

GROUND REFORMING METHOD AND A GROUND REFORMING DEVICE

The present invention relates to a device for ground reforming and a ground reforming method, in which an injection rod is inserted into the ground.

5 Various ground reforming methods are known in which hardening materials are injected into the ground. In these methods, high pressure and high speed jet injection has been applied to slow hardening type materials and instantaneous hardening type
10 hardening materials have been injected under low pressure, approaching ambient pressure. High pressure injection has been conducted up to a pressure of 220 kilogram force per square centimetre and injection devices operating at higher pressures have not been
15 proposed.

 The instantaneous hardening type hardening materials cannot be used at higher pressure because the instantaneous hardening type hardening material is composed of two separated liquids which mix after
20 injection. If these liquids are mixed prior to injection, the hardening material will be wholly or partially hardened in the injection pump or pipe. Therefore, the high pressure injection method has only employed the slow hardening material which requires 'a
25 long period to achieve hardness. However, the slow

hardening type hardening material will sometimes cause problems, owing to its slow hardening speed. For example, if the amount of injected material is increased, the slow hardening type hardening material
5 will flow backwards and leak out of the injection pipe or the like. Such problems are markedly increased when unusual injection angles are used.

In the high pressure injection method, reaction force will be generated at the injection nozzle as the
10 injection pressure is increased and the reaction force will be applied to the injection rod. Thus, serious problems may result and a revolving motion may be introduced by the reaction force.

It is an object of the present invention to
15 provide an improved technique for ground reforming.

According to a first aspect of the invention, there is provided a ground reforming method, comprising

(a) inserting an injection rod into ground to be
20 reformed, wherein said injection rod includes a first conduit and a second conduit, a first injection nozzle communicatable with the first conduit and a second injection nozzle surrounding the first nozzle and communicatable with the second conduit, said first
25 nozzle and said second nozzle arranged in pairs with

the injection made oppositely;

(b) individually feeding first and second fluid into the first and second conduits of the injection rod; and

5 (c) injecting the first and second fluid at high pressure through the first and second nozzles while retracting and revolving the injection rod.

Preferably, said first and second fluids are, respectively, the first and second components of an
10 instantaneous type hardening material, composed of two separate liquids. In an alternative preferred embodiment, the first and second fluids are, respectively, slow hardening type material composed of a liquid and a compressed gas.

15 According to a second aspect of the present invention, there is provided a ground reforming device, comprising an injection rod having a first conduit through which a first fluid is feedable and a second conduit through which a second fluid is
20 feedable; a first injection means communicatable with the first conduit, including a pair of first injection nozzles oppositely arranged in a side wall of the injection rod near to its top; a second injection means communicatable with the second conduit, wherein said
25 second injection means includes a pair of second

injection nozzles surroundingly arranged around
respective first injection nozzles; a high pressure
generating means for providing a high pressure to the
first and second fluid, the high pressure generating
5 means been connected to the injection rod; and a drive
means for supporting and driving the injection rod to
revolve and retract the injection rod.

In a preferred embodiment, the high pressure
generating means generates a pressure of at least two
10 hundred kilogram force per square centimetre.
Preferably, the drive means is movable under its own
power without additional drive means.

The invention will now be described by way of
example only, with reference to the accompanying
15 drawings, in which:

