

DESCRIPTION
SOIL IMPROVEMENT METHOD

Technical Field

The present invention relates to a soil improvement method in a land improvement technique of a construction field, and aims at increasing strength of the soil by supplying a grout material such as air cement milk and a foaming material from the ground into the soil.

Background Art

Generally safety and economic efficiency of work in the underground, such as groundwork of civil engineering and construction, a subway, and an underground shopping area heavily depend on the right or wrong of groundwater countermeasures.

Conventionally, a waterproof method in which a impervious wall prevents the groundwater from flowing in or a groundwater-level lowering method in which the groundwater is drained to the ground to lower the ground water level is well known as the groundwater countermeasures.

The following patents are granted to the inventor and the applicant.

Patent Document 1: Japanese Patent Publication Laid-Open No. 2000-27170 (Japanese Patent No. 3243501)

Patent Document 2: Japanese Patent Publication Laid-

Open No. 2001-11846 (Japanese Patent No. 3280935)

Disclosure of the Invention

Problems to be Solved by the Invention

The above-listed patents relate to a so-called super well point method, that is, a method for lowering the groundwater level to improve the soil.

An outline of the super well point method will be described below: the water is forcibly drained while a strainer portion is formed into a double-tube structure (special separate screen) to keep the well in a vacuum state.

A structural separate screen of the special separate screen has a double structure including an inner tube and a winding strainer. The groundwater flowing from the winding strainer is separated into air and water between the tubes, and the water flow into the well through vent holes located in a lower portion of the tube.

A negative pressure is applied to the inside of the double tube using a vacuum pump, which continuously enables vacuum drainage.

However, the strength of the soil cannot be increased, because the above-listed patents are not the method for supplying the grout material such as the air cement milk and the foaming material from the ground into the soil.

The super well point method which is a deep underground vacuum drainage and consolidated drainage

method has the following effects. First, the development of the special separate screen can exert the vacuum effect in the deep underground, and the vacuum effect can widely be propagated to perform forced drainage. Second, unlike a well point method in which the depth is restricted up to 6 m to 7 m, the forced drainage can be performed in a vacuum in the depth equal to that of the deep well. Third, in the deep well, many wells are required because gravity drainage has poor well efficiency. On the contrary, in the super well point method, the number of wells can be decreased because the well effect is improved by the vacuum effect. Fourth, that the air enters the well to decrease the vacuum effect can be eliminated in the case where the water level is lowered to a screen position by the vacuum deep well method. Fifth, in the super well point method, the forced drainage can be performed in the deep underground by the vacuum effect, the water pumping amount of the super well point method is 1.2 times to tens of times larger than the conventional method according to a geologic condition, and the groundwater level can early be lowered in the wide range.

Means for Solving the Problems

In the present invention, at least two wells are provided at predetermined intervals, and the super well point method is performed to further improve the soil.

In accordance with a first aspect of the invention, a

soil improvement method includes a step of extending perforated pipe from a ground surface of soil to underground, a grout material such as air cement milk and a foaming material being supplied to the underground through the perforated pipe; a step of pumping groundwater near the underground by a super well point method in which at least two wells are drilled with a predetermined interval in the underground, and of putting the underground in a substantially vacuum state by reducing a pressure in a peripheral area of the underground; a step of supplying a grout material from the ground surface into the underground through the perforated pipe; and a step of recharging the groundwater into the underground to a natural groundwater level.

In accordance with a second aspect of the invention, a soil improvement method includes a step of extending perforated pipe to underground from a ground surface of soil in polluted ground, fresh air or fresh water being supplied to the underground through the perforated pipe; a step of reducing a pressure in a peripheral area of the underground while pumping the groundwater near the underground by a super well point method in which at least two wells are provided with the predetermined interval in the underground, thereby putting the underground into a substantially vacuum state; a step of repeating the supply of the fresh air or fresh water through the perforated pipe extended from the ground surface to the underground; and a

step of recharging the groundwater into the underground to a natural groundwater level.

