

DEPTH VIBRATOR PIPE ASSEMBLYDescription

The invention relates to a depth vibrator pipe assembly for a depth vibrator for producing vibro columns, an device comprising such a depth vibrator pipe assembly and a depth vibration method for producing vibro columns.

Depth vibrators are generally used in three methods for improving building ground which differ from one another with regard to the mode of operation and the load removal. With the vibro compaction method granular soils are compacted into themselves. In the vibro replacement method load-carrying columns of gravel or stone chippings are introduced into mixed- and fine-grain non-compactable soils. With the third method pile-like structural foundation elements are produced by means of which relatively high loads can be carried, where a permanent load-bearing compound with vibro replacement columns is not ensured. The various depth vibration methods are also described in the prospectus "The depth vibration method" (Prospectus 10-02D) of the applicant.

In vibro replacement compaction, bottom-feed vibrators are usually used in which coarse granular added material exits at the vibrator tip with compressed air assistance. Because of the special equipment required, support caterpillars with leader guidance have been developed which enable an additional pressure during penetration and compaction. In the vibro replacement method operation takes place in alternate steps. The gravel or stone chippings exiting when the vibrator is raised, is compacted during penetration and displaced laterally into the soil. In this way vibro replacement columns are formed which carry loads when combined with the soil.

Known from DE 101 45 288 A1 is a method for producing vibro replacement columns for improving ground properties of building ground by means of a bottom-feed vibrator. For this purpose the bottom-feed vibrator is vibrated as far as a lowest point. The bottom-feed vibrator is then withdrawn with column material such as stone chippings flowing out from a lower opening. In order to compact the column material, penetration movements are made at intervals. The bottom-feed vibrator has a laterally bypassing feeder pipe with a lower opening. At the upper end the bottom-feed vibrator is connected via an elastic coupling to a hollow rod via which the added material flows in.

Known from DE 101 15 107 A1 is a depth vibrator with a vibrator tube and an eccentric arranged rotatably in the vibrator tube. The vibrator tube is coupled to an extension tube via a coupling. The motor for driving the eccentric is located above the extension tube.

Known from DE 197 07 687 C1 is an device for producing vibro replacement columns in the ground. The device comprises an equipment carrier with a leader, a carriage movable on the leader and a depth vibrator with propulsion head and material conveying tube. A cantilever arm with a cable winch for a container is provided at the upper end of the carriage by means of which material can be supplied to a feed-in air lock. In the upper end position the cantilever arm projects beyond the leader. With a predefined length of the leader, relatively long columns can thus be produced.

With the known vibrator devices and vibration methods, respectively, it is only possible to achieve penetration depths which are smaller than the machine height or the above-ground free space.

It is therefore the object of the present invention to provide a depth vibrator pipe assembly for a depth vibrator to produce vibro columns which makes it possible to achieve penetration depths which are greater than the machine height or the available above-ground free space. The object further consists in providing a corresponding device with such a depth vibrator pipe assembly and a suitable depth vibration method for producing vibro columns.

A solution consists in a depth vibrator pipe assembly for connecting a depth vibrator to a device, comprising: a first pipe body connectable to the device; a second pipe body connectable to the depth vibrator; wherein the first pipe body and the second pipe body are telescopeable relative to one another. An advantage of the telescopeable depth vibrator pipe assembly consists in that columns can be produced therewith whose depth is greater than the available space above the ground or than the height of the depth vibrator. It is also possible to use smaller depth vibrator devices for the same sinking depth. A further advantage of the variable-length pipe arrangement consists in that the transport length of the depth vibrator can be reduced.

Depth vibrator pipe assembly means that the pipe assembly is suitable and designed for use in a depth vibrator. In the installed state the pipe assembly connects a depth vibrator arranged at the lower end with a mast of the device. In this respect the pipe assembly can also be referred to as a telescopeable extension pipe. The first pipe member is connectable to the device, wherein the interposition of other elements such as a carriage or other pipe or adapter members shall also be included. In this respect, the connection of the first pipe body to the device can also be designed as at least indirect. The second pipe body is connectable at least indirectly to the depth vibrator, whereby the interposition of other elements

such as a coupling or an adapter member shall also be included. The first pipe body and the second pipe body have respective connection means for connection to a respective connection component, which for example, can be configured in the form of flange or screw connections or pockets for receiving clamping bolts.

