

METHOD FOR GROUND PROBING

The present invention relates to a method for ground
5 probing and to a method for producing material columns in the
ground after ground probing.

In order to improve the ground, it is fundamentally
known to produce material columns, such as, for example,
gravel columns, in the ground. Such columns are produced, for
10 example, using a vibrator arrangement with a depth vibrator
which is arranged at the lower end of a pipe. The pipe can be
a silo pipe for receiving material when the vibrator
arrangement is designed as what is referred to as a sluice
vibrator for producing vibrating tamped columns, or the pipe
15 can be an extension pipe when the vibrator arrangement is
designed as a "simple depth vibrator" for use in
vibro-compaction. The vibrator arrangement is fastened to a
carrying device which is capable of moving the vibrator
arrangement in the longitudinal direction thereof and which
20 comprises, for example, a leader or a carrying arm of
earth-moving equipment.

For the production of a column (vibrating tamped
column, tamped column), the vibrator arrangement, held by the
carrying device, is introduced into the ground as far as a
25 predetermined depth. The vibrator arrangement is subsequently
moved out of the ground step by step by means of the carrying

device, wherein a desired material, such as, for example, sand or gravel, is introduced into a cavity arising below the vibrator arrangement after the raising thereof. After each introduction of material, the vibrator arrangement is lowered
5 at least once, but customarily repeatedly, into the introduced material in order to compact said material and optionally to drive said material into the ground in a lateral direction. The filler material is either introduced into the cavity below the vibrator from the silo pipe or is
10 introduced into the cavity below the vibrator from above along an annular gap between the vibrator and the ground.

A tamped column produced in such a manner is not a pile, but rather is an element for improving the ground. It therefore always dissipates loads, such as, for example, a
15 building, an earth bank or the like, only together with the ground surrounding said tamped column. The column which is produced in sections is ideally produced in such a manner that sections in weaker (i.e. looser or softer) ground layers have a larger diameter than sections in more compact or
20 stiffer layers. The diameter of a tamped column can therefore vary over the length and depth thereof depending on the structure of the surrounding ground.

In order to be able suitably to dimension the column depending on the ground structure, i.e. in order to be able
25 to realize each of the individual sections with an optimum diameter, information is required regarding the ground

structure. Said information can be obtained, for example, with reference to ground profiles which are obtained by core bores, or by means of ground probing. In areas having changeable geology, i.e. in areas in which the ground structure greatly varies depending on the local position, a considerable outlay on reconnoitering may be necessary, however, in order to obtain ground information for the positions at which columns are intended to be produced.

Said outlay can be omitted and the individual columns can be entirely dimensioned for the weakest ground layer to be anticipated. As a result, the columns can be oversized at a plurality of locations, namely wherever the surrounding ground is relatively strong. However, such oversizing not only means additional costs in respect of the working time and the filler material used, but can also be disadvantageous with respect to the stability. If, for example, in a ground zone in which scarcely any improvement is required, two adjacent columns are nevertheless produced with a large diameter, the differential settling important for the construction erected on the columns (i.e. the settling between adjacent construction parts) is sometimes greater than if the two columns were realized with optimum column thicknesses. If, for example, in the case of two construction parts, the settling in relation to the untreated case (the case without a pillar) is halved, for example to 10 cm in the case of a component of originally 20 cm and from 10 cm to now

5 cm in the case of the other component, the differential settling continues to be 5 cm. If, however, the one settling is reduced by 12 cm, from 20 cm to 8 cm, and the other only by 2 cm, from 10 cm to 8 cm, the differential settling in this case is zero. In other words: although maximum column diameters result in minimum settling, they do not always result in minimum differential settling.

It is therefore the object of the present invention to provide a method for ground probing, which requires little additional outlay, in particular in the production of a material column.

This object is achieved by a method as claimed in claim 1. Refinements and developments of the invention are the subject matter of dependent claims.

15 An exemplary embodiment of the invention relates to a method for ground probing. The method comprises: providing a vibrator arrangement which is held on a carrying device which is designed to penetrate the ground and which has a vibrator motor; inserting the vibrator arrangement into the ground to a predetermined depth; determining a ground profile of the ground when the vibrator arrangement is inserted, wherein the determination of the ground profile comprises measuring at least one operating parameter of the vibrator arrangement when the latter is inserted into the ground, and wherein the ground profile in each case comprises a ground parameter for at least two different ground depths.

In this method, the vibrator arrangement, with which a material column can be produced in the ground, is used for probing the ground, i.e. for determining a ground profile. By using the vibrator arrangement as a ground probe, ground
5 layers of different density (such as, for example, in the case of sands and gravels) or different rigidity (such as, for example, in the case of silts and clays) can be ascertained at least approximately and the layer boundaries between said different ground layers can be determined.

10 Provision is made, in one exemplary embodiment, to produce a material column depending on the ground profile, using the vibrator arrangement. The combination of determining the ground profile during the insertion (the sinking) of the vibrator arrangement into the ground and the
15 subsequent production of a column depending on the ground profile results in a completely integrated production process in which each material column is coordinated with the locally variable ground properties. This is advantageous in respect of differential settling of a construction erected later on
20 the material columns. This may be important specifically in the case of tamped columns. Tamped columns only dissipate load in association with the ground, i.e., in contrast to grouted columns or columns provided with another binding agent, constitute a genuine improvement of the foundation and
25 are not a pile, which merely bridges the loose or soft layers. The present method results in a column thickness

adapted to the ground strength and therefore in an optimum homogenization of the settling behavior. In softer/looser ground, which would settle more if untreated, a thicker tamped column provides for greater reinforcement whereas, for example, in adjacent ground layers which are already more compact/stiffer before production of a column, a weaker column is produced.

The ground profile can be determined in different ways. In one example, provision is made to exert an at least approximately constant force on the vibrator arrangement by the carrying device when the vibrator arrangement is introduced into the ground and to measure a speed, at which the vibrator arrangement is inserted into the ground, as an operating parameter. The vibrator arrangement in this case is inserted into a ground layer all the more rapidly, the less compact or less stiff said ground layer is. Therefore, the insertion speed can be a direct measure of the ground structure and can therefore be suitable for determining the ground profile. For different ground depths, the ground profile here can contain the insertion speed determined for the respective ground depth.

In a further example for determining the ground profile, provision is made to insert the vibrator arrangement, driven by the carrying device, at at least an approximately constant speed into the ground and to measure a power consumption of the vibrator motor when the vibrator

arrangement is inserted into the ground, as an operating parameter. The power consumption on insertion into a ground layer is all the lower in this case, the less compact or less stiff said ground layer is. The power consumption can therefore be a direct measure of the ground structure and can therefore be suitable for determining the ground profile. For different ground depths, the ground profile here can contain the power consumption determined for the respective ground depth. The vibrator motor can be an electric motor or a hydraulic motor. In an electric motor, for example, a current consumption of the motor is representative of the power consumption of the vibrator motor, whereas, in the case of a hydraulic motor, a hydraulic pressure necessary for driving the motor is representative of the power consumption of the vibrator motor.

