

The invention relates to a method and a device for the in situ formation of columns of stabilized and compacted soil.

5 Improving the stability or the bearing capacity of poor quality, loose ground in order to make foundations, embankments, slopes, etc. by the in situ formation of columns of stabilized soil is a known technique.

10 The columns of stabilized soil are arranged, grouped, combined in accordance with configurations such as walls, spurs, a grid, blocks, etc., depending on the desired result, but the basic constituent column is generally in the form of a cylinder of locally occurring soil, the geomechanical properties of which have been improved by incorporating an outside material.

15 In brief, a primary column is obtained by penetrating the ground with a rotary drilling tool. This tool loosens the ground and mixes it with an added material introduced by a wet or dry method via a hollow drive shaft. Once the desired depth has been reached by the
20 tool, the latter is withdrawn.

The added material which is mixed with the locally occurring ground is generally a binder which gives rise to a setting action leading to the formation of a soil concrete, the strength of which depends on the
25 properties of the soil, the quantity and nature of the incorporated binder, and on the degree of homogeneity and compactness of the mixture thus produced.

30 For a given binder and soil, the two characteristic elements which determine the quality of the result obtained are therefore the homogeneity and the compactness of the mixture.

35 Although it is possible, using the various methods and devices of the prior art, to obtain more or less the degree of homogeneity sought after, the problem of recompacting the mixture formed in situ is in no way solved.

An attempt to solve this problem is described in US-A-3,875,571. This document discloses a tool for

consolidating soils which consists in a single auger comprising an upper and a lower section of particular profiles. This tool cuts the ground when it is driven into the soil and upon its withdrawal, mixes a binder with the soil and ensures, by means of its lower section, a compaction of the soil. This tool, as a result of the fact that it comprises a single auger and that the latter has a particular profile, does not allow, however, a homogeneous column of stabilized ground to be obtained, but a stratified column of the "plate stack" type which is not fully satisfactory.

In order for the binder to be properly distributed throughout the mass of treated soil, the latter needs to be completely reworked by the loosening tool so as to destroy as far as possible the bonds existing between the constituent particles of the ground and so as to be able to achieve thereby thorough mixing between the latter and the incorporated binder. The structure of the final mixture obtained is generally looser than that of virgin ground, the destructuring of the latter by the loosening tool causing an increase in volume. This decrease in the compactness of the treated ground tends to lessen the consolidation effect resulting from incorporation of the binder.

The object of the invention is to provide a method and a device which, while ensuring a better degree of homogeneity of the soil/binder mixture, make it possible to recompact the latter in situ, thereby improving considerably the mechanical properties of the column of stabilized soil thus formed.

More particularly, the invention relates to a method for the in situ formation of a primary column of stabilized and compacted soil, comprising a first phase which consists in driving into the ground a rotary drilling tool which loosens the ground and mixes it with an added material, and during which an ascending movement is imparted to at least some of the loosened ground through the drilling tool, and a second phase consisting in withdrawing the drilling tool from the ground,

characterized in that the drilling tool used is a device which comprises at least two parallel shafts, each shaft driving in rotation an auger, each auger being provided at the opposite end to the drive shaft with a loosening drill-head and the distance between the axes of the
5 augers being less than the diameter of one auger, the shafts and shanks of the augers comprising a bore connected to a source of material to be added and at least one orifice which communicates with the said bore being
10 provided on the shank of each auger so as to discharge the material to be added, the augers having opposite pitches and being driven in rotation in opposite directions and which further comprises means for reversing the direction of rotation of the augers, in that the first
15 phase is carried out by driving into the ground said device while discharging a material to be added through said orifice so as to mix it with the loosened ground, and in that the second phase is carried out, after having reversed the direction of rotation of the augers, by
20 exerting a controlled pressure on said device while withdrawing it, so as to impart to the loosened ground mixed with the added material a descending movement, which tends to compact it, through said device.

The invention also relates to a device suitable
25 for implementing the method of the invention, which comprises at least two parallel shafts, each shaft driving in rotation an auger, each auger being provided at the opposite end to the drive shaft with a loosening drill-head and the distance between the axes of the
30 augers being less than the diameter of one auger, the shafts and the shanks of the augers comprising a bore connected to a source of material to be added and at least one orifice which communicates with said bore being provided on the shank of each auger so as to discharge
35 the material to be added and allow it to be mixed with the loosened ground, the augers having opposite pitches and being driven in rotation in opposite directions, and which further comprises means for reversing the direction of rotation of the augers.