Because of the telescopability, the overall length of the pipe assembly can be varied. For this purpose a plurality of pipe bodies are provided which are connected to one another in a longitudinally displaceable manner. In this case, one of the pipe bodies is designed as an inner pipe having a smaller diameter whereas the other pipe body is designed as an outer pipe with a larger diameter in which the inner pipe is moveable. Preferably the inner pipe is assigned to the mast (first pipe body) and the outer pipe is assigned to the depth vibrator (second pipe body). In this way, the pipe body with larger diameter is provided at the lower end so that at the following pipe body with smaller diameter reduced friction forces with respect to the in-situ ground are obtained during insertion into the ground. In principle however an inverse arrangement would be feasible, that is outer pipe at the top and inner pipe at the bottom.

In the retracted position the pipe assembly has a first length, and in the extended position the pipe assembly has a larger second length. It is understood that in principle more than two pipe bodies can also be used which can be telescoped relative to one another.

According to a preferred embodiment, the depth vibrator pipe assembly comprises locking means by which the first pipe body and the second pipe body can be detachably connected to one another at least in a retracted position and in an extended position. It is understood that also an embodiment is possible in which the two pipe bodies can be

fixed to one another in one or more intermediate positions between the retracted and extended position. Thereby, as the case may be, a great flexibility can be achieved with regard to the depth of the columns to be produced. It is in particular provided that the locking means can be transferred into a locking position in which the pipe bodies are firmly connected to one another and in a release position in which the pipe bodies are axially displaceable relative to one another. The actuation of the locking means can be accomplished manually or in an automated manner by a control unit.

Preferably the locking means comprise a plurality of locking units which are arranged distributed over the circumference. It is particularly favourable to use three circumferentially distributed locking units. By this, a particularly secure connection and good support of tilting moments possibly acting between the two pipe bodies is achieved. In principle, however, one, two, four or more than four locking units can be used. According to a first possibility, the locking units can be arranged in one plane. According to a second possibility, the locking units can also be arranged on two or more axially spaced-apart planes whereby a particularly good support of tilting moments is achieved. The latter possibility is particularly well suited for an automated actuation of locking units since a plurality of or all the locking units can be actuated simultaneously.

According to a preferred embodiment, the locking units each comprise a locking element and a receptacle, i.e. receiving, into which the locking element can engage. The receptacle which for example can be configured as a recess or cup-shaped member, is also designated as receiving element. It is provided that the locking element is assigned to one of the two pipe bodies and the receptacle is assigned to the other of the two pipe bodies, wherein

the locking element can be brought into engagement with the appurtenant receptacle. A locking element and a respective receptacle are preferably designed to be compatible with respect to each other such that in the braced condition the locking element engages the corresponding receptacle in a form locking and play-free manner. In particular, the locking element can be configured as a rotationally symmetrical body with a conical end section and the receptacle can be configured as a cup-shaped member with conical inner wall.

According to a first possibility, the locking elements are assigned to the outer pipe and are supported on this whereas the receptacles are assigned to the inner pipe. This configuration is particularly suitable for a manual actuation of the locking elements which can be carried out from outside. According to a second possibility, the locking elements are assigned to the inner pipe, respectively are supported on this, whereas the receptacles are assigned to the outer pipe. This configuration is particularly suitable for an automated actuation which can be carried out from inside via control lines.

For the first possibility it can in particular be provided that the locking elements are supported on, respectively clamped to the associated pipe body by clamping bolts. By screwing in the clamping bolts, the locking element is moved radially inwards and, in the fully braced condition, engages the respective receiver of the other pipe body in a play-free manner. In this way, the first pipe body and the second pipe body are firmly connected to one another.

For the second possibility, it can in particular be provided that the locking elements are supported on the associated pipe body by means of a piston and can be moved radially by hydraulic pressurization of the piston, wherein the locking elements in the braced state engage in the

respective receiving elements of the other pipe body so that the first pipe body and the second pipe body are firmly connected to one another. By means of the hydraulic actuation, a plurality of or all the locking elements can be actuated simultaneously. The pistons each sit radially displaceably in a cylinder of one of the pipe bodies and are firmly connected to the locking element, for example via a screw connection. By means of hydraulic pressurization the piston and the locking element connected thereto are acted upon radially in the direction of the other piston and engages the receptacle formed therein.

According to a preferred embodiment, at least one annular seal is provided between the first pipe body and the second pipe body which seals the annular gap between the first pipe body and the second pipe body. In particular an annular seal can be provided at the upper end of the second pipe body and an annular seal can be provided at the lower end of the first pipe body. The at least one annular seal prevents an undesired ingress of dirt into the annular gap and enables a pressure build-up inside the pipe assembly in order to supply the depth vibrator, for example, with compressed air or water.