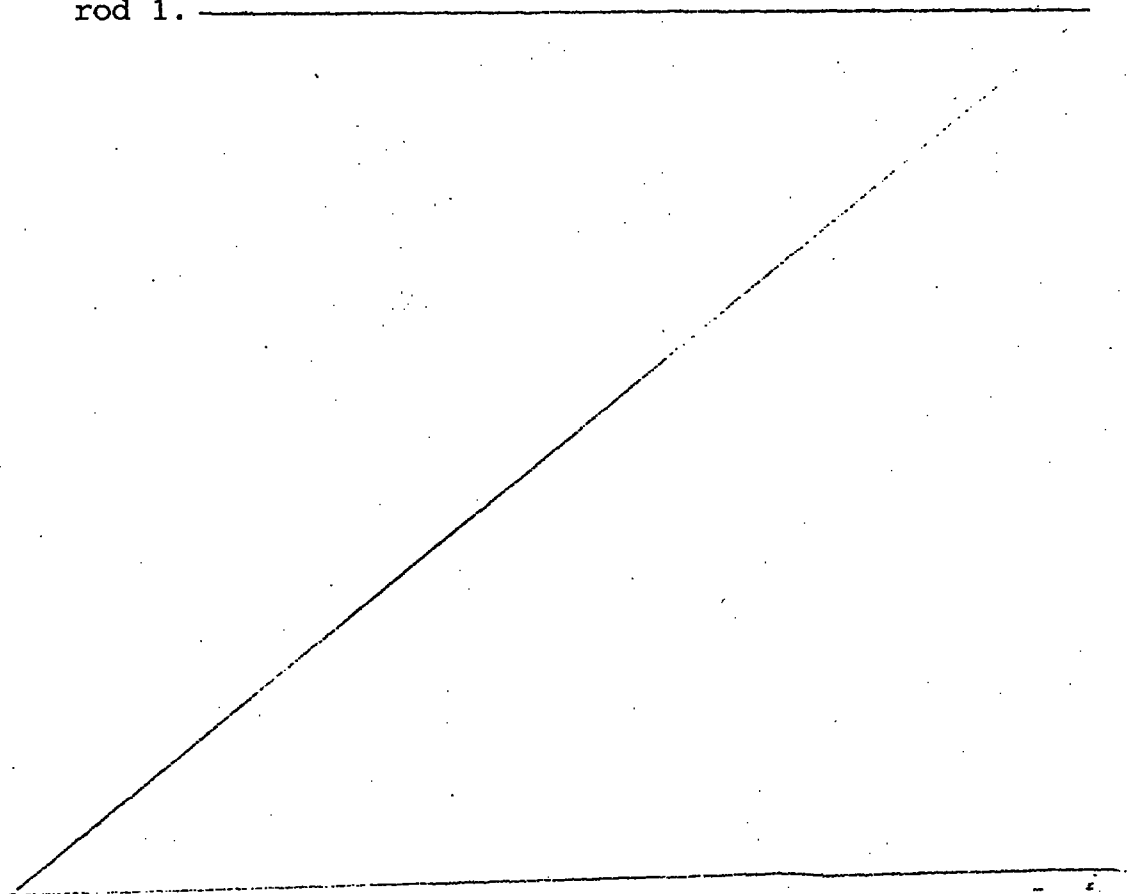
Fig. 1 is a schematic illustration showing one
example of a working state, where the injection rod is
inserted into the ground;

Fig. 2 is a vertical cross section view showing
20 the top portion of the injection rod, according to the
present invention; and

Fig. 3 is a cross sectional view taken along the
line x - x in Fig. 2.

A preferred embodiment of the present invention is
25 detailed in Figure 1, in which reference numeral 1

denotes an injection rod which includes a first conduit 2a and a second conduit 2b, isolated from each other as shown in Fig. 2. The first conduit 2a is arranged in a core of the injection rod 1 and surrounded with the second conduit 2b. The first conduit 2a is communicated with center nozzle 3a and 4a which are oppositely arranged in the side wall near the top of the injection rod 1 and extend radially with respect to the longitudinal axis of the injection rod 1.



As shown in Fig. 3, the second conduit 2b is communicated with surrounding nozzles 3b and 4b, having annular openings which surround, respectively, the centre nozzles 3a and 4a.

The injection rod 1 is supported by a drive unit 5 to revolve and retract the injection rod 1. The

injection rod 1 is further connected to a first feeding pipe 6a and a second feeding pipe 6b through a swivel joint

6. Component A of an instantaneous hardening type

hardening material is fed into the first conduit 2a from

the first feeding pipe 6a, and component B of the

instantaneous hardening type hardening material is fed into

the second conduit 2b from the second feeding pipe 6b.

Alternatively, a slow hardening type hardening

material per se is fed into the first conduit 2a from the

first feeding pipe 6a, and compressed gas is fed into the

second conduit 2b from the second feeding pipe 6b.

The first and second feeding pipes 6a and 6b are

connected to a compressor, not shown in the drawings, to

generate a super high pressure fluid such as the

instantaneous hardening type hardening material or gas.

The compressor includes a piston, a valve chamber, cylinder

and a pressure sensitive member for transmitting pressure

from the cylinder to the valve chamber. The pressure

sensitive member is composed of active oil having different

specific gravity from the instantaneous hardening type

hardening material, and an elastic film actuated by the

active oil. The active oil is moved in response to the

reciprocal motion of the piston so that the hardening material can be introduced into the valve chamber and then discharged out of the chamber by the high pressure. In this compressor the hardening material is isolated from the piston through the pressure sensitive member. Therefore the hardening material can be discharged without energy loss caused by the friction between the piston and the hardening material. The valve chamber is provided with an inlet through which the hardening material is introduced into the chamber and an outlet through which the hardening material is discharged to the feeding pipe. Each the inlet and the outlet is provided with a valve box whose valve seat is sectionally formed in a half spherical recessed shape. The valve seat is further formed with a plurality of orifices in its axial direction. The valve seat receives a valve member formed in a spherical shape adapting for the valve seat. The valve member is always urged toward the valve seat by a spring. This valve mechanism employing the spherical valve member can promote to increase the discharging pressure.