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When the method of the invention is carried out, the following effects are produced:

During the first drilling and mixing phase, the locally occurring soil, which is loosened by the drill-head, is conveyed in an ascending movement through the device of the invention, thereby completing the loosening effect due to the head itself and consequently ensuring better dispersion of the material or binder added, introduced by a dry or wet method, throughout the mass of soil. The loosened soil passes through the whole of the device of the invention as the latter penetrates the ground. In view of the increase in volume caused by the loosening, an expansion effect occurs, which is accentuated by the addition of the material to be added, a more or less large portion of the soil thus made uniform and mixed with the added material being able to emerge at the surface, at the top of the column. If required, this first phase can be repeated once or several times.

During the second compacting phase, once the depth fixed for treatment has been reached, the direction of rotation of the auger elements is reversed, thereby causing a reverse movement of the material as the device of the invention is withdrawn. Thus, in addition to a complementary homogenizing action, continuous recompaction of the ground/added material mixture is achieved by the device during the entire period of its reascent towards the surface. During this compacting phase, the portion of ground extracted during the drilling phase is reintroduced into the drilled column. As a result of the recompaction effect, it is usually necessary to complete filling of the drilled column by adding extra material.

The method of the invention can be applied both to firm ground (argillaceous ground, clay, etc.) and to loose ground (sand, gravel, etc.).

The invention will be clearly understood with the aid of the following description which is given with reference to the attached drawings:

Figure 1 is a diagrammatic view, in elevation and in cross-section, of the ground, showing a device

according to the invention and its use during the first phase of the method of the invention;

Figure 2 is a view similar to that shown in Figure 1, but during the second phase of the invention;

5 Figures 3 and 4 are diagrammatic views showing the direction of rotation of the auger elements of the device of the invention during the first and second phase, respectively, of the method of the invention.

10 The device shown in Figures 1 and 2, which is used to form columns of stabilized and compacted soil according to the method described above, comprises the following elements:

15 Two parallel shafts 1, which are each provided with a bore 1a, drive two helical augers 2 which have opposite pitch and rotate in opposite directions. Each auger is provided at its free end with a loosening drill-head 3 which has been adapted to the type of ground. This may be, for example, as shown, a head in the form of a helix, or else a knife. The distance X between the axes
20 of the augers is less than the diameter of the latter so that the turns of the two augers are effectively engaged with each other so as to ensure a forced movement or flow of the loosened ground 4 by means of the two augers. The shank 5 of each auger also has a bore 5a, which communi-
25 cates with the bore of the corresponding drive shaft, thereby making it possible to convey the material or binder to be added, by a dry or wet method, down to the orifices 6 provided over the height of the shank of each auger so as to ensure that it is thoroughly mixed with
30 the loosened ground.

35 The length of the augers is chosen in accordance with the depth of the column to be formed. It is generally between $\frac{1}{2}$ and $\frac{1}{3}$ the length of the column, but in certain cases it could be increased so as to be of the same length.

It must be noted that the augers, instead of having a continuous helical profile, could be discontinuous, that is to say be replaced by a plurality of helices located at intervals.

In accordance with the depth of the column to be formed, a certain number of double bearings 7 are located at intervals over the height of the drive shafts and the augers so as to keep them parallel.

5 These bearings could be replaced over the height of the drive shafts by a continuous hollow beam which could, if necessary, be used to convey the material or binder to be added to the end of the augers.

10 The two drive shafts 1 are mounted on a geared reducing/reversing device 8, itself connected to a motor 9 which drives them as well as the augers in rotation, in opposite directions and at the same speed. This reducing-motor assembly 8, 9 may be carried by a drilling machine (not shown) installed at the surface in line with the
15 column to be formed, either by means of a slide on which it is able to move longitudinally either freely or by means of a translational device. As a variation, it may be suspended from the jib of a hoist (a crane or similar device).

20 The operation of forming a column of stabilized compacted soil may be described as follows:

 With the carrying appliance installed in line with the chosen position, the shafts and augers are made to rotate in the direction corresponding to screwing of
25 the augers into the ground (Figures 1 and 3). The speed of penetration is controlled so as to optimize the soil-loosening effect. The material or binder to be added may be introduced at any time during the drilling operation. In the case of the wet method, it is pumped by a pump
30 located at the surface through the revolving heads 10 mounted on the end of the drive shafts. In the case of the dry method, it is forced by means of compressed air through the same heads.

 Once the desired depth has been reached, the
35 direction of rotation of the shafts and augers is reversed and the device of the invention is brought back up in a continuous manner (Figures 2 and 4). The direct mechanical effect of the augers tends to make the device move back up by itself. By controlling this upward

movement and exerting a controlled pressure on the device, it is possible to obtain recompaction of the soil/added material mixture. Injection of the material to be added may be continued, if desired, during all or part of this recompaction phase. The soil which is brought to the surface during the drilling phase is conveyed back down into the column. The addition of extra material is usually required in order to fill the hole.

