

PATENT SPECIFICATION

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DRAWINGS ATTACHED

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(54) CONSOLIDATION OF SOIL AND OTHER WATER-PERMEABLE MASSES OF SIMILAR GRAIN SIZE

(71) We, THE CEMENTATION COMPANY LIMITED, a Company registered under the laws of Great Britain, of Cementation House, 681 Mitcham Road, Croydon, in the County of Surrey, England, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to improvements in the consolidation of soil and other water-permeable masses of similar grain size.

It is known to use vertical sand drains or sand piles, as they are sometimes called, to improve the properties of soil for the support of superimposed loads such as, for example, highways, airfields, ore storage yards, buildings, storage tanks and similar structures. These vertical sand drains formed in the soil represent an attempt to augment the consolidation of the soil by providing vertical drainage outlets for the water or moisture squeezed from the soil during the process of settlement by the weight of surcharge or fill. The known method of construction of such sand drains involved driving a steel pipe, 12" to 20" diameter, into the soil in very much the same manner as is done in the case of cast-in-situ concrete piling. The pipe is then filled with clean sand and subsequently withdrawn leaving the sand behind together with any metal or concrete plug which may have initially closed the bottom of the pipe. Bored holes of similar or lesser diameter have also been used.

Hole diameters up to 20" have been required, not to cater for any large flow of water through these drains, but to overcome the many practical problems associated with the construction of the sand drains with the equipment available.

The time required for consolidation of soil is proportional to the thickness of the earth layer to be consolidated. If, therefore, the spacing of the sand drains is appreciably less than the thickness of the earth layer, the rate

of consolidation of the soil mass will be greatly accelerated, since the excess pore water pressure can escape in a radial direction towards the sand drains along a much shorter distance than was the case of previous methods of consolidation by pre-loading without sand drains.

With the known techniques of constructing sand drains the following difficulties are encountered:

1. When the pipe is withdrawn after filling with sand, there is a tendency for arching of the sand to occur and necking to develop, with resulting discontinuity in the sand drain.

2. When the pipe is driven into soft clay, movement of the soil can take place and, if the sand drain spacing is close, completed sand drains may be sheared when the pipe is being driven in the adjacent locations. This causes discontinuity of the drain.

3. During settlement of the soil due to surcharge load, quite often a situation may arise where the sand drains act as piles and support the surcharge load, thereby defeating the whole purpose of the sand drains.

4. Considerable cost is involved in boring holes of the relatively large diameter as referred to hereinbefore.

According to one aspect of the present invention, a method of consolidating soil or other water-permeable masses of similar grain size comprises forming holes in the soil at selected locations, inserting into each such hole a pre-formed wick in the form of a tube of water-permeable material filled with a granular or pulverulent material, and applying a load to the soil or other water-permeable mass.

It is preferred that the filled tube should have a general diameter in the range of 1 inch to 4 inches, but in certain cases, larger diameter wicks may be installed, if necessary, up to 12 inches diameter. The filled tube should have a length not less than 10 feet. Conveniently, the water-permeable material is formed from a woven textile material such as, for example, a cellulosic or jute textile material or

(12)

5 fabric made from coconut coir fibre or any
other suitable synthetic material or fine wire
mesh or any combination of the above stated
materials, chemically treated if the prevailing
10 ground conditions so require to increase the
life of the wick, e.g. to prevent or reduce at-
tack on the material by organisms in the
ground. This material is advantageously such
as to function as a filter between the particles
15 in the ground and the granular or pulverulent
material contained within the tube. The tube
may be composed of a single or a plurality
of layers of material. In the latter case, a lining
may be provided to improve the filtering char-
acteristics of the soil.

20 The granular or pulverulent material is pre-
ferably sand but other materials or combina-
tion of materials may be used such, for exam-
ple, flyash, sawdust and cinder. Where sand
is employed, it is preferably at least partially
wetted once it has been loaded into the tube
prior to inserting the preformed wick into a
hole.

25 According to another aspect of the invention
there is provided a method of consolidating
soil or other water-permeable masses of similar
grain size which comprises forming holes in
the soil or other water-permeable mass at loca-
30 tions spaced from adjacent locations by a dis-
tance less than the depth of the holes, inserting
into each such hole a preformed wick in the
form of a sheath of diameter in the range 1
to 4 inches of flexible water-permeable mat-
35 erial filled with a granular or pulverulent ma-
terial, the water-permeable material being ca-
pable of acting as a filter between the particles
of soil or other water-permeable mass and the
granular or pulverulent material within the
40 preformed wick and forcing water from the
soil or other water-permeable mass through the
water-permeable material of the wicks and up
through the pulverulent material by applying
a load to the soil or other water-permeable
mass.