The drive unit 5 is preferable to be designed that drive angle for the injection rod 1 can be freely changed and the drive unit 5 per se can be moved without additional drive mechanism.

The top of the injection rod 1 is provided with an excavating member 7 and a lubricating unit 8 as shown in Fig. 2. The lubricating unit 8 will discharge lubricant to

assist excavating work of the excavating member 7.

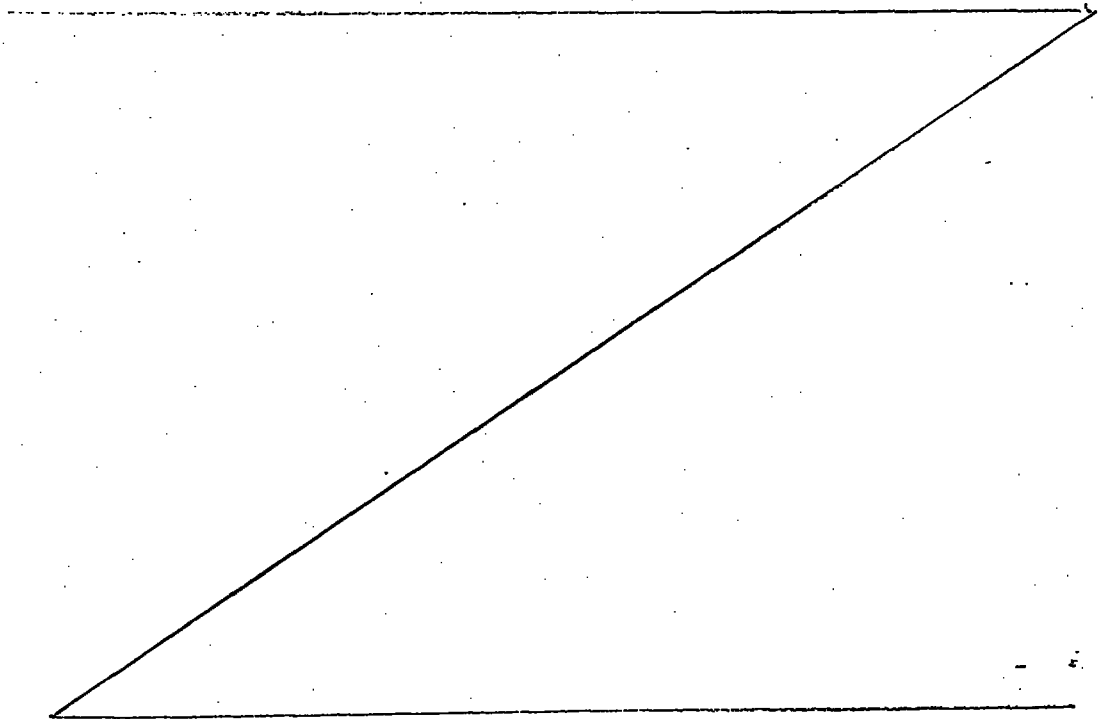
Operation of the ground reforming method according to the present invention will be described. The injection rod 1 with revolving and discharging the lubricant from the lubricating unit 8 is moved towards ground M to be reformed. As the top of the injection rod 1 reaches to a predetermined depth, the lubricating unit 8 closes to stop discharging. The component A of the

hardening material is fed at a super high pressure into the first conduit 2a and the component B of the instantaneous hardening type hardening material (or gas) is fed at a super high pressure into the second conduit 2b. Both the components A and B are injected outwardly from the injection nozzles 3a, 3b, 4a and 4b while the injection rod 1 is moved back with revolving. According to this revolving injection, the components A and B are completely mixed and then an essentially cylindrical hard layer S in the ground M has been generated.

Experiment in sand having N-value 15 to 20 resulted in an excellent reforming effect; that is, the cylindrical hard layer having a large diameter of 3m 70cm was obtained under conditions; injection pressure of 400 kg f/cm^2 , injection rate of 100 l/min, revolving speed of 8 r.p.m, and back-moving speed of 2cm/min.

