drain elements can be provided onto the crane 50 to supply drain elements from the roll as required.

Various other embodiments of the invention will be apparent to the skilled person when having read the above disclosure in connection with the drawing, all of which are within the scope of the invention and accompanying claims.

CLAIMS

1. A method for consolidating water-containing ground (G), the method comprising
 - 5 - providing an elongated drain element (10), the drain element allowing both collection and transport of fluid along a longitudinal direction of the drain element;
 - providing a pump (20) to a bottom end (10A) of the drain element, the pump being a gas-driven Venturi pump, especially an air-driven Venturi pump;
 - providing the drain element with the pump into the ground (G) to be
 - 10 consolidated; and
 - driving the pump to discharge collected fluid from the drain element.
2. The method according to claim 1, wherein the drain element (10) is provided into the ground (G) in a substantially vertical orientation.
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3. The method according to any one of the preceding claims, wherein the drain element (10) comprises a drain member (11) having a corrugated cross-section transverse to the longitudinal direction of the drain element.
4. The method according to claim 3, wherein the drain member (11) has a plate-like configuration having corrugations of the corrugated cross-section in a width direction and having a thickness corresponding a height (H) of the corrugations (11A) of the corrugated cross-section.
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5. The method according to any one of the preceding claims, wherein the drain element (10) comprises a fluid-permeable covering (12) that is impermeable to the ground (G), and wherein the pump (20) is provided inside the covering.
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6. The method according to claim 5 and claim 3 or 4, wherein the drain member (11) is provided inside the covering (12).
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7. The method according to any one of the preceding claims, wherein multiple drain elements (10) are provided into the ground (G), each drain element being

provided with a pump (20).

8. The method according to any one of the preceding claims, wherein the method further comprises

- 5 - providing a top end (10B) of the drain element (10) at least 0.5 meters below a surface level of the ground (G); and/or
- closing a top end (10B) of the drain element (10), such as by providing a foil over the top end.

10 9. The method according to any one of the preceding claims, the method further comprising

- providing a roll (61) of a continuous stretch of drain element (10) without pump(s);
- determining a required length or lengths (D) of the drain element(s)
- 15 corresponding to a depth of ground (G) into which the drain element(s) is/are to be provided;
- unrolling parts of the continuous stretch of drain element from the roll corresponding to the determined length(s); and
- providing pumps (20) at positions corresponding to the determined length(s) of
- 20 the drain element(s).

10. The method according to claim 9, wherein the method further comprises

- rolling the drain element(s) with pump(s) onto a roll (62); and
- 25 - providing the roll to locations where drain elements are to be provided into the ground.

11. The method according to claim 9 or 10, wherein the method further comprises

- 30 - separating the determined length(s) of drain element(s) from the continuous stretch of drain element.

12. A drain element (10) for use in a method according to any one of the

preceding claims, the drain element having an elongated configuration, allowing both collection and transport of fluid along a longitudinal direction of the drain element, and comprising a pump (20) constructed and arranged to discharge collected fluid from the drain element, the drain element being configured such that the pump (20) is provided
5 at a bottom end (10A) of the drain element (10) and being configured to be provided with the pump into the ground (G) to be consolidated, wherein the pump (20) is a gas-driven Venturi pump, especially an air-driven Venturi pump.

13. The drain element according to claim 12, wherein the pump (20) is
10 arranged within the drain element.

14. The drain element according to claim 12 or 13, wherein the drain element (10) comprises a drain member (11) having a corrugated cross-section transverse to the longitudinal direction of the drain element.

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15. The drain element according to claim 14, wherein the drain member (11) has a plate-like configuration having corrugations of the corrugated cross-section in a width direction and having a thickness corresponding a height (H) of the corrugations (11A) of the corrugated cross-section.

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16. The drain element according to any one of claims 12 to 15, wherein the drain element (10) comprises a fluid-permeable covering (12) that is impermeable to the ground (G), and wherein the pump (20) is provided inside the covering.

17. The drain element according to claim 16 and claim 14 or 15, wherein
25 the drain member (11) is provided inside the covering (12).