In accordance with a third aspect of the invention, in the soil improvement method of the first aspect, the ground surface in outer peripheries of at least the two super well point method wells provided with the predetermined interval is covered with an airtight material such as a sheet, pavement with a concrete material or an asphalt material, or new sludge.

In accordance with a fourth aspect of the invention, in the soil improvement method of the first or second aspect, an operation of the super well point methods in which at least the two wells are provided with the predetermined interval is stopped, or the airtight material with which the ground surface is covered is removed while the operation of the super well point method is stopped, and air is supplied by natural air supply generated by a difference in pressure between the underground and the ground surface.

In accordance with a fifth aspect of the invention, in a soil improvement method, in multilayer soil of a clay layer and sand layers, super well point methods in which at least two wells are provided with a predetermined interval suck a gap water of the sand layer below the clay layer to reduce the pressure, thereby applying a stress load to the clay layer to perform consolidated drainage of the clay layer.

In accordance with a sixth aspect of the invention, in a soil improvement method, in multilayer soil of a clay layer and sand layers, super well point methods in which at least two wells are provided with a predetermined interval suck the sand layer below the clay layer to reduce a pressure, and a vacuum state is made to evaporate water in the clay layer, thereby performing dewatering.

In accordance with a seventh aspect of the invention, in a soil improvement method, in multilayer soil of a clay layer and sand layers, super well point methods in which at least two wells are provided with a predetermined interval suck the sand layer below the clay layer to reduce a pressure, a portion below an already-existing aboveground structure placed in the unevenly-settled ground surface is drilled to make a hole with a boring machine, a permanent grout material such as a foaming material is injected from the hole to improve the soil, and the permanent grout material is injected to lift up the unevenly-settled construction.

In accordance with an eighth aspect of the invention, in a soil improvement method, in soil including a sand layer, super well point methods in which at least two wells are provided with a predetermined interval suck the sand layer to reduce a pressure, thereby lowering a water level of underground, and then a dynamic consolidation method is performed.

In accordance with a ninth aspect of the invention, in

a soil improvement method, in an operation of a super well point method in which at least two wells are provided with a predetermined interval in underground including sand layers, a relationship in which pressure pumping action is imparted to one of the two wells while a suction operation is imparted to the other well is alternately repeated in each predetermined time, thereby generating water-binding action in the underground.

Effect of the Invention

The present invention has the following effects because of the above-described configurations. That is, various vacuum effects are generated when the water pumping and the consolidated drainage are performed with a high vacuum level of about -0.085 Mp in the deep underground. When the vacuum effects are utilized, the consolidated drainage can early be performed, and the new soil improvement is achieved in a multiple manner using the feature of the vacuum effects.

In the first to fifth aspects, when at least the two super well point methods suck the soil by the vacuum effects, it can be expected that the water level is partially largely lowered. Therefore, the cohesive soil is improved not by a method for pressurizing the cohesive soil with a mound, but by a method for lowering a pumping pressure in a lower portion of the cohesive soil to increase the stress load. In the second aspect, the

polluted ground can efficiently be purified.

In the sixth aspect, at least the two super well point methods can suck the soil to promote the settlement of a remaining settlement amount of cohesive soil even in the already-existing construction.

In the seventh aspect, the unevenly-settled construction generated can be lifted up and corrected by the permanent grout material.

In the eighth aspect, the water level is lowered to a deep position to make an unsaturated soil by a combination of at least the two super well point methods and the dynamic consolidation method, so that a shock can be propagated to the deep position to widely improve the soil.

In the ninth aspect, a water-binding effect of the sandy soil can be expected by a swing cleaning effect of the super well point method. Additionally, the super well cleaning effect removes clay and colloid components from the loose sandy soil to achieve soil strengthening.

Brief Description of the Drawings

FIG. 1 is a flowchart showing a soil improvement method according to an embodiment of the invention.

