

Method Employing Aerosol to Perform Disturbance Processing on Soft Soil Foundation

Technical Field

The invention relates to a foundation-processing method, which is suitable for the process
5 of the soft soil foundation, specifically relates to a method employing an aerosol to perform
disturbance processing on the soft soil foundation, and belongs to the technical field of civil
engineering.

Background Art

10 Soft soil is mostly distributed in the southeastern coastal areas of China, and is divided into
littoral environmental sediments, sea-land transition environmental sediments (delta sediments),
river environmental sediments, lake environmental sediments and marsh environment sediments
according to geological genesis. With the production development of human society and the
continuous increase of population density, more and more soft soil will be used as foundations of
15 buildings. When the soft soil is used as the foundation or other uses, it needs to be reinforced,
because the soft soil has the properties such as high water content, high void ratio, high flow
plasticity and so on. At present, for such projects, the drainage consolidation method is a
commonly used method for processing foundations. The principle of the method is to provide a
vertical drain such as a sand well, a plastic drainage board and the like, so as to bring the pore
20 water in soil layers to be discharged mainly from the horizontal direction by the vertical drain,
resulting in increasing the drainage ways of the soil layers, shortening the drainage distance, and
accelerating the soil drainage consolidation under the effect of loading, so that the soil will be
greatly settled in a short time, thereby achieving the purposes of improving soil strength and
reducing post-construction settlement.

25 The heap (vacuum) preloading drainage consolidation method is a more economical and
effective soft foundation processing method, but it also has greater limitations, mainly in that:

(1) The property of the soft soil is not being changed: according to relevant researches and
engineering practices, we know that the permeability coefficient of softer soil is extremely low, the
order of magnitude is 10^{-7} to 10^{-8} , and the main influence is that:

30 ① Deep soil does not drain: because the additional stress generated by heaping is an
exponential decreasing function changed with depth, the effective processing depth of the

drainage consolidation method is not more than 10m;

② The construction period is longer: after completing the upper heaping, it takes a long time to preload to meet the bearing capacity requirement;

③ The post-construction settlement is larger: after the construction, due to the effect of building loads, the deep soil is compressed for a long time, resulting in creep settlement.

(2) The horizontal drainage channel is not added: the drainage board is the vertical drain, and a sand bed course is the horizontal drain, but there is no horizontal drainage layer in underground soft soil.

(3) It is more difficult to strengthen drainage facilities after heaping. After completing constructing the drainage board and laying the sand bed course and then starting heaping, it is difficult to repair if there is a problem with the drainage facilities.

Summary of the invention

The technical problem to be solved by the present invention is to address the defect presented in the drainage consolidation heap preloading method in prior art, and to provide a method employing an aerosol to perform disturbance processing on a soft soil foundation. The method is to inject the aerosol to the deep soil of the soft soil foundation, and can accelerate the consolidation speed of the soil, deepen the processing depth of the soil, and reduce the long-term creep of the soil.

In order to achieve the purpose stated above, the present invention adopts the following technical solution:

A method employing the aerosol to perform disturbance processing on the soft soil foundation comprises the following steps:

(1) Vertically providing a drainage channel: the soft soil foundation to be processed are subjected to surveying and setting out, determining the processing area and site leveling according to "Technical Code for Ground Treatment of Buildings", and then a plurality of vertical drains is constructed to the required depth. The top of said drains (1) emerges from the surface layer of the soft soil foundation; and the plurality of drains are arranged in a triangle shape or a square shape. The setting of the drainage channel is completed right after providing all drains, and all drains are generally referred to as the drainage channel.

Said drain is a plastic drainage board or a bagged sand well.

The diameter (d_w) of said bagged sand well is 70 mm-120 mm; and the diameter of said plastic drainage board is an equivalent diameter d_p (that is, the diameter of a circular tube having the same hydraulic radius), $d_p=2(b+\delta)/\pi$, wherein d_p is the equivalent conversion diameter (mm) of the plastic drainage board, b is the width of the plastic drainage board (mm), and δ is the thickness of the plastic drainage board (mm).

The effective drainage diameter of said drain is d_e . When the drains are arranged in an equilateral triangle shape, $d_e=1.05L$, and when the drains are arranged in a square shape, $d_e=1.13L$. L is the distance between the drains, and L is preferably 0.7-1.5m.

The hole diameter ratio of said drain $n=d_e/d_w$ ($n=15-22$), wherein d_w is the diameter of the drain, and $d_w=d_p$ for the plastic drainage board.

(2) Providing a bed course and digging a gutter: after completing providing the drains described in the step (1), two layers of bed courses are evenly laid on the surface layer of the soft soil foundation to be processed, so as to cover the top of the drains. The thickness of the bottom bed course is 30cm, and the total thickness of the two layers of the bed courses is at least 50cm. The top of said drain protrudes from the bottom bed course, and is above the horizontal plane for at least 50cm, so as to make the drain to be bent and buried in the sand bed course. The gutter is formed by digging sands around the soft soil foundation to be processed, in order to discharge water out of the site in time.