In another example for determining the ground profile, provision is made to insert the vibrator arrangement, driven by the carrier device, at at least an approximately constant speed into the ground and, as an operating parameter, to measure a vibration amplitude of a tip of the vibrator arrangement. This method is suitable in particular when a vibrator arrangement is used with a depth vibrator. The vibration amplitude on insertion into a ground layer can be all the more high here, the less compact or less stiff said ground layer is. The vibration amplitude can therefore be a direct measure of the ground structure and can

therefore be suitable for determining the ground profile. For various ground depths, the ground profile here can contain the vibration amplitude determined for the respective ground depth.

5 In principle, the ground profile can be a continuous ground profile, i.e. an associated ground parameter is determined for each ground depth. However, the ground profile can also be determined in such a manner that ground parameters are determined only for predetermined ground
10 depths which can be spaced apart uniformly or nonuniformly.

 In one exemplary embodiment, the material column is produced is produced depending on the ground profile in such a manner that a diameter of the material column at a certain ground depth is dependent on the ground parameter determined
15 for said ground depth. The ground parameter determined for a certain ground depth is dependent, for example, on a ground density and/or a ground rigidity. In this case, the material column can be produced in such a manner that the diameter of the material column increases with decreasing ground density
20 and/or decreasing ground rigidity. The ground profile is therefore used to determine a column profile which defines which properties the column is intended to have at which ground depth. One property of the column here can be the diameter thereof, but also can be the strength thereof.

25 In one example, the production of the material column comprises producing at least two segments. The production of

each segment here comprises: a) raising the vibrator arrangement by a predetermined displacement distance such that a cavity arises below the vibrator arrangement; b) introducing a filler material into the cavity; c) inserting the vibrator arrangement into the filler material in order to compact the filler material; and d) repeating method steps a) to c) n times, where $n \geq 0$. For the production of a segment at a predetermined ground depth, the number n of repetitions in step d) can be dependent on the ground parameter determined for said ground depth. Provision is therefore made in one alternative for the ground parameter to be dependent on a ground density and/or a ground rigidity, and for the number n of repetitions to increase with decreasing ground density and/or decreasing ground rigidity. In a further example, provision is made for repetitions to be carried out until a desired strength of the column in the respective segment is achieved. The strength of the column can be determined, for example, with reference to the power consumption of the vibrator motor. The column, or a segment, here is all the more firm, the greater the power consumption of the vibrator when the latter is inserted into the previously introduced filler material.

The vibrator arrangement can be designed in the manner of a conventional vibrator arrangement. In one example, provision is made for the vibrator arrangement to have a vibrator pipe with an upper and a lower end and a

vibrator which is arranged on the vibrator pipe and has the vibrator motor. The vibrator can be designed as a depth vibrator and can be fastened to a lower end of the vibrator pipe, but can also be designed as a top vibrator and can be
5 fastened to an upper end of the vibrator pipe.

The pipe can be a silo pipe with a material tank which, in the region of a lower end of the vibrator arrangement, has a material outlet via which filler material can be introduced into a cavity produced below the vibrator
10 arrangement. However, the pipe can also serve as a simple extension pipe. In this case, filler material is introduced into the cavity produced below the vibrator arrangement via a gap between the pipe and the surrounding ground.

The carrying device may comprise a carrying arm of
15 earth-moving equipment or may comprise a mast and a slide moveable on the mast.

A further exemplary embodiment relates to a method for producing a material column in the ground. The method comprises providing a vibrator arrangement which is held on a
20 carrying device and is designed to penetrate the ground, inserting the vibrator arrangement into the ground and repeatedly moving the vibrator arrangement in the ground between reversing points, namely an upper reversing point and a reversing point, and introducing filler material into the
25 ground when the vibrator arrangement is moved from the lower reversing point to the upper reversing point, and detecting a

position of the vibrator arrangement in the ground. In this method, the reversing points are predetermined by a control system, and a movement of the vibrator arrangement between the reversing points is depicted in an electronic display which indicates a desired direction of movement of the vibrator arrangement and the position of the vibrator arrangement between the reversing points.

This method permits semi-automatic and nevertheless precise production of material columns in the ground. The vibrator arrangement can be moved manually by an equipment operator, but in accordance with the display device. It is thereby ensured that the vibrator arrangement is moved between reversing points predetermined by the control system, wherein said reversing points change over the course of the production of a column. The actual position of said reversing points in the ground does not have to be depicted and is also not of interest to the equipment operator.

Exemplary embodiments are explained in more detail below with reference to figures. The figures serve to illustrate the basic principle of the present invention, and therefore only the aspects necessary for understanding said basic principle are illustrated. The figures are not necessarily to scale. The same reference numbers denote identical or equivalent parts having an identical or equivalent meaning.

Figure 1 illustrates an exemplary embodiment of a

vibrator arrangement which is held by a carrying device and has a depth vibrator for producing a material column in the ground;

Figure 2 illustrates a cross section through the depth vibrator;

Figure 3 illustrates an exemplary embodiment of a vibrator arrangement with a top vibrator for producing a material column in the ground;

Figure 4 illustrates an exemplary embodiment in which the carrying device comprises a carrying arm of earth-moving equipment;

Figure 5 illustrates an exemplary embodiment in which the carrying device comprises a leader and a slide guided on the leader;

Figure 6 shows schematically a cross section of ground having different ground layers, a ground profile of the ground, a column profile and a material column which is produced in the ground and has a varying diameter;

Figure 7 shows a further example of a column profile based on a ground profile,

Figure 8 shows schematically the upward and downward movements of the depth vibrator in a first example of a method for producing a material column according to figure 6 with a plurality of segments;

Figure 9 illustrates a further example of a method for producing a segment of a material column;

Figure 10 shows an example of a display for an equipment operator in a semi-automatic method for producing a material column in the ground.

For better understanding of the invention, first of all various exemplary embodiments of devices for producing material columns in the ground, which devices are suitable for carrying out the method according to the invention, are explained below. Said exemplary embodiments serve for better understanding and are not limiting. In principle, any device suitable for producing material columns, in particular tamped columns or vibrating tamped columns in the ground, are suitable for carrying out the method.