It should be noted that, as the bores of the augers are independent ducts, it is possible, if desired, to feed one of the bores with a material to be added which is different from that feeding the other bore, so that these materials react in situ together or with the ground.

As a result of the invention, it is possible to obtain columns of stabilized and compacted soil, the mechanical properties of which are far superior to those of columns obtained in accordance with the prior art, without recompaction.

A particularly interesting application of the method and the device of the invention is the stabilization of railway territory.

It is obvious that the embodiment described is merely an example and that it could be modified, in particular by the substitution of equivalent technical features, without necessarily departing from the scope of the invention, such as defined by the claims.

CLAIMS

1. A method for the in situ formation of a primary column of stabilized and compacted soil, comprising a first phase which consists in driving into the ground a rotary drilling tool which loosens the ground and mixes it with an added material, and during which an ascending movement is imparted to at least some of the loosened ground through the drilling tool, and a second phase consisting in withdrawing the drilling tool from the ground,

characterized in that the drilling tool used is a device which comprises at least two parallel shafts (1), each shaft driving in rotation an auger (2), each auger being provided at the opposite end to the drive shaft with a loosening drill-head (3) and the distance between the axes of the augers being less than the diameter of one auger, the shafts and the shanks (5) of the augers comprising a bore (5a) connected to a source of material to be added and at least one orifice (6) which communicates with the said bore being provided on the shank of each auger so as to discharge the material to be added, the augers having opposite pitches and being driven in rotation in opposite directions and which further comprises means for reversing the direction of rotation of the augers,

in that the first phase is carried out by driving into the ground said device while discharging a material to be added through said orifice (6) so as to mix it with the loosened ground, and

in that the second phase is carried out, after having reversed the direction of rotation of the augers, by exerting a controlled pressure on said device while withdrawing it, so as to impart to the loosened ground mixed with the added material a descending movement, which tends to compact it, through said device.

2. A method according to Claim 1, characterized in that the driving and mixing operations of the first phase are repeated at least once.

3. A device suitable for implementing the method of

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the invention, which comprises at least two parallel shafts (1), each shaft driving in rotation an auger (2), each auger being provided at the opposite end to the drive shaft with a loosening drill-head (3) and the distance between the axes of the augers being less than the diameter of one auger, the shafts and the shanks (5) of the augers comprising a bore (5a) connected to a source of material to be added and at least one orifice (6) which communicates with said bore being provided on the shank of each auger so as to discharge the material to be added and allow it to be mixed with the loosened ground, the augers having opposite pitches and being driven in rotation in opposite directions, and which further comprises means for reversing the direction of rotation of the augers.

4. A device according to Claim 3, characterized in that the drill-head is in the form of a helix.

5. A device according to Claim 3, characterized in that the shafts and augers are kept parallel by means of double bearings (7).

6. A device according to Claim 3, characterized in that the bore of one of the augers is connected to a source of material to be added different from the material to be added of the source connected to the bore of the other auger.

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Claims

1. A method for the in situ formation of a primary column of stabilized and compacted soil, comprising a first phase which consists in driving into the soil a rotary drilling tool which loosens the soil and mixes it with an added material, and

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during which an ascending movement is imparted to at least some of the loosened soil through the drilling tool, and a second phase consisting in withdrawing the drilling tool from the ground, characterized by using, as a drilling tool, a device which comprises at least two parallel shafts (1), each shaft driving in rotation an auger (2), each auger being provided at the opposite end to the drive shaft with a loosening drill-head (3) and the distance between the axes of the augers being less than the diameter of an auger, the shafts and the shanks (5) of the augers comprising a bore (5a) connected to a source of material to be added and at least one orifice (6) which communicates with the said bore being provided on the shank of each auger so as to discharge the material to be added, the augers having opposite pitches and being driven in rotation in opposite directions and which further comprises means for reversing the direction of rotation of the augers, by carrying out the first phase by driving into the soil said device while discharging a material to be added through said orifice (6) so as to mix it with the loosened soil, and

by carrying out the second phase, after having reversed the direction of rotation of the augers, by exerting a controlled pressure on said device while withdrawing it, so as to impart to the loosened soil mixed with the added material a descending movement, which tends to compact it, through said device.

2. A method as claimed in claim 1, characterized in that the driving and mixing operations of the first phase are repeated at least once.

3. A device suitable for implementing the method of the invention, which comprises at least two parallel shafts (1), each shaft driving in rotation an auger (2), each auger being provided at the opposite end to the drive shaft with a loosening drill-head (3) and the distance between the axes of the augers being less than the diameter of an auger, the shafts and the shanks (5) of the augers comprising a bore (5a) connected to a source of material to be added and at least one orifice (6) which communicates with the said bore being provided on the shank of each auger so as to discharge the material to be added and allow it to be mixed with the loosened soil, the augers having opposite pitches and being driven in rotation in opposite directions, and which further comprises means for reversing the direction of rotation of the augers.