FIG. 2 is a sectional view showing a configuration including a well, a impervious wall, vertical perforated pipe, and an airtight sheet in the soil improvement method according to the embodiment of the invention.

FIG. 3 is a sectional view showing a configuration

including a well, an aboveground structure, curved perforated pipe, and a pavement in the soil improvement method according to the embodiment of the invention.

FIG. 4 is a partial sectional view showing a relationship among soil particles, free water, adsorption water, and an air bubble in a steady state in the soil improvement method according to the embodiment of the invention.

FIG. 5 is a partial sectional view showing a relationship between the soil particles and the adsorption water in a state in which groundwater (free water) and the air bubble are eliminated in the soil improvement method according to the embodiment of the invention.

FIG. 6 is a partial sectional view showing a relationship among the soil particles, the adsorption water, and air in an air supply state in the soil improvement method according to the embodiment of the invention.

FIG. 7 is a partial sectional view showing a relationship among the soil particles, the free water, the adsorption water, and the air bubble in a water recharge state in the soil improvement method according to the embodiment of the invention.

FIG. 8 is a sectional view showing a well (super well point method) used in a step of pumping the groundwater and a step of reducing a pressure in soil in the soil improvement method according to the embodiment of the invention.

FIG. 9 is a schematic diagram showing lift-up work in which a permanent grout material is injected into a foundation region of a gate-shape crane which is a construction by the soil improvement method of the invention.

FIG. 10 is an enlarged transverse sectional view of part of FIG. 9.

FIG. 11 is an explanatory view showing a conventional sandy soil improvement method.

FIG. 12 is an explanatory view showing a sandy soil improvement method of the invention.

FIG. 13 is a schematic explanatory view of the invention in which a swing cleaning system is adopted.

FIG. 14 is a schematic explanatory view of the invention in which a swing cleaning system is adopted in at least two wells (super well point method).

FIG. 15 is an analysis diagram showing grain sizes of soil particles after swing cleaning of FIG. 13.

Explanations of Letters or Numerals

1 Soil

1a Ground surface

1b Underground

1c Groundwater surface

1₁ Sand layer

1₂ Clay layer

1₃ Sand layer below clay layer

- 2 Well (super well point)
 - 2a Casing
 - 2b Airtight cover
 - 2c Strainer
 - 2d Sediment pit
 - 2e Water pump
 - 2f Drain pump
 - 2g Vacuum pump
 - 2h and 2i Piping
 - 2j Water tank
- 3 Instrument for supplying grout such as air cement milk and foaming material
 - 3a Perforated pipe
 - 3b Piping
 - 3c Valve
- 4a Soil particles
- 4b Free water (groundwater)
- 4c Adsorption water
- 4d Air or air bubble
- 4e Vacuum portion
- 5 Impervious wall
- 6 Airtight material
- 7 Construction foundation
- 8 Aboveground structure
- 8' Support post
- 8" Horizontal beam
- 9 Grout material

Best Mode for Carrying Out the Invention

In the above-described configurations of the invention, the best mode for carrying out the invention is as described below.

The case in which two wells having high water pumping efficiency are drilled as groundwater pumping means to utilize the super well point method will be described as the best mode for carrying out the invention with reference to the drawings.

FIG. 1 is a flowchart showing a soil liquefaction prevention method of an embodiment of the invention. Referring to FIG. 1, cohesive soil improvement work in the embodiment is performed as follow: Step (1): a impervious wall is constructed as preparatory work so as to surround target soil. Step (2): plural wells (super well point) are placed. Step (3): instruments for supplying the air cement milk or the foaming material are placed to the ground and into the soil. Step (4): a ground surface is covered with an airtight material. Step (5): the groundwater in the soil is pumped and an air bubble in the soil is removed by the super well point method placed in Step (2). Step (6): a liquid substance is supplied into the soil by the instrument for supplying the air cement milk or the foaming material of Step (3). Step (7): part of or the whole of the airtight material with which the ground surface is covered in Step (4) is removed. Step (8): the supply

instrument placed in Step (3) is removed. Step (9): the groundwater in the soil is recharged to a natural water level. Step (10): the two wells placed in Step (2) are removed. Step (11): the impervious wall constructed in Step (1) is removed.