The telescopable extension pipe can be constructively adapted to the respective method or the respective device. Thus, according to a first embodiment the pipe assembly can be configured to carry out a vibro replacement process. In this case, the two pipe bodies each comprise a material pipe through which material for compacting the ground can flow as well as a cable conduit which is disposed laterally adjacent to the material pipe and through which an electrical cable can be guided for the bottom-feed vibrator. Preferably in this embodiment, at least one reinforcement is provided on an inner wall of the material pipe in the region of the locking units which protects the locking unit from through-flowing material. The

reinforcement can be designed as a ring which is fixed in the pipe body above the locking units, for example, by means of welding. According to a second embodiment, the pipe assembly can be designed for carrying out a vibro compaction process in which a material supply is not provided. In this case, the pipe bodies each have an inner channel through which an electrical cable for the pressure vibrator can be guided. A water flushing to the depth vibrator can optionally be guided through the inner channel. According to a further embodiment, the telescopable extension pipe can also be configured for carrying out a method for producing pile-like foundation elements. In this case, the pipe assembly, which is configured at least similarly or identically as for the vibro replacement method, comprises a material pipe through which a hardenable suspension is supplied as fill material. The pile-like foundation elements thus produced are also designated as vibro concrete columns or premixed vibro mortar columns.

The solution of the aforesaid object further consists in a device for depth vibration comprising: an apparatus with a mast, a depth vibrator pipe assembly, which is held height-adjustably on the mast and which has one or more of the aforesaid configurations; a depth vibrator which is fastened to a lower end of the depth vibrator pipe assembly; and a cable tensioning device which is designed in such a manner that an electrical cable for the depth vibrator is guided, in a tensioned condition during telescoping of the first pipe body relative to the second pipe body.

The apparatus according to the invention affords the same advantages which have already been mentioned in connection with the depth vibrator pipe assembly. In particular columns with a greater depth can be produced with the same size of depth vibrator device or a smaller depth vibrator

device can be used for the same sinking depth. In addition the device has a particularly small transport length. The device can be configured for carrying out the vibro compaction method, vibro replacement method and/or for producing pile-like foundation elements.

According to a preferred embodiment, the cable tensioning device comprises a plurality of deflection pulleys via which the electrical cable is guided and a weight which acts on at least one of the deflecting rollers in order to tension the cable. The cable tensioning device ensures that the electrical cable for the depth vibrator remains undamaged during telescoping of the pipe assembly.

The device can have a carriage which is held in a height-adjustable manner on the mast wherein the depth vibrator pipe assembly and the cable tensioning device are fastened to the carriage and moved together with same. Alternatively the depth vibrator with pipe assembly can also be used suspended on a crane or digger.

The solution of the aforesaid object further consists in a depth vibration method for producing columns in the ground with a device which can have one or more of the said configurations comprising the steps: inserting the depth vibrator into the ground with retracted pipe assembly up to a first depth; releasing the locking means effective between the first pipe body and the second pipe body; extending the pipe assembly from the retracted into an extended position wherein the electrical cable is guided by the cable tensioning device; closing the locking means so that the first pipe body and the second pipe body are axially firmly connected to one another in the extended position; inserting the depth vibrator into the ground with extended pipe assembly up to a second depth which is greater than the first depth; constructing a first column section in the ground upon pulling the depth vibrator with

extended pipe assembly; releasing the locking means active between the first pipe body and the second pipe body in the extended position; retracting the pipe assembly from the extended into a retracted position, wherein the electrical cable is guided by the cable tensioning device; closing the locking means so that the first pipe body and the second pipe body are axially firmly connected to one another in the retracted position; constructing a second column section above the first column section upon pulling the depth vibrator with retracted pipe assembly.

With the method according to the invention, the same advantages are achieved as with the device or the pipe assembly. It is understood that all the process features apply to the aforesaid device or pipe assembly and conversely all the device features apply to the method.