As explained above, the ground reforming device can inject the instantaneous hardening type hardening material at a super

high pressure 200 kg f/cm² or more. The two components of the instantaneous hardening type hardening material can be sufficiently and uniformly mixed immediately before application to the ground without back-flowing or leakage. On the other hand, when compressed gas such as air is injected from one injection nozzle, hardening material injected from the other nozzle can be splashed to a great distance. Further bubbles will generate by mixing the hardening liquid material and compressed gas. These bubbles will generate dynamic rupture effect by breaking these bubbles so that greater area will be hardened into a high density cylindrical hard layer by ruptured hardening material. The cylindrical hard layer may be formed in any configuration such as parallel arrangement or alignment as required.



An example of a two component instantaneous hardening material is as follows:

A component (500l) DENKA^{*}-ES 100KG, DENKA-ES SETTER 2 to 4Kg, Water to make 500l

5 B component (500l) Portland Cement 400Kg, Water to make 500l

(* "DENKA" is a registered trade mark)

When using instantaneous hardening material a number of precautionary measures would be taken. It would be normal to check the ambient temperature and to adjust the mixing ratio of the hardening material accordingly should the temperature be higher than 28°C or there-abouts to avoid premature hardening. Also to avoid nozzle blockage it would be usual to prefilter the hardening material components using a mesh with openings that are smaller than the nozzle diameters. Typically such diameters range between 1.8 mm and 3.2 mm. Since strong acid water and soil prevent satisfactory hardening of the hardening material, the PH value of the soil that is to be treated and of the water that is to be mixed in the preparation of the A and B components should also be checked. After working, the inside of the injection

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rod and all connective hoses etc should be subjected to a high pressure water washing for at least a ten minute period and the nozzle section should be dismantled and also washed thoroughly.

5 "TOUGH LOCK-3" manufactured by Sumitomo Cement Company for example may be used as the slower hardening material for the modified method described above.

10 A particular application of instantaneous hardening material is in the hardening of moist and water laden soils. In such soils slower hardening type materials have a tendency to disperse in soil water prior to hardening and are generally inappropriate.

15 Conversely in well drained soils, sandy soils and the like, slower hardening type hardening material may be used. An advantage of the modified method described above is that the hardening material is spread widely around the injection nozzle.

20 It will be apparent from the foregoing that the ground reforming device described can be used to treat a wide variety of soil conditions e.g. moist and water laden soils, organic soils, acid soils etc with either instantaneous or slower hardening type
25 hardening materials as appropriate.



- 12 -

CLAIMS

1. A ground reforming method, comprising

5 (a) inserting an injection rod into ground to be reformed, wherein said injection rod includes a first conduit and a second conduit, a first injection nozzle communicatable with the first conduit and a second injection nozzle surrounding the first nozzle communicatable with the second conduit, said first
10 nozzle and said second nozzle arranging in pairs with the injection made oppositely;

(b) individually feeding first and second fluid into the first and second conduits of the injection rod; and

15 (c) injecting the first and second fluid at high pressure through the first and second nozzles while retracting and revolving the injection rod.

2. A ground reforming method according to claim
20 1, wherein said first and second fluids are, respectively, the first and second components of an instantaneous type hardening material, composed of two separate liquids.



- 13 -

3. A ground reforming method according to claim 1, wherein the first and second fluids form a slow hardening type hardening material and are composed of a liquid and a compressed gas.

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4. A ground reforming device, comprising an injection rod having a first conduit through which a first fluid is feedable and a second conduit through which a second fluid is feedable;

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a first injection means communicatable with the first conduit, including a pair of first injection nozzles oppositely arranged in a side wall of the injection rod near to its top;

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a second injection means communicatable with the second conduit, wherein said second injection means includes a pair of second injection nozzles surroundingly arranged around respective first injection nozzles;

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a high pressure generating means for providing a high pressure to the first and second fluid, the high pressure generating means been connected to the injection rod; and

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a drive means for supporting and driving the injection rod to revolve and retract said injection rod.



- 14 -

5 5. A ground reforming device according to claim 4, wherein the first and second fluids are, respectively, the first and second components of an instantaneous type hardening material composed of two separate liquids.

10 6. A ground reforming device according to claim 4, wherein the first and second fluids are, respectively, slow hardening type hardening materials composed of a liquid and a compressed gas.

15 7. A ground reforming device according to any of claim 4 to 6, wherein the high pressure generating means generates a high pressure of at least two hundred kilogram force per square centimetre.

20 8. A ground reforming device according to any of claim 4 to 7, wherein the drive means is movable under its own power without additional driving means.

9. A ground reforming method when performed substantially as described hereinbefore with reference to the accompanying drawings.



- 15 -

10. A ground reforming device constructed, adapted and arranged to perform substantially as described hereinbefore with reference to and as shown in the accompanying drawings.