In the embodiment, sometimes Steps (1) and (4) and Steps (7) and (11) corresponding thereto can be eliminated depending on a structure of the target soil and a construction existing on the ground or a ground surface state. Steps of the cohesive soil improvement work will be described in detail, and then a state change in the soil will be described.

Example

(Step (1): construction of impervious wall 5)

As shown in FIG. 2, a impervious wall 5 is constructed to a necessary depth with a steel sheet pile so as to surround underground 1b of multilayer soil 1 which is the improvement target including sand layers 1_1 and 1_3 and a clay layer 1_2 . At this point, it is assumed that the impervious wall 5 is constructed such that a top end height of the impervious wall 5 is projected from a ground surface 1a, and that a water sealing property is ensured between components such as the steel sheet pile constituting the impervious wall 5.

(Step (2): placement of well 2 (super well point))

Then plural (two in the shown example) wells 2 (super

well point) are placed in the impervious wall 5 constructed in Step (1).

As shown in FIG. 8, the well 2 (super well point), which is a large-capacity and high-pump-head pumping system, mainly includes a casing 2a, an airtight cover 2b, a strainer 2c, a sediment pit 2d, a water pump 2e, a vacuum pump 2g, pieces of piping 2h and 2i, and a water tank 2j. In the well 2, the independent vacuum pump 2g and water pump 2e satisfy a function of collecting the water into the well 2 and a function of pumping the water to the outside of the well 2. The inventor proposed the well 2 (see Patent Document 1). FIG. 8 shows the state in which a groundwater surface 1c is lowered, and arrows in FIG. 8 indicate groundwater and air flow directions. FIG. 8 also shows the state in which a negative pressure is propagated in a lower portion of the well 2. In FIG. 2, aboveground instruments shown in FIG. 8 are omitted.

(Step (3): placement of grout material supply instrument 3)

Then, as shown in FIG. 2, necessary pieces of perforated pipe 3a are placed in the impervious wall 3d constructed in Step (1) by a hole drilling method such as boring work, and pieces of piping 3b and 3b and a valve 3c are disposed in an upper end portion of the perforated pipe 3a, thereby forming a supply instrument 3 acting as a passage through which the grout material is introduced from the ground. The valve 3c is closed in a stage in which the

supply instrument 3 supplying the grout material such as the air cement milk and the foaming material is placed. In FIG. 2, arrows indicate a direction in which a grout material 9 flows from the ground surface 1a to the underground 1b. The supply instrument 3 can also be used to supply fresh air or fresh water.

(Step (4): coverage with airtight material 6)

The ground surface 1a of the underground 1b, which becomes the target of liquefaction prevention to be surrounded by the impervious wall 3d constructed in Step (1), is covered with an airtight material 6, and the airtight material is retained in an end portion of the airtight material and some of openings generated by the perforated pipe 3a and well 2. Therefore, the passage through which the grout material 9 passes from the ground is limited to one system of the supply instrument 3 placed in Step (3). For example, an airtight sheet, a pavement made of an asphalt material or a concrete material, and new sludge which does not smell bad can be used as the airtight material 6. Examples of the grout material 9 include the air cement milk and the foaming material.

In a predetermined range of the target underground 1b, an area whose side portion and top portion are sealed is constructed through Steps (1) to (3).

(Step (5): groundwater pumping and air bubble removal)

The well 2 placed in Step (2) by utilizing the super well point method acts to collect the groundwater existing

in the underground 1b into the well 2 and to pump up the groundwater collected in the well 2 to the ground, thereby lowering the groundwater surface 1c to the required groundwater level. At this point, in the state of the underground 1b, the groundwater existing in an area above the groundwater surface 1c in the underground 1b is pumped up and removed, and the grout material 9 existing in the underground 1b is also removed. Therefore, a highly vacuum state (hereinafter referred to as "substantially vacuum") is formed although soil particles constituting the underground 1b exist. FIG. 8 shows the state in which the groundwater surface 1c becoming the natural groundwater level is lowered.