Figure 1 schematically shows a first exemplary embodiment of a device for producing material columns in the ground. Said device comprises a vibrator arrangement 1 which has a pipe 11 with an upper and a lower end, wherein a vibrator 12 is arranged at the lower end of the material pipe 11. The vibrator 12 is fastened to the material pipe 11 in a vibration-damped manner in a way not illustrated in detail, and therefore vibrations arising due to vibrating movements of the vibrator 12 are not transmitted or at least are only transmitted to a small extent to the material pipe 11. In figure 1, as also in figure 2 which has yet to be explained

below, the material pipe 11 is illustrated in cross section, and the remaining components are illustrated in side view.

In the example illustrated, the pipe 11 is designed as a silo pipe or material pipe and, at the lower end thereof, has an outlet to which a further pipe 16 is connected, said further pipe being guided parallel to the vibrator 12 as far as a tip of the vibrator 12 and, in the region of the tip of the vibrator, forming a material outlet 13 of the vibrator arrangement 1. The further pipe 16 can be fastened to the material pipe 11 in a vibration-damped manner. The material pipe 11 has, for example, a cylindrical geometry. The further pipe 16 can be realized, for example, in such a manner that it partially surrounds the vibrator 12, and then has, for example, a crescent-shaped geometry in cross section.

The vibrator 12, which is arranged at a lower end of the material pipe 11, or the entire vibrator arrangement 1, is also referred to as a depth vibrator. Said depth vibrator 12 can be designed in the manner of a conventional depth vibrator. Figure 2 shows a cross section through said depth vibrator in a section plane which runs perpendicularly to the plane of the drawing illustrated in figure 1.

With regard to figure 2, the depth vibrator has, for example, an unbalance or an eccentric 21 which is mounted in a vibrator housing so as to be rotatable about a shaft 22. During the operation of the depth vibrator, said eccentric

is set into vibrations by a vibrator motor, such as, for example, a hydraulic motor or an electric motor (not illustrated), as a result of which the vibrator tip of the depth vibrator 12 moves along a circular path.

5 Figure 3 shows a device with a vibrator arrangement which is designed as a top vibrator and in which the vibrator 12 is arranged at the top of the pipe 11. The vibrator 12 and the pipe 11 here are not decoupled in terms of vibration, and therefore vibrating movements of the vibrator 12 are
10 transmitted to the material pipe. Like the depth vibrator 12 according to figure 1, the vibrator 12 according to figure 3 also has a motor (not illustrated) which drives the vibrator 12.

 With regard to figures 1 and 3, the vibrator
15 arrangement, irrespective of the specific configuration thereof as a depth vibrator or as a top vibrator in the upper region of the material pipe 11, has a material supply which is illustrated merely schematically in figures 1 and 2 and which, in the example, has a material container 14 arranged
20 at the side of the material pipe 11, and a flap 15 arranged between the material container 14 and the interior of the material pipe 11. The flap 15 can be opened and closed, wherein, when the flap is open, material G, such as, for example, gravel, broken stones or sand, can flow out of the
25 material container 14 into the interior of the material pipe 11. In one exemplary embodiment, it is provided that, when

the flap 15 is closed, a positive pressure can be produced in the interior of the material pipe 11, which is illustrated in cross section in figure 1, by means of the pressure device thereof (not illustrated specifically). The production of
5 such a positive pressure can be required in particular when material columns which reach below the water table are intended to be produced in the ground. A positive pressure is required in this case in order to introduce material into the ground counter to the pressure of the groundwater.

10 Instead of a simple flap 15 between the material container 14 and in the interior of the material pipe 11, a material sluice (not illustrated) with two flaps can also be provided, via which the material G is introduced into the interior of the material pipe 11. Such a material sluice can
15 prevent a positive pressure which is built up in the interior of the material pipe 11 escaping every time material is resupplied.

In principle, any known material supplies can be used, such as, for example, even those in which material are
20 introduced under pressure directly into the material pipe 11 via a conveying hose.

The vibrator arrangements 1 illustrated in figures 1 and 2 serves merely for illustrating the basic principle of vibrator arrangements. It should be emphasized that, in
25 conjunction with the present invention, any vibrator arrangements, such as depth vibrators or top vibrators, can

be used, in particular even vibrator arrangements having a different type of material supply or having a different manner of arrangement of material pipe 11 and vibrator 12.

With regard to figures 1 and 2, the device also
5 comprises a carrying device 2 to which the vibrator arrangement is fastened. Said carrying device 2 can be realized in different ways.

Figure 4 shows an exemplary embodiment of a device for producing material columns in the ground. In this device,
10 the carrying device 2 to which the vibrator arrangement 1 is fastened comprises a carrying arm of earth-moving equipment. The vibrator arrangement here is fastened to the tip the carrying element 21. The carrying arm can be moved in particular in such a manner that it exerts a force on the
15 vibrator arrangement, the force acting in the longitudinal direction of the pipe 11, in order thereby to insert the vibrator arrangement 1 into the ground or to remove said vibrator arrangement again from the ground. This is also explained below.

20 Figure 5 shows a further exemplary embodiment of a device for producing material columns in the ground. In this device, the carrying device 2 comprises a tower or a leader
25 on which a slide 24 is moveable in the longitudinal direction of the tower 25. The tower 25 can stand perpendicularly in order to produce vertical columns in the ground. However, the tower could also be inclined in relation

to the surface in order, in this case, to produce columns running obliquely in the ground. A carrying element 21 which is connected to the pipe 11 is fastened to the slide 24 such that the vibrator arrangement 1 is moveable along the mast 25 with the aid of the slide 24. The material pipe 11 of the vibrator arrangement 1 runs approximately parallel to the tower 25, and therefore, by movement of the slide 24 on the tower 25, the vibrator arrangement 1 can be moved in the longitudinal direction thereof. A cable device with a cable 23 (only illustrated schematically), a gearwheel device, or the like, for example, is present in order to move the slide 24. The slide 24 is in particular movable on the mast 25 in such a manner that it exerts a force on the vibrator arrangement, said force acting in the direction of movement of the slide 24, and therefore in the longitudinal direction of the pipe 11, and being able to bring about insertion of the vibrator arrangement into the ground. Said force can be exerted, for example, by the fact that the slide 24 is pulled downwards on the mast 25 by a defined force by means of the cable 23.

Of course, earth-moving equipment and a mast with a movable slide are merely examples of carrying devices which are suitable for moving the vibrator arrangement 1 in the longitudinal direction thereof, i.e. in the longitudinal direction of the pipe 11. Any other lifting units, such as,

for example, lifting units with electrically driven cable, belt or spindle arrangements, can likewise be used.