Preferred embodiments are explained hereinafter with reference to the drawings. In the figures:

Figure 1 shows a depth vibrator pipe assembly according to the invention in a first embodiment

- A) in a first side view;
- B) in longitudinal section along line of intersection 1B-1B from Figure 1A;
- C) in a second side view;
- D) in plan view;
- E) viewed from below;
- F) the locking arrangement according to Figure 1B in detail;

Figure 2 shows a depth vibrator device according to the invention with a depth vibrator pipe assembly according to the invention

- A) in side view;
- B) in perspective view from obliquely in front with extended depth vibrator pipe assembly;

- C) in perspective view from obliquely in front with retracted depth vibrator pipe assembly;
- D) the locking arrangement according to Figure 2C in detail;

Figure 3 shows the cable tensioning device of the depth vibrator device according to the invention according to Figure 2 in detail

- A) in a first side view;
- B) in a second side view;
- C) the clamping device according to line of intersection 3D-3D from Figure 3A as detail;
- D) the deflection pulley mounting according to line of intersection 3C-3C from Figure 3A as detail;

Figure 4 shows a depth vibration method according to the invention for producing a vibro replacement column according to Figures 2 and 3

- A) in the initial state;
- B) with depth vibrator inserted in the ground to a first depth with retracted pipe assembly;
- C) in the extended state of the pipe assembly;
- D) with depth vibrator inserted in the ground to a second depth with extended pipe assembly;
- E) after creating a first column section upon pulling the depth vibrator with extended pipe assembly;
- F) in re-retracted state of the pipe assembly;
- G) after creating a complete column upon drawing the depth vibrator with retracted pipe assembly (in the final state);

Figure 5 shows the depth vibrator pipe assembly according to the invention in a second embodiment;

- A) in longitudinal section;

- B) the actuating device of the pipe assembly according to Figure 5A in perspective view, partially cutaway, in retracted position;
- C) the actuating device of the pipe assembly according to Figure 5A in perspective view, partially cutaway, in extended position;

Figure 6 shows a depth vibrator device according to the invention with depth vibrator pipe assembly according to Figure 5

- A) in side view;
- B) in perspective view from obliquely in front with depth vibrator penetrated into the ground with retracted pipe assembly;
- C) in perspective view from obliquely in front with depth vibrator penetrated into the ground with extended pipe assembly;

Figure 7 shows a depth vibration method according to the invention for producing a vibro replacement column by means of a device according to Figure 6

- A) in the initial state;
- B) with depth vibrator penetrated into the ground to a first depth with retracted pipe assembly;
- C) in the extended state of the pipe assembly;
- D) with depth vibrator penetrated into the ground to a second depth with extended pipe assembly;
- E) after creating a first column section by pulling the depth vibrator with extended pipe assembly;
- F) in re-retracted state of the pipe assembly;
- G) after creating a complete column upon drawing the depth vibrator with retracted pipe assembly (in the final state).

Figures 1A to 1F are described jointly hereinafter. A depth vibrator pipe assembly 2 for a vibro compaction or vibro replacement device are shown.

Columns for improving building ground or drainage columns in the ground can be created using a vibro replacement device. In the vibro replacement method load-carrying columns of gravel or stone chippings are installed into soils, in particular into mixed and fine-grained non-compactable soils. For this purpose a depth vibrator (not shown here) to be connected to the pipe assembly 2 is penetrated into the ground. The pipe assembly 2 and, respectively, the depth vibrator connected thereto is guided by a suitable device such as a digger, a crane or a supporting caterpillar. The depth vibrator comprises an electronically driven imbalance which sets the vibrator in horizontal vibration. The depth vibrator can be designed in the form of a bottom-feed vibrator in which additional material flowing through the pipe assembly exits at the vibrator tip.

With a vibro premix device, pile-like foundation elements are created in the ground by introducing a hardenable suspension such as concrete, which elements can carry high loads. The foundation elements are produced in the same way as in the vibro replacement method. Said methods can also be combined with one another.

The depth vibrator pipe assembly 2 comprises a first pipe body 3 which is to be connected at least indirectly to the device (not shown here) and a second pipe body 4 which is to be connected at least indirectly to the depth vibrator (not shown here). For being connected to the device, the depth vibrator pipe assembly 2 has at the first end 5, which corresponds to the upper end in the installed state, first connecting means 6 which are designed in the form of screw connections, without being restricted thereto. At the

lower end 7 of the pipe assembly 2 second connecting means 68 are provided by which the pipe assembly is connectable to the depth vibrator or an interposed elastic coupling (not shown), respectively.