(Step (6): supply of grout material 9 such as air cement milk or foaming material)

The valve 3c is opened, and the supply instrument 3 placed in Step (3) utilizes a pressure difference to supply the grout material 9 such as the air cement milk and the foaming material from the ground to the underground 1b through the pieces of piping 3b and 3b and perforated pipe 3a. At this point, the pumping and degassing functions of the well 2 are stopped before Step (6) in which the grout material 9 is supplied to the underground 1b. Because the underground 1b is in the substantially vacuum state as described above, the underground 1b is filled with the grout material 9 at remarkably high diffusion speed. The supply instrument 3 is also used when the fresh air or

fresh water is supplied instead of the grout material 9.

(Step (7): removal of airtight material 6)

Then the airtight material 6 provided in Step (4) is removed. At this point, because the pressure near the ground surface 1a of the underground 1b is brought close to an atmospheric pressure due to Step (3), the pressure difference between the underground 1b and the ground is eliminated to easily remove the airtight material 6.

(Step (8): removal of grout material supply instrument 3)

Then, the grout material supply instrument 3 is removed to perform back-filling of the piping pit.

(Step (9): water recharge)

The groundwater pumped in Step (5) is recharged to the groundwater surface 1c becoming the natural groundwater level using the well 2. In Step (9), in the case of a small water head difference between the groundwater surface 1c after pumping the groundwater and the groundwater surface 1c in the natural state, the flow may go to Step (10) without recharging the groundwater taken from the well 2. Step (9) depends on a scale of the work.

(Step (11): removal of well 2 (super well point))

Then, the well 2 is removed to perform back-filling of the well pit.

(Step (12): removal of impervious wall 5)

Finally the impervious wall 5 is removed to end the series of steps. In the case where the need for

periodically repeating the action of improving the soil 1 arises, the perforated pipe 3a of the supply instrument 3, the well 2, and the impervious wall 5 may be left in order to decrease the number of man-hours for the next work.

Another embodiment in an environment different from that of Steps (1) to (10) will be described below. However, an overlapping portion is omitted and only a changed portion is described.

As shown in FIG. 3, the ground surface 1a is paved by the airtight material such as the concrete and the asphalt, a construction foundation 7 and an aboveground structure 8 such as a large oil tank and lime tank are constructed in the underground 1b which becomes the improvement target, and the improvement target covers the wide range of the underground 1b. An example of each of the cases will be described below.

In such cases, Steps (1), (4), (7), and (11) can be omitted. Because of the wide range of the underground 1b, the action can be taken without constructing the impervious wall 5 in Step (1) by lowering the groundwater surface 1c in the surroundings of the target underground 1b, and thus the removal of the impervious wall 5 in Step (11) is also eliminated. The ground surface 1a is covered with the airtight material 6, and a vinyl sheet, a waterproof tent, the pavement made of the cement or asphalt, the fresh sludge which does not smell bad, or the like is used as the airtight material 6 according to the target or ease of

procurement. Even if the airtight material 6 is not constructed, in the case of a soil structure in which a highly-airtight impermeable layer is widely formed in the upper-layer area of the target underground 1b of the soil improvement, the airtight material 6 can be replaced with the impermeable layer (not shown).

However, because the already-existing construction foundation 7 and aboveground structure 8 are located in the ground surface 1a of the underground 1b of the multilayer soil 1 including sand layers 1_1 and 1_3 and a clay layer 1_2 which become the improvement target, the configuration of the supply instrument 3 in Step (3) is changed to perform curve boring to the lower-layer soil below the construction foundation 7 unlike the perforated pipe 3a vertically disposed as shown in FIG. 2, and the perforated pipe 3a is placed while laying between the right and the left of the construction foundation 7. Therefore, the permanent grout 9 such as the foaming material can be effectively supplied in Step (6).