Figure 6 schematically shows a cross section of a ground 100 in which a material column 30 consisting of a filler material, such as, for example, gravel or sand, is arranged. The ground detail illustrated by way of example in figure 6 has a plurality of different ground layers 101, 102, 103, 104 which lie one above another and can each have different ground properties, such as, for example, density or strength. For the reasons explained at the beginning, it is desirable to adapt the material column 30 to the ground properties in such a manner that the material column 30 ideally has a diameter adapted to the properties of the respective ground layer 101-104 in each of the individual ground layers 101-104. The material column 30 illustrated in figure 6 has various material column sections 31, 32, 33, 34, wherein one of said material column sections 31-34 is arranged in each ground layer 101-104 and has a diameter adapted to the properties of the respective ground layers.

A method for producing a material column 30 which is adapted to the ground properties and which can have a diameter varying over the length thereof, specifically depending on the properties of the ground surrounding the column, is explained below.

Said method comprises providing a vibrator arrangement which is held on a carrying device and is

designed to penetrate the ground and which has a vibrator motor. Said vibrator arrangement 1 can be designed, for example, in a manner corresponding to one of the vibrator arrangements 1 which have previously been explained with reference to figures 1 and 3 to 5 and are held on a carrying device 2. The method also comprises inserting the vibrator arrangement 1 into the ground 100 (which is likewise illustrated in figures 1 and 3) as far as a predetermined depth. When the vibrator arrangement is inserted into the ground, a ground profile is determined, wherein the determination of the ground profile comprises measuring at least one operating parameter of the vibrator arrangement 1 when the latter is inserted into the ground 100, and wherein the ground profile in each case comprises a ground parameter P for at least two different ground depths. Such a ground profile which assigns a ground parameter P different ground depths of the ground 100, is illustrated schematically in figure 6 next to the ground cross section. The ground parameter P is, for example, a density or a strength of the ground, but can also take into consideration a plurality of ground properties, such as, for example, density and strength. In the exemplary embodiment illustrated in figure 6, the individual layers differ, and therefore the ground parameter P for the individual ground layers 101-104 different. Of course, this is merely an example. It is also possible, of course, for two ground layers having the same

property, such as, for example, two clay layers, to enclose a layer having a different property, such as, for example, a sand layer, or for a clay layer to be incorporated between two sandy, silty ground layers. In the last-mentioned case, it can be desirable, for example, to produce column sections having a smaller diameter in the sandy, silty layers than in the clay layer.

In addition, the method can comprise producing the material column 30 with the use of the vibrator arrangement 1 depending on the determined ground profile or can comprise producing same depending on a column profile which is produced on the basis of the ground profile. The column profile defines which properties the column is intended to have at which ground depth. One property of the column here can be the diameter thereof, but can also be the strength thereof. The material column 30 illustrated schematically in figure 6 is such a material column which is produced depending on the ground profile or the column profile. For the purposes of explanation, it should be assumed, for example, that the ground parameter P which is illustrated in the ground profile according to figure 6 represents a density or strength of the ground. The column 30 illustrated in figure 6 is based on a column profile in which the desired diameter of the material column 30, which can be removed from the ground profile, decreases as the density/strength increases. In this case, the lowermost ground layer 104 has

the greatest density/strength, and therefore the material column section 34 produced in this ground layer 104 has the smallest diameter. The uppermost ground layer 101 has the second lowest density/strength, and therefore the material column section 31 produced there has the second smallest diameter. The third ground layer 103 from the top, i.e. starting from the surface 101, has the third greatest density/strength, and therefore the material column section 33 produced there has the third smallest diameter while the second ground layer 102 from the top has the lowest density/strength, and therefore the material column section 32 produced there has the largest diameter.

As explained, the material column 30 is produced in a plurality of sections, the height and position of which in the ground and the properties of which is dependent on the column profile which can be produced with reference to the ground profile. The column profile can be deduced from the ground profile, for example, in such a manner that the position of a boundary between material column sections in the column profile corresponds to the position of the boundary between two ground layers in the ground profile. Such a column profile is illustrated in figure 6 next to the ground profile. In the column profile, S denotes a column property to be set, wherein each ground depth is assigned such a column property. The column property can be, for example, a diameter or a strength of the column at the

particular position. Figure 6 illustrates a material column 30 produced according to such a column profile, i.e. a column in which each material column section 31-34 is optimally adapted to the surrounding ground layer 101-104 such that a boundary between two material column sections runs level with a boundary between two ground layers. The column here has at least approximately the same properties within a material column section.

However, the boundary between two column sections in the column profile does not necessarily have to correspond to the boundary between two ground layers in the ground profile. Figure 7 shows an exemplary embodiment of a column profile which is deduced from the ground profile according to figure 6 and in which the boundary between two material column sections does not correspond to the boundary between two ground layers. The material column 30 is produced segmentally with a plurality of segments arranged one above another, wherein one of the column sections 31-34 explained can consist of one or more segments. The boundaries between individual segments are likewise illustrated (by dotted lines) in the column profile according to figure 7. Said segments can, for example, each have the same height, but the properties of the individual segments can differ. In this case, with the desired column height being taken into consideration, the segment height predetermines the depth positions at which boundaries between two segments and

therefore boundaries between two material columns can run. The segment height can be, for example, a height of between 1 m and 2 m. Which property is assigned to a segment in the column profile is dependent upon, for example, in which
5 ground layer the segment corresponding to the ground profile mainly runs. In the method explained, the vibrator arrangement 1, which in any case has to be introduced into the ground 100 in order to produce the material pillar 30, serves upon insertion into the ground as a type of ground
10 probe which permits determination of the ground profile. In this method, a ground profile of the ground surrounding the subsequent column can be exactly determined with little outlay for each column to be produced, and therefore each column can be produced in a manner optimally adapted to the
15 respective ground conditions.

The ground profile can be determined in various ways when the vibrator arrangement 1 is inserted into the ground. In one exemplary embodiment, provision is made to insert the vibrator arrangement 1, driven by the carrying device 2, into
20 the ground 100 at an approximately constant speed and, in the process, to measure the power consumption of the vibrator motor when the vibrator arrangement is inserted into the ground. The vibrator motor can be an electric motor or a hydraulic motor. In the case of an electric motor, for
25 example, a current consumption of the motor (given a known constant supply voltage of the vibrator motor) is

representative of the power consumption of the vibrator motor
whereas, in the case of a hydraulic motor, a hydraulic
pressure, which is necessary for driving the motor, is
representative of the power consumption of the vibrator
5 motor. In general, the power consumption of the vibrator
motor is all the more high, the more compact/firm the ground
is during insertion at a constant speed. The power
consumption of the vibrator motor at a certain ground depth
therefore constitutes a direct measure of the
10 density/strength of the ground at the particular depth, and
therefore a direct measure for the ground parameter P.