4. A device as claimed in claim 3, characterized in that the drilling head is in the form of a helix.

5. A device as claimed in claim 3, characterized in that the shafts and augers are kept parallel by means of double bearings (7).

6. A device as claimed in claim 3, characterized in that the bore of one of said augers is connected to a source of a material to be added different from the material to be added of the source connected to the bore of the other auger.

Patentansprüche

1. Verfahren zum In-situ-Herstellen eines elementaren Pfahles aus verfestigter und verdichteter Erde, das zwei Schritte aufweist, von denen der erste Schritt darin besteht, daß in den Boden ein rotierendes Bohrwerkzeug getrieben wird, das den Boden lockert und ihn mit einem Zusatzmaterial mischt, und in dessen Verlauf zumindest einem Teil des gelockerten Bodens eine Aufwärtsbewegung durch das Bohrwerkzeug hindurch aufgeprägt wird, und der zweite Schritt im Zurückziehen des Bohrwerkzeugs aus dem Boden besteht,

dadurch gekennzeichnet, daß als Bohrwerkzeug eine Vorrichtung verwendet wird, die mindestens zwei parallele Wellen (1) aufweist, wobei jede Welle einen Bohrer (2) in Drehung versetzt, jeder Bohrer an seinem der Antriebswelle entgegengesetzten Ende mit einem Auflockerungs-Bohrkopf (3) versehen ist und der Abstand zwischen den Bohrerachsen kleiner als der Durchmesser eines Bohrers ist, die Wellen und die Schäfte (5) eine Bohrung (5a) aufweisen, die mit einer Quelle für das Zusatzmaterial verbunden ist und mindestens eine Öffnung (6), die mit dieser Bohrung in Verbindung steht, am Schaft jedes Bohrers vorgesehen ist, um das Zusatzmaterial abzugeben, die Bohrer gegensinnig ausgebildet und in entgegengesetzter Drehrichtung antreibbar sind, und die ferner eine Einrichtung zur Drehrichtungsumkehr der Bohrer aufweist,

daß der erste Schritt in der Weise verwirklicht wird, daß in den Boden die Vorrichtung eingetrieben wird, während gleichzeitig ein Zusatzmaterial durch die Öffnung (6) so abgegeben wird, daß es mit dem gelockerten Boden gemischt wird und daß der zweite Schritt nach der Drehrichtungsumkehr der Bohrer in der Weise verwirklicht wird, daß auf die Vorrichtung beim Zurückziehen eine geregelte Abstützkraft ausgeübt wird, um dem mit dem Zusatzmaterial gemischten gelockerten Boden eine Abwärtsbewegung durch die Vorrichtung hindurch aufzuprägen, welche die Tendenz hat, ihn zu verdichten.

2. Verfahren nach Anspruch 1, dadurch gekennzeichnet, daß die Vorgänge des Eintreibens und Mischens im ersten Schritt mindestens einmal wiederholt werden.

3. Vorrichtung zum Durchführen des erfindungsgemäßen Verfahrens, mit mindestens zwei parallelen Wellen (1), wobei jede Welle einen Bohrer (2) in Drehung versetzt, jeder Bohrer an seinem der Antriebswelle entgegengesetzten Ende mit einem Auflockerungs-Bohrkopf (3) versehen ist und der Abstand zwischen den Bohrerwellen kleiner ist als der Durchmesser eines Bohrers, die Wellen und Schäfte (5) der Bohrer eine Bohrung (5a) aufweisen, die mit einer Quelle für Zusatzmaterial versehen ist, und mindestens eine Öffnung (6), die mit dieser Bohrung in Verbindung steht, an dem Schaft jedes Bohrers vorgesehen ist, um das Zusatzmaterial abzugeben und dessen Mischung mit dem gelockerten Boden zu ermöglichen, die Bohrer gegensinnig ausgebildet und in entgegengesetzter Drehrichtung antreibbar



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sind, und ferner mit einer Einrichtung zum Umkehren der Drehrichtung der Bohrer.

4. Vorrichtung nach Anspruch 3, dadurch gekennzeichnet, daß der Bohrkopf wendelförmig ausgebildet ist.

5. Vorrichtung nach Anspruch 3, dadurch gekennzeichnet, daß die Wellen und Bohrer mit

Hilfe von Doppellagern (7) parallel gehalten sind.

6. Vorrichtung nach Anspruch 3, dadurch gekennzeichnet, daß die Bohrung eines der Bohrer mit einer Quelle für Zusatzmaterial verbunden ist, das von dem Zusatzmaterial der mit der Bohrung des anderen Bohrers verbundenen Quelle verschieden ist.

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