Other configurations are similar to those of Steps (2), (3), (5), (6), and (8) to (10).

A physical phenomenon generated in the underground 1b which becomes the soil improvement target will microscopically be described along with explanation in which the function is exerted more effectively by adopting the super well point method as the groundwater pumping step in the embodiment.

As shown in FIG. 4, soil particles 4a mainly constituting the underground 1b, groundwater 4b in the form of free water, adsorption water 4c adsorbing to the soil particles 4a with a physicochemical (electric) binding force, and an air bubble 4d existing in the free water 4b exist in a steady state before the soil improvement construction.

As shown in FIG. 5, in the state of the underground 1b after the pressure-reducing action of the underground 1b and the pumping of the groundwater 4b are performed in Step (5), the groundwater 4b is collected into the well 2 because the groundwater 4b is in the state of the free water 4b, and only the soil particles 4a and the adsorption water 4c exist. At this point, the pressures in fields of the soil particles 4a and the adsorption water 4c substantially become a vacuum state 4e. The improvement of the vacuum level makes a difference between the well point method and the super well point method, which allows the grout material 9 such as the air cement milk and the foaming material to be smoothly supplied to the underground 1b to maximize the supply of the grout material. Therefore, the improvement of the vacuum level becomes extremely effective means in the condition that the super well point method can be adopted.

As shown in FIG. 6, in the state in which the grout material is supplied to the underground 1b from the ground surface 1a in Step (6), the area which is temporarily put

in the substantial vacuum state 4e is filled with the supplied air.

As shown in FIG. 7, in the state in which the groundwater 4b is recharged into the underground 1b to recover the groundwater surface 1c to the groundwater level in the steady state in Step (9), the free water 4b invades the area filled with the air, and the amount of air existing in the groundwater 4b is increased, so that the air content of the groundwater 4b is increased. Because a degree of unsaturation of the groundwater 4b which is usually in the unsaturated state further progresses, a water ratio is relatively decreased to restrain an increase in water pressure of gap water existing between the soil particles, and decrease of frictional force between soil particles is restrained. Therefore, the soil can be improved.

FIGS. 9 and 10 show a gate-shaped construction 8 such as a crane in which a horizontal beam 8" is supported by right and left support posts 8'. In FIGS. 9 and 10, after consolidated drainage is performed early to uneven settlement of the foundation portions 7' supporting the construction by vacuum dewatering of the at least two super well point methods, the permanent grout material 9 such as the foaming material is injected below the foundation portion 7' by the curved perforated pipe 3 of FIG. 3, so that the foundation portion can be lifted up.

FIG. 11 shows comparison of the loose sandy soil

improvement work. That is, in the case of only the conventional dynamic consolidation method (FIG. 11(b)), the strength is not increased too much because of a weak shock below the groundwater surface generated by the dynamic consolidation method, and it cannot be expected that the strength is increased in the cohesive soil and below. Therefore, as shown in FIG. 11(a), when at least the two super well point methods are used in addition to the dynamic consolidation method, the consolidated drainage is performed early by the vacuum dewatering, and the groundwater level is lowered, so that the shock generated by the dynamic consolidation method can be transferred to a deeper portion and the dewatering of the clay layer l_2 can be performed by the vacuum effect.

Referring to FIG. 12, in at least the two super well point methods, a large amount of water ($Q \approx 1$ to 4.0 t/min) is delivered into the underground, and the vacuum suction is performed at a high vacuum level ($P_v = -0.1$ to 0.08 MP). The water delivery is substantially equal to the vacuum suction in time.

A fine component of the sand is removed to adjust a matrix of the particles, thereby increasing the strength of the sandy soil (see FIG. 13). The decrease in strength of the sandy soil is attributed to the fact that the sand largely contains colloid and silt components. The water-binding effect can be expected by the swing effect.