Both when earth-moving equipment with a carrying arm
is used (as illustrated, for example, in figure 4) and when a
mast 25 with a slide 24 arranged on the mast 25 is used (as
15 illustrated in figure 5), the vibrator arrangement 1 can be
inserted into the ground 100 at a constant speed. In order to
determine the ground profile, during the insertion only the
power consumption of the vibrator motor depending on the
ground depth is to be measured, and the measured values
20 obtained for the power consumption are to be assigned to the
respective ground depths. The ground depth which is to be
assigned to a certain power consumption corresponds here to
the position of the tip 13 of the vibrator arrangement in the
ground at the respective power consumption. The position of
25 the vibrator tip 13 in the ground 100, i.e. the distance
between the vibrator tip 13 and the surface 101, can be

determined in a conventional manner. For example, with reference to a carrying arm, when a carrying device is used with earth-moving equipment, and, for example, with reference to the position of the slide 24 on the mast 25, in the case
5 of a carrying device with a mast.

In a further example for determining the ground profile, provision is made to apply an at least approximately constant force to the vibrator arrangement 1 by the carrying device 2 when the vibrator arrangement 1 is introduced into
10 the ground 100 and, in the process, to measure a speed at which the vibrator arrangement is inserted into the ground. Said speed is generally dependent on the ground structure, since, at a certain ground depth, the speed decreases as the density/strength of the ground increases at the respective
15 ground depth. The insertion speed can therefore constitute a direct measure for the density/strength of the ground and therefore a direct measure for the ground parameter P. Both by means of a carrying arm of earth-moving equipment and by means of a slide moveable on a mast, a constant force which
20 acts in the longitudinal direction of the vibrator arrangement 1 can be applied to the vibrator arrangement 1 when the latter is inserted into the ground. The speed can be measured, for example, by the fact that, at regular intervals, for example every 0.5 second, the penetration
25 depth of the vibrator arrangement is measured and that a conclusion is made regarding the speed from the difference of

the penetration depth (displacement difference) between two measuring times, with knowledge of the period of time between two measuring points (time difference), i.e.

5 $v = \Delta x / \Delta t,$

wherein v is the speed, Δx is the displacement difference and Δt is the time difference.

In a further example for determining the ground
10 profile provision is likewise made to insert the carrying device into the ground at an at least approximately constant speed and, in the process, to measure a vibration amplitude at the tip 13 of the vibrator arrangement as an operating parameter. The vibration amplitude here can decrease with
15 increasing strength of the ground.

An absolute value of the ground parameter P determined when the vibrator arrangement 1 is inserted into the ground is less relevant for the subsequent production of the material column 30 than a change in said ground parameter
20 P over the depth x . At ground depths at which such a change occurs, such as, for example, at the ground depths x_1 , x_2 , x_3 according to figure 6, there is a layer boundary between two adjacent ground layers, and therefore, with reference to the ground profile, it is possible in particular to read the
25 ground depths at which layer boundaries between adjacent ground layers are present.

With regard to the preceding explanation, the individual material column sections are produced depending on the column profile which is deduced from the ground profile, wherein the column profile assigns a property, such as, for example, diameter or strength, to the column at each depth position. The column profile is produced, for example, in such a manner that the material column 30 produced according to the column profile has a larger diameter wherever the ground profile indicates a low density/strength of the ground, and has a smaller diameter wherever the ground profile indicates a greater density/strength of the ground. Alternatively, the column profile is produced, for example, in such a manner that the material column 30 produced according to the column profile has a greater strength wherever the ground profile indicates a low density/strength of the ground, and has a lower strength wherever the ground profile indicates a higher density/strength of the ground.

The production of the material column can begin after the depth vibrator has been introduced to a predetermined depth, which is denoted by x4 in the example according to figure 6. Said maximum depth defines the base of the material column 30 to be produced. A segment of the material column can be produced in a manner which is basically known by the vibrator arrangement 1 being raised by a predetermined displacement distance by the carrying device 2 such that a cavity arises below the vibrator arrangement 1 (step a) by a

filler material G being introduced (step b) into the cavity arising below the vibrator arrangement 1 by raising of the vibrator arrangement 1, and by the vibrator arrangement 1 being inserted into the introduced filler material in order
5 thereby to compact the filler material G or to push the latter to the side into the surrounding ground (step c). The vibrator arrangement can be inserted here into the filler material in accordance with the displacement distance by which said vibrator arrangement was previously raised. Said
10 method steps, namely raising the vibrator arrangement, introducing the filler material and inserting the vibrator arrangement into the filler material can be repeated n times, where $n \geq 0$. The number n of repeating steps here is dependent on the desired diameter of the material column section to be
15 produced. The number of repetitions is all the more great here, the larger the desired diameter is, wherein the diameter is all the more large, the lower the previously determined density/strength of the ground is. This number n of repetitions can be fixedly predetermined for each desired
20 column diameter, i.e. it is already ascertained at the beginning of the production of a segment how many repetitions are carried out.

If, for example, a column segment is to be produced with a certain strength, the number n is not yet ascertained
25 at the beginning of production. In this case, during each repetition, the strength of the segment is measured, and

there is no further repetition whenever the desired strength is reached. The strength of the column can be determined, for example, with reference to the power consumption of the vibrator motor. The column or a column section is all the more strong, the greater the power consumption of the vibrator is when the latter is inserted into the previously introduced filler material.

Figure 8 schematically shows the production of a material column. The position of the vibrator tip 13 of the vibrator arrangement 11 over the is illustrated in figure 7. The method begins at a time t_0 , at which the vibrator tip has been introduced into the ground as far as the depth x_4 . Before the time t_0 , the vibrator arrangement 1 is introduced into the ground, for example according to one of the previously explained methods, in which the ground profile is determined.

In the case of the method explained with reference to figure 8, six segments of the material column 30 are produced, wherein, in the example, in order to produce each of said segments, the vibrator tip is raised at least twice in order to discharge filler material, and is subsequently lowered again into the filler material. The individual segments each have the same height, which is apparent with reference to figure 8 by the fact that amplitudes of an upward and downward movement of the vibrator tip for the

production of the individual segments are in each case identical.

According to figure 8, a first segment is produced between the ground depths x_3 and x_4 , and therefore this
5 segment corresponds to the material column section 34 according to figure 6. Two further segments lying one above the other are produced between the ground depths x_2 and x_3 , said further segments forming the material column section 33 according to figure 6. The number of repetitions carried out
10 is greater for the segments of this material column section 33 than for the material column section 34, in order thereby to produce the material column section 33 with a larger profile than the material column section 34. A further segment which, in the example, corresponds to the material
15 column section 32 according to figure 6 is produced between the ground depths x_1 and x_2 , wherein, for this material column section 32, the number of repetitions is still greater than for the material column section 33 in order to produce said material column section 32 with an even larger diameter,
20 since the ground surrounding this section 32 has the lowest density/strength. Finally, two further segments are produced one above the other between the ground depths x_0 (which corresponds to the level of the surface 110) and x_1 . These two segments form the material column section 31 according to
25 figure 6, which has a smaller diameter than the material

column sections 32, 33, but a larger diameter than the material column section 34.