Said bed course is a sand bed course or a crushed stone bed course. The sand in said sand bed course is medium coarse sand, and the clay particle content is equal to or less than 3% (the sand material may contain a small amount of gravel having a particle diameter of equal to or less than 50 mm). Said sand bed course has a dry density of more than 1.5 t/m^3 and a permeability coefficient of more than $1 \times 10^{-2} \text{ cm/s}$.

The depth of said gutter is at least 1.0 m. The bottom of the gutter is backfilled with the pond slag having gradation and fine particle diameter, and the backfilling depth is at least 50 cm.

(3) Providing a protective casing or a punched channel: after completing providing the bed course and the gutter described in the step (2), a protective casing is buried through the bed course and into the soft soil foundation to be processed.

Alternatively, after completing providing the bed course and the gutter described in the step (2), a heaped-load is laid on the bed course, and then the punched channel is constructed through the heaped-load and the bed course and into the soft soil foundation to be processed by

using punching technique.

Said protective casing has a length of being ensured to pass through the bed course, and is punched into the soft soil foundation for a depth of at least 50cm. The diameter of said protective casing is 10-15 cm.

- 5 Said punched channel has a depth of being ensured to pass through the heaped-load and the bed course, and is punched into the soft soil foundation for a depth of at least 50cm. The diameter of said punched channel is 10-15 cm.

When using the heap preloading means, said heaped-load (5) is typically a pond slag. When laying the first layer, it typically uses the pond slag having gradation and fine particle diameter, the mud content is less than 5%, and the compactness is required to be more than 90 %. The total height of the heap is checked and calculated according to the foundation processing bearing capacity requirements and the construction period. The calculation formula is:

$$\bar{U} = \sum_{i=1}^n \frac{q_i}{\sum \Delta p} \left[(T_i - T_{i-1}) - \frac{\alpha}{\beta} e^{-\beta t} (e^{\beta T_i} - e^{\beta T_{i-1}}) \right]$$

- 15 wherein, $\bar{U}$ is the average consolidation degree of the foundation within t time; q_i is the loading rate of the i-th load (kPa/d); $\sum \Delta p$ is the load cumulative value at all levels (kPa); T_i and T_{i-1} are the starting time and ending time of the i-th load loading (from the zero point, unit d), respectively; α and β are parameters, and can be calculated and selected according to the drainage consolidation conditions of the foundation soil. When using the vacuum
- 20 preloading, the heaped-load is selected from a sealing membrane, and the loading means of continuously vacuuming to the maximum pressure for once can be used. The under-membrane vacuum degree under vacuum preloading should be stably maintained at equal to or more than 86.7 kPa (650 mmHg). The sealing membrane should use a gas-impermeable material with good anti-aging property, good toughness and strong puncture resistance.

- 25 As for the calculation formula of the total heap height, because it is difficult to calculate, generally, it is usually based on engineering experience when designing and calculating. In addition, many formulas and parameters refer to the α and β parameters.

(4) Providing an injection pipe (8): After completing providing the protective casing or the

punched channel in step (3), the injection pipe is passed through the protective casing or the punched channel, and pressed into or drilled into the soft soil foundation to be processed. One injection pipe is provided for every 3-5 m. The injection pipe is located outside the drain. The drains are distributed in a triangle shape or a square shape in the soft soil foundation. Although
5 the injection pipe is located outside the drain, the injection pipe is located inside the triangle shape or the square shape, and is preferably located in the center.

The material of said injection pipe is a rigid material. Injection holes are evenly distributed on the pipe wall. The diameter of the injection hole is typically 2-5 mm, and the size and the distribution density of the injection holes can be self-adjusted according to design. According to
10 design requirements, the length of the injection pipe is equal to or less than the depth of the drain buried in the soft soil.

(5) Injecting aerosol: connecting the injection pipe to an aerosol injection apparatus, then connecting the gas inlet of the injection pipe to the exhaust port of an air pump through a conduit, connecting the gas inlet of the air pump to the discharge of an aerosol generator; then placing an
15 aerosol solution prepared by adding water to the aerosol raw materials in the solid or liquid form into the aerosol generator, opening the switches of the aerosol generator and the aerosol injection apparatus, forming the aerosol by the aerosol solution in the aerosol generator under high pressure, introducing the aerosol into the injection pipe under pressure, injecting the aerosol to the soft soil foundation to be processed under high pressure by the injection pipe; and after
20 injecting for reaching the design range and the injection design time, lifting the injection pipe to the next design depth for further injecting from low to high step by step until completing all injection operation.

The aerosol raw material is a polyacrylamide-based chemical material.

In said aerosol solution, the mass concentration of the aerosol raw material is
25 6/10000-9/10000.

Said aerosol generator is the aerosol generator presenting in the prior art or being commercially available and having an aerosol-generating function, and preferably an industrial high pressure atomization container.

Said aerosol injection apparatus is the apparatus presenting in the prior art or being
30 commercially available and having an aerosol-injection function, and preferably a high pressure jet grouting pile construction equipment.

Said aerosol is introduced into the injection pipe under pressure, and the pressure is at least 0.6 MPa, preferably 0.8-1 MPa.