45 The preformed drainage wicks developed
according to the invention function effectively
as drains and have the following advantages
over the originally developed sand drain tech-
nique:—

50 i) Using a tube filled with pulverulent or
granular material, the continuity of the drain
throughout the depth installed is fully ensured.

55 (ii) The preformed wick is flexible enough
to deform sufficiently under a superimposed
consolidating load and will not act as a pile.

60 (iii) Only simple and readily available tools
are required for installation of the wicks in
the soil, and cost is substantially less than that
of the previously used 9" to 20" diameter
sand drains.

65 iv) As the usual sand drains are replaced
by preformed drainage wicks of relatively
much smaller diameter, it is possible to use
holes drilled in the soil of correspondingly
small diameters so that the spacing of the holes

can be reduced, which is a desirable factor in
this field. Drilling holes of small diameters is
less costly also.

70 Wicks can be installed in the earth soil by
any method known in the art. Thus, it may
be done by forming a hole in the ground by
driving a pipe or boring a cased hole of any
geometrical section with or without an expend-
able point, or making a hole in the ground
75 of any shape by stabilising the sides, e.g. by
a wash method without any casing and placing
the wick in the hole in a dry, partially satu-
rated or fully saturated state with the top and
bottom of the wick at the required depth. Any
casing pipe if required for stabilising the hole,
80 is withdrawn after installing the wick.

Accordingly, in carrying out the method
proposed by the invention no complicated or
costly machineries are required.

85 Embodiments of the invention will now be
described by way of example, reference being
made to the accompanying drawings in
which:—

90 Fig. 1 shows a wick for use in the method
proposed by the invention,

Fig. 2 is a view similar to Fig. 1 of another
wick,

95 Fig. 3 is a section along the line III—III
of Fig. 1,

Fig. 4 is a section along the line IV—IV
of Fig. 2,

100 Fig. 4a is a section through two wicks one
contained within the other the inner wick con-
taining coarser granular material, the annulus
between the two containing a finer granular
material, the two granular materials, together
with the water permeable material forming the
tube, acting as a combined graded filter.

105 Figs. 5, 6 and 7 show the formation of holes
in the ground by three different methods,

110 Figs. 8, 9 and 10 show wicks in position
in the holes shown in Figs. 5, 6 and 7 respec-
tively, and Fig. 11 shows the application of
consolidating load on the soil in which the pre-
formed wicks have been installed.

115 The preformed wicks shown in Fig. 1 to
4 each comprise a tube 1 of jute hessian mat-
erial filled with sand 2. The tube 1 of Figs.
1 and 3 is formed from a single layer of mat-
erial and that of Figs. 2 and 4 of a double
layer of material. Any form of flexible woven
textile material is suitable for the tube 1 pro-
vided its functions to retain the sand and is
permeable to moisture. It should also function,
either alone or jointly with the outer layer of
120 sand adjacent to the tube, as a filter to remove
a substantial proportion of the solid soil con-
stituents from the moisture sweeping to the
interior of the tube. The double layer of mat-
erial of the tube 1 shown in Figs. 2 and 4
improves its strength and filtering characteris-
tics. The tube 1 may be of any mean dia-
meter and it may be of any length to suit
the conditions on site.

130 Fig. 5 shows the formation of a hole in the

ground by driving a four inch diameter casing 3 having an expendible point 4. Once the casing has been driven, a preformed wick 6, which has preferably been at least partially pre-wetted, is inserted down the casing (Fig. 8). The casing 3 is then withdrawn leaving behind the preformed wick and the expendible point. The process is then repeated at an adjacent location.

- 10 The use of an expendible point 4 is not essential in the formation of the hole as can be seen from Fig. 6. Fig. 9 shows the preformed wick 6 inserted down the tube 3 before the latter is withdrawn. Fig. 7 shows an uncased hole 5 formed by wash technique in known manner into which a preformed wick 6 is then inserted (Fig. 10).

- 15 Fig. 11 shows a section of soil having a number of preformed wicks disposed therein with a consolidating load 7 placed thereon to assist in expelling moisture from the soil into and upwardly out of the preformed wicks, thereby preparing a supporting foundation for superimposed loads.