The heights of the individual segments is determined by the displacement distance by which, at the beginning of production of the respective segment, the vibrator arrangement 1 is raised in relation to the ground or in relation to the segment produced immediately beforehand, in order to discharge filler material. The individual segments can each be produced with the same height. However, depending on the ground structure, it is also possible to produce the individual segments with different heights, in particular in order to adapt the individual material column sections to the thickness of the individual ground layers in such a manner that the optimum material column section can be determined for each ground layer.

In the method explained with reference to figure 8, the vibrator arrangement always moves during the production of a segment over the entire height (or depth) of the segment, i.e. the vibrator arrangement, after discharging filler material, moves through the discharged filler material again as far as the base of the segment in order to compact said filler material. However, the filler material discharged in the final repeating step is then no longer compacted, but rather the vibrator arrangement moves as far as the upper end of the next segment, wherein the cavity located therebelow is filled with filler material. However, said filler material is

subsequently only still compacted in the region of the segment then to be produced.

Figure 9 illustrates an alternative to the method according to figure 8 with reference to the production of a segment, in the example of the segment between the ground depths x3 and x4. In this method, as also in the method according to figure 8, at the beginning of the production of the segment the vibrator arrangement moves from the lower end of said segment (at the position x4) to the upper end of said segment (at the position x3), wherein the resulting cavity between x4 and x3 is filled with filler material. The stroke or the upward displacement distance by which the vibrator arrangement is moved in this case is denoted by h1 in figure 9. However, the vibrator arrangement subsequently no longer moves downward as far as the lower end of the segment, but rather, starting from the upper end, only by a distance or downward displacement distance h2, where $h2 < h1$, and subsequently upward again as far as the upper end, i.e. by the distance h2, such that the stroke h2 in the first repeating step is smaller than the stroke h1 in the first step. A stroke h3 in the next repeating step is again smaller than in the preceding step. In the example, after said repeating step, the production of said segment ends and the production of a new segment begins by the vibrator arrangement moving (or being moved) as far as the upper end of the subsequent segment.

The first stroke h_1 defines the height of the segment. Said stroke is, for example, 1 m and is generally between 1 m and 2 m. In one example, provision is made for a difference Δh of the stroke (stroke difference) between two steps to be the same in each case. With regard to the example according to figure 9, then: $h_1 = h_2 + \Delta h$ and $h_2 = h_3 + \Delta h$. In one example, provision is made to raise the vibrator arrangement (and, in the process, to discharge filler material) and again to lower said vibrator arrangement with a reduced stroke (in order to compact the filler material) until the stroke is smaller than or equal to a predetermined value. Said value corresponds, for example, to the difference Δh . If, for example, $h_1 = 1$ m and $\Delta h = 20$ cm, the following steps are carried out for the production of a segment: raising 1 m, lowering 80 cm, raising 80 cm, lowering 60 cm, raising 60 cm, lowering 40 cm, raising 40 cm, lowering 20 cm, raising as far as the upper end of the next segment. Via the stroke difference Δh , the number of repetition steps and therefore the diameter or the strength of the segment can be set in this method. In general, the diameter increases as the stroke difference Δh becomes smaller, since, in this case, more repeating steps are carried out, and therefore more material is introduced.

In one method, provision is made for the column profile for each segment to define the height thereof and the stroke difference Δh . In a further method, provision is made

for the column profile for each segment to define the height thereof and the stroke difference Δh and, in addition, to define a maximum power consumption of the vibrator motor, wherein the production of a segment ends when the stroke is smaller than the predetermined minimum value, i.e. when all of the repetition steps have been carried out, or when the maximum power consumption is reached. In the case of the previously explained vibrator arrangements which have a silo pipe or material pipe 11, filler material is introduced into the ground from the silo pipe or material pipe. The dimensions, i.e. in particular the diameter of the column, are produced by calculation from the integral of the quantity of filler material which is output into the ground during the sum total of all the upward movements and which can easily be calculated by the known cross section of vibrator and material pipe and by the upward displacement distance. If, for example, the vibrator cross section is a cross section of 0.2 m^2 , then at a point at which the vibrator moves up and down, for example, 5 times, a column cross section with an area of $5 \times 0.2 = 1.0 \text{ m}^2$ is produced there by calculation.

In a further exemplary embodiment of a vibrator arrangement (not illustrated), the pipe 11 is designed merely as an extension pipe. In this vibrator arrangement, filler material is introduced into the cavity below the vibrator arrangement by the fact that material is brought downward

from above past the pipe, i.e. in an annular gap between the pipe 11 and the surrounding ground.

The previously explained method can be carried out fully automatically in a manner controlled by a computer. The computer is designed to control the carrying device 2 and obtains information regarding the position of the vibrator arrangement 1 by means of a suitable sensor and the operating parameter (such as, for example, power consumption of the vibrator motor, insertion speed or vibration amplitude) of the vibrator arrangement. The controlling of the carrying device 2 by the computer can include, during the insertion, depending on the specific method, the insertion of the vibrator arrangement 1 at a constant speed or a constant application of force, wherein, during the insertion, the computer assigns the values obtained for the operating parameter to the respective ground depths in order thereby to obtain the ground profile.

The column profile can be produced automatically, i.e., for example, in a software-controlled manner, from the ground profile, as illustrated, for example, in figure 6. As explained, different segments which each have a predetermined height and property are defined in the column profile. Examples of such column profiles are illustrated in figures 6 and 7. The individual segments can be produced corresponding to one of the methods explained previously with reference to figures 6 to 9.

The controlling of the carrying device 2 by the computer for the production of each segment includes raising the vibrator arrangement at least once by a predetermined displacement distance (upward displacement distance) and
5 lowering the latter again at least once by a predetermined displacement distance (downward displacement distance). As explained, upward displacement distance and downward displacement distance can be identical in a step, but can also differ by a stroke difference Δh . Both when a top
10 vibrator is used with a silo pipe and when a depth vibrator is used with a silo pipe, during each raising of the vibrator arrangement filler material automatically flows into the cavity below the vibrator arrangement 1, and therefore it merely has to be ensured that there is always sufficient
15 filler material in the silo pipe. The height of a segment to be produced, i.e. the displacement distance by which the vibrator arrangement 1 is raised for the first time from the bottom of the recess or from the upper end of a previously produced segment, and the diameter and/or the strength of the
20 material column section are controlled in a manner already explained by the computer depending on the previously determined column profile which is dependent on the ground profile. The diameter and/or the strength of a segment is can be set in the manner explained by the number of repetitions.
25 In the case of this automatic method, an equipment operator only still has a checking and safety function and moves the

vibrator arrangement 1 with the carrying apparatus 2 from point to point at which a material column is intended to be produced.