When said injection pipe injects the aerosol, the injection rate is at most 2 s/revolution, the injection radius is at least 3m, and the injection time is at least 600 seconds/hole. The injection
5 rate is preferably 1-1.5 s/revolution, the injection radius is preferably 4-5 m, and the injection time is preferably 650-700 seconds/hole.

In the method of the present invention, when injecting the aerosol, the two injection ranges need to have a certain overlap to ensure that the entire injection area is completely injected (in the figure, the large circle indicates the injection range, and the small circle indicates the overlap of
10 the two injection ranges), and the injection depth is not greater than the depth of the drain.

In the method of the present invention, the aerosol being originally the chemical material in the solid or liquid form (such as polyacrylamide) is prepared as a solution with the designed concentration (recommended to the maximum saturation concentration); wherein a certain amount of an inorganic high cationic material and sludge are brought in contact, and then a
15 neutralization reaction can occur on the surface of the sludge, thereby forming an unhardened structure of the sludge and providing initial microvoids. The amphiphilic high molecule polymer material in the functional material system changes the surface property of the sludge, resulting in changing the sludge from hydrophilicity into hydrophobicity and forming a micro-drainage surface in the sludge. The two interact each other to form a micro-surface drainage system in the sludge
20 effectively, and the apparent phenomenon is that the permeability coefficient of the sludge increases and the strength of the soil increases.

In the method of the present invention, the liquid to be injected into the soil is atomized to form the aerosol, and is injected into the interior of the soil by applying high pressure. The role of the technique is, on one hand, to enable the chemical components in the gas to uniformly act on
25 the soil within the injection range and to occur a chemical reaction, and on the other hand, to form a horizontal cutting plane with a small thickness in the soil, add a horizontal drainage channel, shorten the drainage distance and achieve the effect of rapid drainage.

Compared to the prior art, the method of the invention has the following advantages:

(1) Turning the original soft soil into another kind of "soil": wherein, a certain amount of an
30 inorganic high cationic material and sludge are brought in contact, and then a neutralization reaction can occur on the surface of the sludge, thereby forming an unhardened structure of the

sludge and providing initial microvoids. The amphiphilic high molecule polymer material in the functional material system changes the surface property of the sludge, resulting in changing the sludge from hydrophilicity into hydrophobicity and forming the micro-drainage surface in the sludge. The two interact each other to form the micro-surface drainage system in the sludge effectively, thereby increasing the permeability coefficient of the sludge and increasing the strength of the soil.

The aerosol also has the following characteristics:

① It is green environmental protection, and has no damage to the environment. The aerosol directionally adsorbs the sludge, then exists in the soil eventually, and will not remain in the water. The technique is safe and environmentally friendly.

② The manufacturing technique is simple, and the product quality is easy to control and stable.

③ It is soluble in water, and has higher solubility.

④ It is high efficiency, and the addition amount is very few, thereby ensuring low cost.

⑤ The addition of the functional material can quickly improve the permeability of the soil, improve the strength of the soil, and be fast and stable, without increasing the construction period and increasing the post-construction settlement.

(2) Increasing the processing depth, shortening the construction period and reducing the post-construction settlement: since the injection concentration, pressure, rate, radius and injection time of the aerosol can be designed according to the target requirements of the foundation processing, it means that the depth and the construction period of the foundation processing can be self-controlled. By the action of the aerosol, the permeability coefficient of the foundation soil can be increased, thereby rapidly draining, accelerating the consolidation of the foundation soil, and achieving the purpose of shortening the construction period. By the injection depth of the aerosol, the deep soil of the foundation can be processed, and the processing depth is increased, so that the post-construction settlement becomes smaller.

(3) Adding a horizontal drainage channel: by injecting the aerosol, a horizontal cutting plane with a small thickness is formed in the soil, thereby adding the horizontal drainage channel, shortening the drainage distance and achieving the effect of rapid drainage.

(4) Difficult to strengthen the drainage facilities after heaping: since the buried protective casing is removed after the end of the construction period, the solution for processing the soft soil

foundation by the aerosol can be amended at any time during the construction period.

(5) Controllable cost: due to the high efficiency of the aerosol, the very few amount of the addition, the low cost and the popularity of the construction equipment, it enables that the cost of processing the foundation by the method of the present invention becomes controllable, and furthermore, the shortening of the construction period can greatly reduce the cost of the foundation processing.

Therefore, the foundation processing effect of the method of the invention is far superior to the traditional method, and is an original new method.

10 Description of the figures

Figure 1: technique flow diagram of the method of the invention.

Figure 2: a graph showing the regularity of the permeability coefficient of the soft soil foundation changing with time, the soft soil foundation being processed by the method of the Example 1 of the present invention and by the method of the Comparative Example 1, respectively.

Figure 3: a graph showing the regularity of the change of the porosity of the soft soil foundation processed by the method of the Example 1 of the present invention and by the method of the Comparative Example 1.

Figure 4: a graph showing the regularity of the change of the cross shear strength of the soft soil foundation processed by the method of the Example 1 of the present invention and by the method of the Comparative Example 1.