CLAIMS

1. A soil improvement method comprising:

a step of extending perforated pipe (3a) to underground (1b), a grout material (9) being supplied from a ground surface (1a) of soil (1) to the underground (1b) through the perforated pipe (3a);

a step of pumping groundwater near the underground (1b) by a super well point method in which at least two wells (2) are drilled with a predetermined interval in the underground (1b), and of putting the underground (1b) in a substantially vacuum state by reducing a pressure in a peripheral area of the underground;

a step of supplying a grout material (9) such as air cement milk or a foaming material from the ground surface (1a) into the underground (1b) through the perforated pipe (3a); and

a step of recharging the groundwater into the underground (1b) to a natural groundwater level.

2. A soil improvement method comprising:

a step of extending perforated pipe (3a) to underground (1b), fresh air or fresh water being supplied from a ground surface (1a) of soil (1) in polluted ground to the underground (1b) through the perforated pipe (3a);

a step of reducing a pressure in a peripheral area of the underground (1b) while pumping the groundwater near the underground (1b) by a super well point method in which at least two wells (2) are provided with the predetermined

interval in the underground (1b), thereby putting the underground (1b) into a substantially vacuum state;

a step of repeating the supply of the fresh air or fresh water through the perforated pipe (3a) extended from the ground surface (1a) to the underground (1b); and

a step of recharging the groundwater into the underground (1b) to a natural groundwater level.

3. The soil improvement method according to claim 1, wherein the ground surface (1a) in outer peripheries of at least two wells (2) for the super well point method provided with the predetermined interval is covered with an airtight material (6) such as an airtight sheet, pavement with a concrete material or an asphalt material, or new sludge.

4. The soil improvement method according to claim 1 or 2, wherein an operation of the super well point methods in which at least the two wells (2) are provided with the predetermined interval is stopped, or the airtight material (6) with which the ground surface (1a) is covered is removed while the operation of the super well point method is stopped, and

air is supplied by natural air supply generated by a difference in pressure between the underground (1b) and the ground surface (1a).

5. A soil improvement method, wherein, in multilayer soil of a clay layer (1₂) and sand layers (1₁) and (1₃), super well point methods in which at least two wells (2)

are provided with a predetermined interval suck a gap water pressure of the sand layer (1₃) below the clay layer (1₂) to reduce the pressure, thereby applying a stress load to the clay layer (1₂) to perform consolidated drainage of the clay layer (1₂).

6. A soil improvement method, wherein, in multilayer soil of a clay layer (1₂) and sand layers (1₁) and (1₃), super well point methods in which at least two wells (2) are provided with a predetermined interval suck the sand layer (1₃) below the clay layer (1₂) to reduce a pressure, and a vacuum state is made to evaporate water in the clay layer (1₂), thereby performing dewatering.

7. A soil improvement method, wherein, in multilayer soil of a clay layer (1₂) and sand layers (1₁) and (1₃), super well point methods in which at least two wells (2) are provided with a predetermined interval suck the sand layer (1₃) below the clay layer (1₂) to reduce a pressure,

a portion below an already-existing aboveground structure (8) placed in the unevenly-settled ground surface (1a) is drilled to make a hole with a boring machine,

a permanent grout material (9) is injected from the hole to improve the soil, and

the permanent grout material (9) is injected to lift up the unevenly-settled construction (8).

8. A soil improvement method, wherein, in soil including a sand layer, super well point methods in which at least two wells (2) are provided with a predetermined

interval suck the sand layer to reduce a pressure, thereby lowering a water level of underground (1b), and then

a dynamic consolidation method is performed.

9. A soil improvement method, wherein, in an operation of a super well point method in which at least two wells (2) are provided with a predetermined interval in underground (1b) including sand layers (1₁) and (1₃), a relationship in which pressure pumping action is imparted to one of the two wells while a suction operation is imparted to the other well is alternately repeated in each predetermined time, thereby generating water-binding action in the underground (1b).