The method can also be carried out as a
5 semi-automatic method, in which the vibrator arrangement 1 is first of all inserted into the ground in a computer-controlled manner and the ground profile is determined, and in which, during production of the material column 30, the carrying device 2 is controlled by an
10 equipment operator, to be precise depending on specifications which are displayed by the computer on a display device (display). The display here shows symbols which, for example, indicate to the equipment operator in which direction the carrying device is intended to be moved, i.e. upward or
15 downward, and how far the carrying device is intended still to be moved. A sequence (a-f) of such symbols in the production of a material column section is illustrated in figure 8. In the example, a display for the symbols comprises a directional arrow as a first symbol and a displaceable bar as a second symbol. Figure 8 illustrates the display for
20 seven different times. The directional arrow indicates to the equipment operator in which direction the carrying arm is intended to be moved. An arrow upward, such as, for example, in figures 8a and 8b, symbolizes a movement upward, whereas
25 an arrow downward, as in figures 8d, 8e and 8f, symbolizes a movement downward. The bar (illustrated shaded) indicates how

far the carrying device 2 together with the vibrator arrangement 1 is still intended to be moved in the direction predetermined by the directional arrow. If the display is completely filled by the bar, as illustrated, for example, in figure 8c, or is completely empty, as illustrated, for example, in figure 8c, the reversing point for a reversal of the direction of movement of the carrying device is reached.

The display is controlled by the computer depending on the previously determined column profile and on the current penetration depth of the vibrator arrangement 1 or of the vibrator tip 13 in the ground. The movement of the bar symbolizes here the movement of the vibrator arrangement 1 upward or downward. In the display according to figure 8, a lower end of the display or of the bar marks a lower reversing point for a downward movement of the vibrator arrangement and an upper end marks an upper reversing point for an upward movement of the vibrator arrangement. Each of said reversing points represents a ground depth, wherein the ground depths represented by the upper and lower reversing point change over the course of the production of a pillar.

Depending on the type of production method, the upper and the lower reversing point during the production of a segment can in each case remain the same, or the upper reversing point can remain the same and the lower reversing point can change. This is explained below for the production

of a column segment which, in the case of the column 30 according to figure 6, forms the lower column section 34.

In the case of a method according to figure 8, in which the vibrator arrangement is always moved over the entire height of the segment during the individual repeating steps, the lower reversing point of the display always represents the ground depth x_4 and the upper reversing point always represents the ground depth x_3 . After production of the lowermost column section or segment 34, the ground depth assigned to the upper reversing point changes, i.e. the display indicates a necessary upward movement of the vibrator arrangement 1 until the vibrator arrangement has moved to a ground depth between x_2 and x_3 , at which a first segment of the column section 33 is produced.

In the case of a method according to figure 9, in which the stroke changes with each repetition step, the upper reversing point always represents the ground depth x_3 , and the lower reversing point changes with each repetition step, and therefore, for example, the first reversing point during a first insertion represents the ground depth $x_4 - \Delta h$, at a second insertion represents the ground depth $x_4 - 2\Delta h$, and at a third insertion (not illustrated in figure 9) represents $x_4 - 3\Delta h$, etc. After the lowermost column section or segment 34 is produced, the ground depth assigned to the upper reversing point changes, i.e. the display indicates a necessary upward movement of the vibrator arrangement 1 until the vibrator

arrangement has moved to a ground depth between x_2 and x_3 , at which a first segment of the column section 33 is produced.

The equipment operator does not have to know the actual position of the reversing points in the ground, the
5 the ground depth which is assigned to a reversing point, and also the number of repetition steps per segment. These are predetermined by a computer or a control system on the basis of the previously determined column profile and are assigned to the reversing points of the display.

10 The display shows a first reversing point and a second reversing point which are each assigned a ground depth, and a movement of the vibrator arrangement between the two reversing points both with respect to a movement speed and with respect to a direction of movement. For this
15 purpose, the position of the vibrator arrangement in the ground (between the two reversing points) is detected at regular or irregular time intervals and depicted on the display. In the example according to figure 10, a lower reversing point is represented by a lower end of a display
20 and an upper reversing point is represented by an upper end of the display, an arrow shows the desired direction of movement (predetermined direction of movement) and a bar illustrates the position of the vibrator arrangement between the reversing points. Apart from a bar and an arrow, any
25 other symbols for displaying the desired direction of

movement and the extent of the movement still required are, of course, suitable.

The previously explained automatic or semi-automatic methods, in which a material column 30 is produced in the ground with a plurality of segments depending on a column profile, is independent of the manner of determination of the column profile. As explained, said column profile can be produced automatically from a ground profile which is determined when the vibrator arrangement is inserted into the ground.

However, the column profile can also be produced manually from a ground profile, such as, for example, from a ground profile determined when the vibrator arrangement is inserted into the ground, or else from a ground profile determined by means of a core bore. For example, first of all only the number and the position of the individual segments in the column profile can therefore be predetermined, wherein the individual segments are then manually assigned properties, such as, for example, diameter or strength (which determine the method for producing the individual segments). Said assignment can take place depending on the ground profile. This procedure can be selected in particular when the ground construction is basically known, i.e. when it is known which types of ground layers are present and in which sequence said ground layers are present, but if it is not precisely known how thick the individual ground layers are.

In this case, the ground profile indicates in particular the layer boundaries, i.e. indicates at which depths the boundaries between individual layers are located. An operator, such as, for example, a ground engineer, with knowledge of the position of the layer boundaries, can then assign certain properties to individual segments in the column profile. The column profile is displayed, for example, on a display. Properties can be assigned to individual segments by means of any input tools, such as a keyboard, in a voice-controlled manner or directly at the display, if the latter is designed as a touchpad, such as, for example, as a touchpad of a smartphone or of a tablet computer. A column profile provided in such a manner can then be used in one of the previously explained production methods.

Features which have been explained previously in conjunction with an exemplary embodiment can, of course, also be combined with features of other exemplary embodiments, even if this has not been explicitly mentioned previously, if said features do not cancel one another out.