Of which: 1-drain, 2-bed course, 3-gutter, 4-protective casing (or punched channel), 5-heaped-load, 6-aerosol injection apparatus, 7-aerosol generator, and 8-injection pipe. $\diamond$ is the data of the soft soil foundation, $\square$ is the data of the foundation after being processed by the method of the Comparative Example 1, and $\triangle$ is the data of the foundation after being processed by the method of the Example 1. The large circle indicates the injection range, and the small circle indicates the overlap of two injection ranges. The injection depth is not greater than the depth of the drain.

30 Specific Embodiments

The specific embodiments of the technical solution of the present invention are described in

detail below, but the present invention is not limited to the following description:

5 In the method of the present invention, both of the drains and the bed course are left in the soil without the need of being taken out. The heaped-load is usually not unloaded and outward transported, and is heaped to the designed standard height for earthwork balance. The protective casing is used for the aerosol-injection, has no effect on the foundation processing, and can be left until completing the foundation processing and then taken out, in order to prepare to inject the aerosol again. The processing time is typically 3-4 months.

Example 1:

10 The soft soil foundation of a sea-enclosing project is processed. The soft soil layer is 20-25m thick, and the surface layer is the dredger fill with a thickness of 3-5m. The design parameters of the soft soil foundation are shown in the following table.

Layer number	Indicator Upper layer name	Bulk density γ (kN/m ³)	Consolidated quick shear		Permeability coefficient	
			Internal friction angle φ (°)	Cohesive strength C (kPa)	Horizontal direction Kh (*10 ⁻⁶ cm/s)	Vertical direction Kv (*10 ⁻⁶ cm/s)
② ₁	Sludge	15.3	5.5	9.7		
② ₃	Powdery clay	19.2	14.4	27.7	0.27	0.18
② ₄	Sludge clay	17.5	9.5	14.9	0.03	0.01
③ ₁	Powdery clay containing breccia, Breccia containing powdery clay	19.6	15.1	30.4	0.84	0.43
③ _{1a}	Powdery clay	19.3	16.3	35.2	0.47	0.29
③ ₃	Clay	19.1	16.3	37	0.10	0.08

A method employing an aerosol for performing disturbance processing on a soft soil foundation comprises the following steps:

(1) Vertically providing drainage channel: the drainage channel for processing the foundation is designed according to "Technical Code for Ground Treatment of Buildings", and is subjected to surveying and setting out, determining the processing area of the soft soil foundation and site leveling according to the design. A plurality of vertical drains are constructed to the designed depth, and the top of the drains 1 emerges from the surface layer of said soft soil foundation.

Said drain uses a plastic drainage board, the depth of the drain constructed into the soft soil foundation is 18m, and the specification of the drain is SPB-B type. The equivalent diameter d_p of the plastic drainage board is 66.8mm. The plurality of drains are arranged in a square shape. The effective drainage diameter d_e of the drain is 1.356m, and L is 1.2m.

(2) Providing a bed course and digging a gutter: after completing providing the drain described in the step (1), two layers of the bed courses 2 are evenly laid on the surface layer of the soft soil foundation to be processed so as to cover the top of the drain. The thickness of the bottom bed course is 30cm, and the total thickness of the two layers of the bed courses is 60cm. The length of the top of said drain protruding from the bottom bed course is at least 50cm. The gutter 3 is formed by digging sands in the area within the range of 2-5m around the soft soil foundation to be processed, so as to discharge water out of the site in time.

Said bed course is a sand bed course. The sand in the sand bed course is medium coarse sand, and the clay particle content is equal to or less than 3% (the sand material may contain a small amount of gravel having a particle diameter of equal to or less than 50 mm). Said sand bed course has a dry density of more than 1.5 t/m^3 and a permeability coefficient of more than $1 \times 10^{-2} \text{ cm/s}$.

The depth of said gutter 3 is at least 1.5 m. The bottom of the gutter is backfilled with a pond slag, and the backfilling depth is 50 cm.

(3) Providing a protective casing: after completing the construction of the bed course and the gutter described in the step (2), a protective casing 4 is buried through the bed course an into the soft soil foundation to be processed.

The protective casing has a length of being ensured to pass through the bed course, is

punched into the soft soil foundation for a depth of 50cm, and has a diameter of 10cm.

(4) Providing an injection pipe (8): after completing providing the protective casing in step (3), the injection pipe is passed through the protective casing, and pressed into or drilled into the soft soil foundation to be processed. One injection pipe is provided for every 3-5m.

- 5 The injection pipe is located outside the drain and inside the square shape. According to design requirements, the length of the injection pipe is equal to or less than the depth of the drain buried in the soft soil.

The material of said injection pipe is a rigid material. Injection holes are evenly distributed on the pipe wall. The diameter of the injection hole is typically 2-5 mm, and the
10 size and the distribution density of the injection holes can be self-adjusted according to design.