- 20 It will be understood that although the holes 5 are generally vertically extending they may also extend at an angle to the vertical.

WHAT WE CLAIM IS:—

- 25 1. A method of consolidating soil or other water-permeable masses of similar grain size comprising forming holes in the soil or other water-permeable mass at selected locations, inserting into each such hole a preformed wick in the form of a tube of water-permeable material filled with a granular or pulverulent material and applying a load to the soil or other water-permeable mass.

- 30 2. A method according to Claim 1 in which the diameter of each wick is in the range of 1—4 inches.

- 35 3. A method according to Claim 2 in which the water-permeable material is selected from the group consisting of a cellulosic material, a jute textile material, fabric made from coconut coir fibre, a synthetic material and fine wire mesh or from a combination of such materials.

- 40 4. A method according to Claims 2 or 3 in which the tube of water-permeable material comprises a single layer of such material.

- 45 5. A method according to Claims 2 or 3

in which the tube of water-permeable material is formed from a plurality of layers of such material.

- 55 6. A method according to any of Claims 2 to 5 in which the granular or pulverulent material is sand.

- 60 7. A method according to any of Claims 2 to 6 in which the holes are formed by driving a pipe or boring a cased hole and the pipe or casing is withdrawn after a wick has been inserted therein.

- 65 8. A method according to any one of Claims 2 to 6 in which the holes are formed as uncased holes.

9. A method according to any of Claims 2 to 8 in which each wick is at least partially pre-wetted before being inserted into the hole.

- 70 10. A method according to any one of claims 2 to 9 in which the preformed wick is at least 10 feet long.

- 75 11. A method of consolidating soil or other water-permeable masses of similar grain size which comprises forming holes in the soil or other water-permeable mass at locations spaced from adjacent locations by a distance less than the depth of the holes, inserting into each such hole a preformed wick in the form of a sheath of diameter in the range 1 to 4 inches of flexible water-permeable material filled with a granular or pulverulent material, the water-permeable material being capable of acting as a filter between the particles of soil or other water-permeable mass and the granular or pulverulent material within the preformed wick and forcing water from the soil or other water-permeable mass through the water-permeable material of the wicks and up through the pulverulent material by applying a load to the soil or water-permeable mass.

- 80 12. A method of consolidating soil or other water-permeable masses of similar grain size substantially as described herein.

- 85 13. A preformed wick in the form of a tube of water-permeable material filled with granular or pulverulent material for use in the method according to any of Claims 2 to 10.

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40 2. A method according to Claim 1 in which the diameter of each wick is in the range of 1—4 inches.

45 3. A method according to Claim 2 in which the water-permeable material is selected from the group consisting of a cellulosic material, a jute textile material, fabric made from coconut coir fibre, a synthetic material and fine wire mesh or from a combination of such materials.

50 4. A method according to Claims 2 or 3 in which the tube of water-permeable material comprises a single layer of such material.

5. A method according to Claims 2 or 3

in which the tube of water-permeable material is formed from a plurality of layers of such material.

6. A method according to any of Claims 2 to 5 in which the granular or pulverulent material is sand. 55

7. A method according to any of Claims 2 to 6 in which the holes are formed by driving a pipe or boring a cased hole and the pipe or casing is withdrawn after a wick has been inserted therein. 60

8. A method according to any one of Claims 2 to 6 in which the holes are formed as uncased holes. 65

9. A method according to any of Claims 2 to 8 in which each wick is at least partially pre-wetted before being inserted into the hole.

10. A method according to any one of claims 2 to 9 in which the preformed wick is at least 10 feet long. 70

11. A method of consolidating soil or other water-permeable masses of similar grain size which comprises forming holes in the soil or other water-permeable mass at locations 75

spaced from adjacent locations by a distance less than the depth of the holes, inserting into each such hole a preformed wick in the form of a sheath of diameter in the range 1 to 4 inches of flexible water-permeable material filled with a granular or pulverulent material, the water-permeable material being capable of acting as a filter between the particles of soil or other water-permeable mass and the granular or pulverulent material within the preformed wick and forcing water from the soil or other water-permeable mass through the water-permeable material of the wicks and up through the pulverulent material by applying a load to the soil or water-permeable mass. 80

12. A method of consolidating soil or other water-permeable masses of similar grain size substantially as described herein. 85

13. A preformed wick in the form of a tube of water-permeable material filled with granular or pulverulent material for use in the method according to any of Claims 2 to 10. 95

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