PATENT CLAIMS

1. A method which comprises:

providing a vibrator arrangement (1) which is held on
5 a carrying device (2) which is designed to penetrate the
ground (100) and which has a vibrator motor;

inserting the vibrator arrangement (1) into the
ground (100) to a predetermined depth;

determining a ground profile of the ground (100) when
10 the vibrator arrangement (1) is inserted, wherein the
determination of the ground profile comprises measuring at
least one operating parameter of the vibrator arrangement (1)
when the latter is inserted into the ground (100), and
wherein the ground profile in each case comprises a ground
15 parameter (P) for at least two different ground depths.

2. The method as claimed in claim 1 which furthermore
comprises:

producing a material column (30) in the ground
20 depending on the ground profile, using the vibrator
arrangement (1).

3. The method as claimed in claim 1, which furthermore
comprises:

25 inserting the vibrator arrangement, driven by the
carrying device (2) at at least an approximately constant

speed, into the ground;

measuring a power consumption of the vibrator motor as an operating parameter when the vibrator arrangement is inserted into the ground (100).

5

4. The method as claimed in claim 1, which furthermore comprises:

exerting an at least approximately constant force on the vibrator arrangement (1) by the carrying device (2) when the vibrator arrangement (1) is introduced into the ground (100);

measuring a speed at which the vibrator arrangement is inserted into the ground, as an operating parameter.

15 5. The method as claimed in claim 1, which furthermore comprises:

inserting the vibrator arrangement (1), driven by the carrying device (2) at at least an approximately constant speed, into the ground;

20 measuring a vibration amplitude of a tip of the vibrator arrangement (1) as an operating parameter when the vibrator arrangement is inserted into the ground (100).

6. The method as claimed in one of the preceding claims, in which the material column (30) is produced depending on the ground profile in such a manner that a

25

diameter of the material column (30) at a certain ground depth is dependent on the ground parameter determined for said ground depth.

5 7. The method as claimed in claim 6,

in which the ground parameter determined for a certain ground depth is dependent on a ground density and/or a ground rigidity, and

10 in which the material column is produced in such a manner that the diameter of the material column increases with decreasing ground density and/or decreasing ground rigidity.

8. The method as claimed in one of the preceding claims,
15 in which the production of the material column (30) comprises producing at least two segments, wherein the production of each segment comprises:

a) raising the vibrator arrangement (1) by a predetermined upward displacement distance such that a cavity
20 arises below the vibrator arrangement (1);

b) introducing a filler material (G) into the cavity;

c) inserting the vibrator arrangement (1) into the filler material by a predetermined downward displacement distance;

25 d) repeating method steps a) to c) n times, where $n \geq 0$.

9. The method as claimed in claim 8, in which the upward displacement distance and the downward displacement distance in steps a) and b) are identical in each case.

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10. The method as claimed in claim 8, in which the downward displacement distance in step b) is smaller by a displacement difference (Δh) than the upward displacement distance in the immediately preceding step a), and in which
10 each repetition the upward displacement distance in step a) is identical to the downward displacement distance in the immediately preceding step b).

11. The method as claimed in claim 10, in which the
15 displacement difference (Δh) in all of the repetitions is identical.

12. The method as claimed in one of claims 8 to 11, in which, for the production of a material column section at a
20 predetermined ground depth, the number n of repetitions in step d) is dependent on the ground parameter determined for said ground depth.

13. The method as claimed in claim 12,
25 in which the ground parameter is dependent on a ground density and/or a ground rigidity, and

in which the number n of repetitions increases with decreasing ground density and/or decreasing ground rigidity.

14. The method as claimed in one of claims 8 to 11, in
5 which the strength of the segment is measured during production, and in which the number n of repetitions is dependent on the measured strength.

15. The method as claimed in one of the preceding claims,
10 in which the vibrator arrangement comprises:

a vibrator pipe (11) with an upper and a lower end;

a vibrator (12) which is arranged on the vibrator
pipe (11) and has the vibrator motor.

15 16. The method as claimed in claim 15, in which the vibrator (12) is designed as a depth vibrator and is fastened to a lower end of the vibrator pipe (11).

17. The method as claimed in claim 15, in which the
20 vibrator (12) is designed as a top vibrator and is fastened to an upper end of the vibrator pipe (11).

18. The method as claimed in claim 15, in which the pipe
is designed as a silo pipe.

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19. The method as claimed in one of the preceding claims,

in which the carrying device (2) comprises a carrying arm of earth-moving equipment.

20. The method as claimed in one of claims 1 to 18, in
5 which the carrying device comprises a mast (25) and a slide (24) movable on the mast.

21. A method for producing a material column (30) in the ground (100), wherein the method comprises:

10 providing a vibrator arrangement (1) which is held on a carrying device (2) and is designed to penetrate the ground (100);

inserting the vibrator arrangement into the ground (100);

15 repeatedly moving the vibrator arrangement in the ground between reversing points, namely an upper reversing point and a reversing point, and introducing filler material into the ground when the vibrator arrangement is moved from the lower reversing point to the upper reversing point; and

20 detecting a position of the vibrator arrangement in the ground;

wherein the reversing points are predetermined by a control system, and

25 wherein a movement of the vibrator arrangement between the reversing points is depicted in an electronic display which indicates a predetermined direction of movement

of the vibrator arrangement and the position of the vibrator arrangement between the reversing points.

22. The method as claimed in claim 21, which comprises
5 producing at least two segments of the material column,
wherein the production of a segment comprises:

a) raising the vibrator arrangement (1) by a
predetermined upward displacement distance as far as an upper
reversing point such that a cavity arises below the vibrator
10 arrangement (1);

b) introducing a filler material (G) into the cavity;

c) inserting the vibrator arrangement (1) into the
filler material by a predetermined downward displacement
distance as far as a lower reversing point;

15 d) repeating method steps a) to c) n times, where $n \geq$
0.

23. The method as claimed in claim 22, in which the upper
reversing points in each repetition are identical, and in
20 which the lower reversing points in each repetition are
identical.

24. The method as claimed in claim 8, in which the
downward displacement distance in step b) is smaller by a
25 displacement difference (Δh) than the upward displacement
distance in the immediately preceding step a), and in which

each repetition the upward displacement distance in step a) is identical to the downward displacement distance in the immediately preceding step b).

5 25. The method as claimed in claim 10, in which the displacement difference (Δh) in all of the repetitions is identical.

26. The method as claimed in one of claims 21 to 25,
10 in which the display has a lower end which represents a lower reversing point and has an upper end which represents an upper reversing point,

and in which a bar arranged between the upper and the lower end indicates the position of the vibrator arrangement
15 between the reversing points.

27. The method as claimed in claim 16, in which a direction arrow in or next to the display indicates the desired direction of movement of the vibrator arrangement.