(5) Injecting an aerosol: connecting the injection pipe 8 to an aerosol injection apparatus 6, then connecting the gas inlets of the injection pipe to the exhaust port of an air pump through a conduit, connecting the gas inlet of the air pump to the discharge of an
15 aerosol generator 7; then placing an aerosol solution prepared by adding water into the aerosol raw materials in the solid or liquid form into the aerosol generator, opening the switches of the aerosol generator and the aerosol injection apparatus, forming the aerosol by the aerosol solution in the aerosol generator under high pressure, introducing the aerosol into the injection pipe under pressure of 1.0 MPa, injecting the aerosol to the soft soil foundation
20 to be processed under high pressure by the injection pipe, with an injection rate of 1.5 s/revolution, an injection radius of 4 m and an injection time of 650 second/hole; and after reaching the designed injection time, lifting the injection pipe to the next design depth for further injecting until completing all injection operations.

Said aerosol raw material is polyacrylamide, and in the aerosol solution, the
25 concentration of the polyacrylamide is 6/10000.

Said aerosol generator is an industrial high pressure atomization container.

Said aerosol injection apparatus is a high pressure jet grouting pile construction equipment.

Upon being processed by the method of the present invention, the permeability
30 coefficient of the soft soil foundation is increased by two orders of magnitude, the void ratio

decreases, and the cross-plate shear strength is obviously enhanced. The variations of each parameter changing with time are shown in Figs. 2, 3 and 4.

After the entire area has been injected, the protective casing is taken out. After about 3-4 months, each indicator of the soft soil foundation meets the processing requirements.

5 Example 2:

The method for processing the soft soil foundation is the same as that of Example 1, except that, in the step (1), said drain is a bagged sand well, the diameter d_w is 100 mm, the drains are arranged in a square shape, the effective drainage diameter of the drain d_e is 1.356 m, and L is 1.2 m. Upon being processed by the method of the present invention, the permeability coefficient of the soft soil foundation is increased by two orders of magnitude, the void ratio decreases, and the cross-plate shear strength is obviously enhanced. The variations of each parameter changing with time are basically the same as that of Example 1.

After the entire area has been injected, the protective casing is taken out. After about 3-4 months, each indicator of the soft soil foundation meets the processing requirements.

15 Example 3:

The method for processing the soft soil foundation is the same as that of Example 1, except that, in the step (3), after completing providing the bed course and the gutter, the heaped-load is laid on the bed course, and then a punched channel is constructed through the heaped-load and the bed course and into the soft soil foundation to be processed by using punching technique. Said punched channel has a depth of being ensured to pass through the backfilling soil and the bed course, is deep into the soft soil foundation for a depth of 50 cm, and has a diameter of 10 cm.

Said heaped-load is heap preloaded. The material is a pond slag, and the heaped-load height is 3 m. It is heaped for twice respectively. The first layer is laid for 1.5 m, and uses the pond slag having gradation and fine particle diameter; the mud content is less than 5%, and the compactness is required to be more than 90%. The total backfilling height is calculated according to the foundation processing bearing capacity requirements.

Upon being processed by the method of the present invention, the permeability coefficient of the soft soil foundation is increased by two orders of magnitude, the void ratio decreases, and the cross-plate shear strength is obviously enhanced. The variations of each

parameter changing with time are basically the same as that of Example 1.

After the entire area has been injected, and then after about 3-4 months, each indicator of the soft soil foundation meets the processing requirements.

Example 4:

5 The method for processing the soft soil foundation is the same as that of Example 3, except that, in the step (3), the heaped-load is a sealing membrane, and uses the loading means of continuously vacuuming to the maximum pressure for once, wherein, the pressure is 100 kPa. Upon being processed by the method of the present invention, the permeability coefficient of the soft soil foundation is increased by two orders of magnitude, the void ratio
10 decreases, and the cross-plate shear strength is obviously enhanced. The variations of each parameter changing with time are basically the same as that of Example 1.

After the entire area has been injected, the sealing membrane is peeled off, and then after about 3-4 months, each indicator of the soft soil foundation meets the processing requirements.

15 Comparative Example 1:

The method for processing the soft soil foundation is the same as that of Example 1, except that, in the step (5), the injected aerosol is changed to high-pressure air, so as to achieve the purpose of disturbing the foundation soil. The permeability coefficient of the soft soil foundation processed is increased by two orders of magnitude, the void ratio decreases,
20 and the cross-plate shear strength is not enhanced. The variations of each parameter changing with time are shown in Fig. 2, 3 and 4. After the entire area has been injected, the protective casing is taken out, and then after about 6-9 months, each indicator of the soft soil foundation meets the processing requirements.

It can be seen from Fig. 2, 3 and 4 that, the sludge soft soil is a very structural soil, and
25 it takes a long time to recover after being disturbed. If the sludge soft soil is disturbed during heap preloading, the settlement will be difficult to be stabilized, and although it can increase the settlement amount, it needs to last for a long time. However, the incorporation of the aerosol can quickly restore the strength of the disturbed soil, and will greatly increase the strength of the soil, so that the settlement is tended to be faster stabilized.

30 The above examples are merely illustrative of the technical concept and technical

features of the present invention, and are not intended to limit the scope of the present invention. Equivalent transformations or modifications made in accordance with the spirit of the invention are intended to be included within the scope of the invention.

Claims

1. A method employing an aerosol to perform disturbance processing on a soft soil foundation is characterized in comprising the following steps:

5 (1) Vertically providing a drainage channel: the soft soil foundation to be processed is subjected to surveying and setting out, determining the processing area and site leveling according to the requirements in "Technical Code for Ground Treatment of Buildings"; then a plurality of vertical drains is constructed into the soft soil; the top of said drain (1) emerges from the surface layer of said soft soil foundation; and said drains are generally referred to as
10 the drainage channel;

 (2) Providing a bed course and digging a gutter: after completing providing the drain described in the step (1), the bed course (2) is evenly laid on the surface layer of the soft soil foundation to be processed so as to cover the top of the drain; and the gutter (3) is formed by digging sand around the soft soil foundation to be processed, so as to discharge water out of
15 the site in time;

 (3) Providing a protective casing or a punched channel: after completing providing the bed course and the gutter described in the step (2), the protective casing is buried through the bed course and into the soft soil foundation to be processed;

 alternatively, after completing providing the bed course and the gutter described in the
20 step (2), a heaped-load (5) is laid on the bed course, and then the punched channel (4) are constructed through the heaped-load and the bed course and into the soft soil foundation to be processed by using punching technique;

 (4) Providing an injection pipe (8): after completing providing the protective casing or the punched channel in the step (3), the injection pipe is passed through the protective casing
25 or the punched channel, and pressed into or drilled into the soft soil foundation to be processed;

 (5) Injecting an aerosol: connecting the gas inlet of the injection pipe (8) to the discharge of an aerosol generator (7); then placing an aerosol solution prepared by adding water into the aerosol raw materials in a solid or liquid form into the aerosol generator,
30 opening the switches of the aerosol generator and an aerosol injection apparatus, forming

the aerosol by the aerosol solution in the aerosol generator under high pressure, introducing the aerosol into the injection pipe under pressure, injecting the aerosol to the soft soil foundation to be processed by the injection pipe under high pressure; and after injecting to reach the designed range and the designed injection time, lifting the injection pipe to the next design depth for further injecting from low to high step by step until completing all injection operations.

2. The method according to claim 1 is characterized in that, in the step (1), a plurality of said drains are arranged in a triangle shape or a square shape; the distance between each drain L is 0.7-1.5 m; said drain is a plastic drainage board or a bagged sand well; the diameter of said bagged sand well d_w is 70-120 mm; and the diameter of said plastic drainage board is an equivalent diameter d_p , $d_p=2(b+\delta)/\pi$; wherein b is the width of the plastic drainage board, and δ is the thickness of the plastic drainage board.

3. The method according to claim 1 is characterized in that, in the step (2), said bed course (2) is two layers, the thickness of the bottom bed course is 30 cm, and the total thickness of the two layers of the bed course is at least 50 cm; the top of said drain protrudes from the bottom bed course, and is above the horizontal plane for at least 50 cm; said bed course is a sand bed course of a crushed stone bed course; and the depth of said gutter (3) is at least 1.0 m.

4. The method according to claim 1 is characterized in that, in the step (3), when providing the protective casing, said protective casing has a length of being ensured to pass through the bed course, is punched into the soft soil foundation for a depth of at least 50 cm, and has a diameter of 10-15 cm; and alternatively, when providing the punched channel, said punched channel has a depth of being ensured to pass through the heaped-load and the bed course, is punched into the soft soil foundation for a depth of at least 50 cm, and has a diameter of 10-15 cm.

5. The method according to claim 1 is characterized in that, in the step (3), when said heaped-load (5) is heaped by the means of heap preloading, the material is a pond slag; and alternatively, when said heaped-load (5) is heaped by vacuum preloading, the material of the heaped-load uses a sealing membrane.

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6. The method according to claim 1 is characterized in that, in the step (4), in the soft soil foundation, one injection pipe is provided for every 3-5 m; injection holes are evenly distributed on the pipe wall of said injection pipe; the diameter of the injection hole is 2-5 mm, and the length of the injection pipe is equal to or less than the depth of the drain buried in the soft soil.

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7 The method according to claim 6 is characterized in that, the drains are distributed in the soft soil foundation in a triangle shape or a square shape, and said injection pipe is located outside the drains and inside the triangle shape or the square shape.

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8. The method according to claim 1 is characterized in that, in the step (5), said aerosol raw material is polyacrylamide, and in said aerosol solution, the mass concentration of the aerosol raw material is 6/10000-9/10000.

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9. The method according to claim 1 is characterized in that, said injection pipe (8) is connected to the aerosol injection apparatus (6), then the gas inlet of the injection pipe is connected to the exhaust port of the air pump through a conduit, and the gas inlet of the air pump is connected to the discharge of the aerosol generator (7).

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10. The method according to claim 1 is characterized in that, in the step (5), said aerosol is introduced into the injection pipe under pressure of at least 0.6 MPa; and when the aerosol is injected to the soft soil foundation to be processed under high pressure by said injection pipe, the injection rate is at most 2 s/revolution, the injection radius is at least 3 m, and the injection time is at least 600 second/hole.

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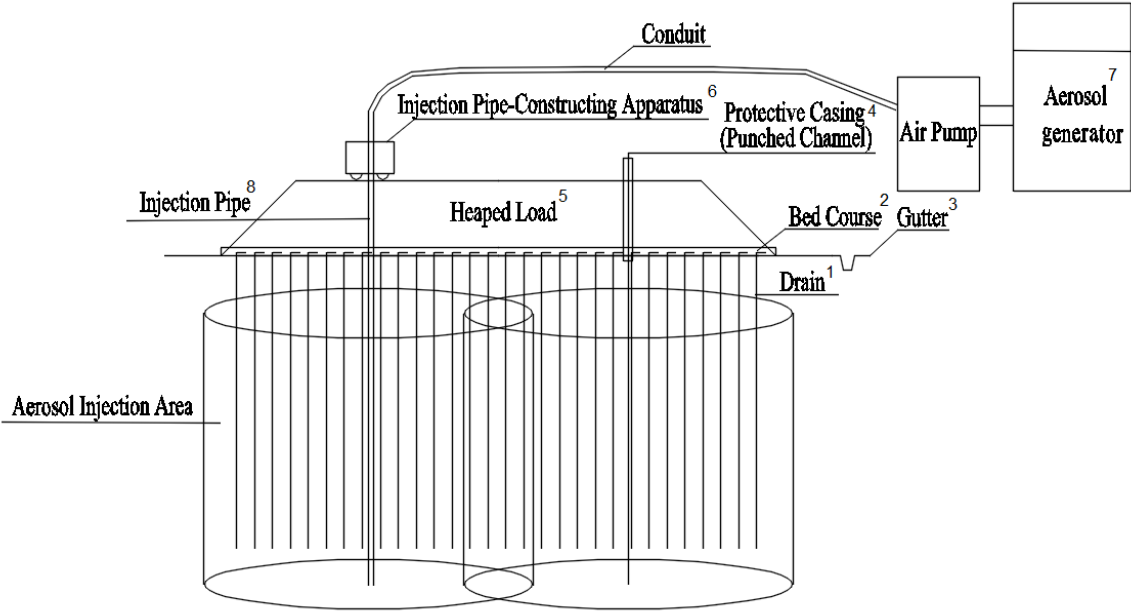


Fig. 1

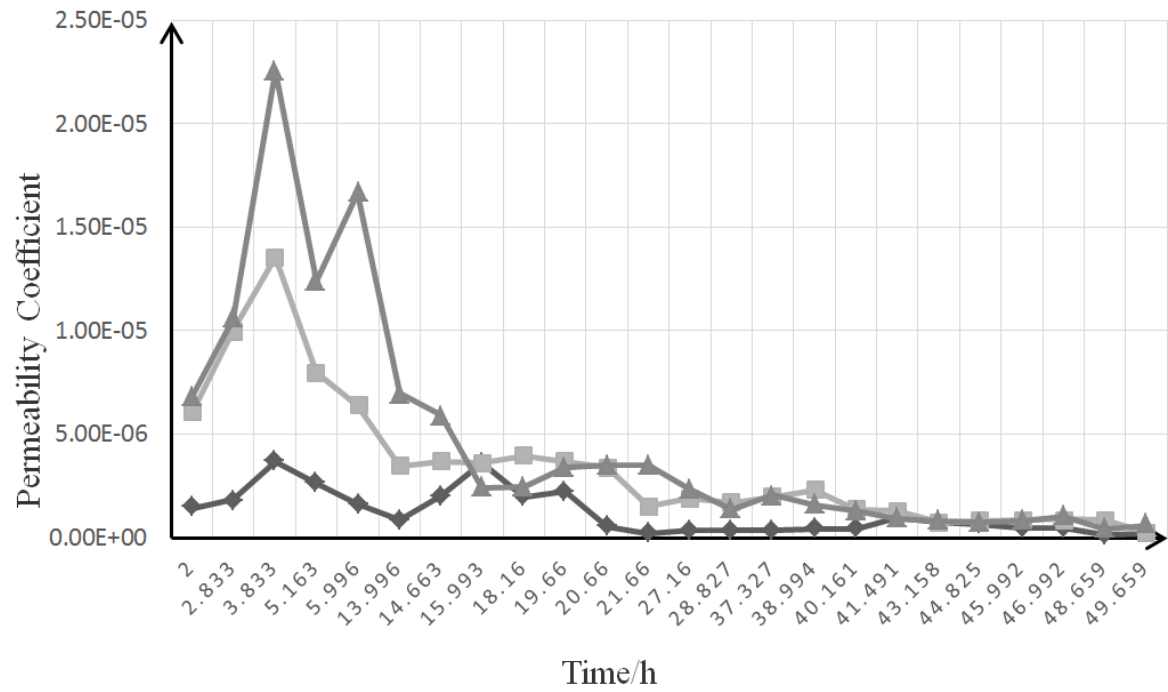


Fig. 2

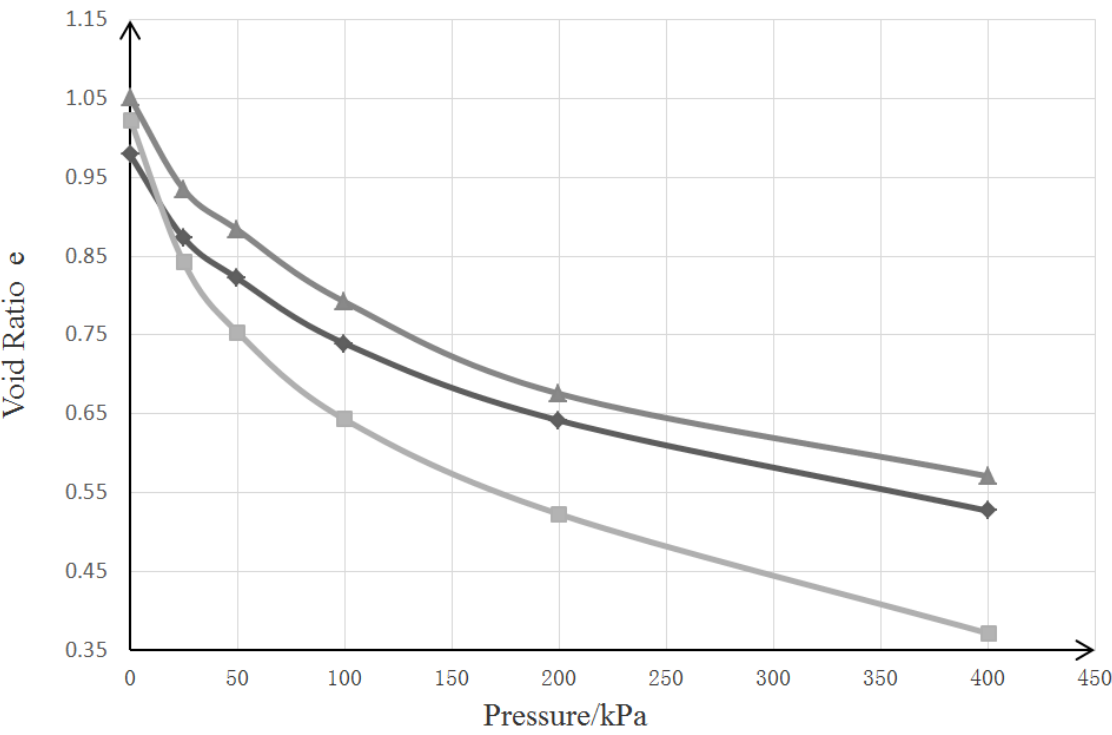


Fig. 3

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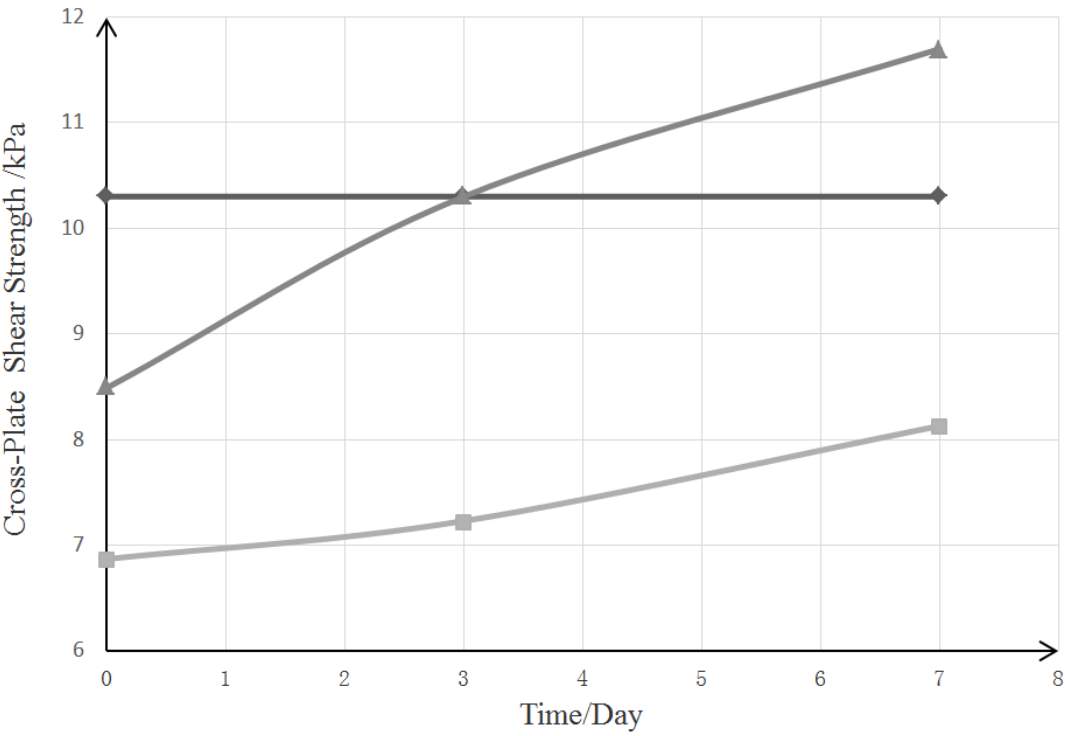


Fig. 4