The pipe assembly is configured such that the first pipe body 3 and the second pipe body 4 can be telescoped relative to one another and can be firmly connected to one another in at least two positions for transmission of forces. Figures 1A to 1C show the pipe assembly 2 in the retracted position in which the pipe assembly 2 has a short first length L1. As already mentioned above the present pipe assembly is configured for use in connection with a bottom-feed vibrator. For this purpose the two pipe bodies 3, 4 each have a material pipe 8, 9 through which material can flow from the device to the bottom-feed vibrator, as well as cable conduit 10, 11 which is disposed laterally adjacent to the respective material pipe 8, 9 and through which an electrical cable can be guided for control and power supply of the bottom-feed vibrator.

It can be seen that the first pipe body 3 facing the device is retracted in the second pipe body 4 facing the depth vibrator. In this respect the first pipe body 3 can also be designated as inner pipe and the second pipe body 4 can also be designated as outer pipe. In order to enable the telescopability, the material pipe 8 and the cable conduit 10 of the first pipe body 3 each have a smaller outside diameter than the corresponding inside diameter of the material pipe 9 and the cable conduit 11 of the second pipe body 4.

Detachable locking means 12 are provided between the first pipe body 3 and the second pipe body 4. The locking means 12 can be transferred into a release position in which the two pipe bodies 3, 4 are longitudinally displaceable relative to one another, and into a closed or locking

position in which the two pipe bodies 3, 4 are firmly braced to one another. Specifically, the locking means 12 are designed such that the first pipe body 3 and the second pipe body 4 can be firmly connected to one another at least in a retracted first position with short length L1 and in an extended second position with greater length L2.

The locking means 12 comprise a plurality of locking units 13 which are arranged distributed over the circumference. In the present embodiment the circumferentially distributed locking units 13 are provided in a locking plane wherein a different number and different arrangement in a plurality of planes is also possible. Each locking unit 13 has a locking element 14 which can be firmly clamped to the second pipe body 4 and a compatible receiving element 15 which is firmly connected to the first pipe body 3. Figures 1B and 1F show the locking means 12 in the closed position, more specifically in the retracted condition of the pipe assembly 2. Compatible means that the locking elements 14 in the braced state engage the respective receptacle 15 in a form fitting and play-free manner so that the two pipe bodies 3, 4 are firmly attached to one another in this connection region.

The locking elements 14 are designed bolt-shaped and each have a flange section 16 which is radially supported on a supporting face of the second pipe body 4, and a conical end section 17 which can engage through radial through openings 24 in the pipe wall of the outer pipe 4 into the respective receptacle 15 of the inner pipe 3. The receiving elements 15 are designed to be cup-shaped and have a flange section 18 which is radially supported against the inner pipe 3, and an internally conical cup section 19 into which the cone section 17 of the locking element 14 can engage. The receiving elements 15 are firmly connected to the inner pipe 3. For this purpose the inner pipe 3 can have a welded-in annular section 20 with circumferentially

distributed openings 21 in which respectively one receiving element 15 is inserted and fixed. The welded-in annular section 20 has a larger wall thickness than the axially adjoining pipe sections.

For releasing and, respectively, interlocking the locking elements 14, a plurality of clamping bolts 22 are provided which are screwed into an internal thread in the outer pipe 4, and with a bolt head can be supported on the locking element 14. With release bolts 23 which are each screwed into an internal thread of the locking element 14 and which are supported with their end on a supporting surface of the outer pipe 4, the locking elements 14 can be released again if required and removed from the receptacles 15. The number of clamping bolts 22 is greater than the number of release bolts 23.

It can be seen in Figure 1B in particular that the inner pipe 3 has two groups of receptacles 15, 15' and specifically a first group of receptacles 15 in an (upper) first end portion of the inner pipe 3 and a second group of receptacles 15' in a (lower) second end portion of the inner pipe 3. In the retracted state of the pipe assembly 2 the locking bodies 14 can be brought into engagement with the first receptacles 15. In this state, the pipe assembly 2 has a short first length L1 as shown in Figures 1A to 1C. After releasing the locking bodies 14 from the receptacles 15 of the first group, the first pipe body 3 can be withdrawn from the second pipe body 4 until the joining plane of the outer pipe 4 axially overlaps with the second group of receptacles 15'. In this position the locking bodies 14 can be inserted in the receptacles 15' of the second group and braced wherein a greater second length L2 of the pipe assembly is defined. Stops can be provided which axially delimit a relative retraction movement and/or extension movement of the two pipe bodies 3, 4. The stops should be designed such that the joining plane of the outer

pipe 4 on reaching the retraction stop lies in the first joining plane of the inner pipe 3, and on reaching the extension stop lies in the second joining plane of the inner pipe 3. In an overlapping state of the joining planes, the openings 24 for the locking members 14 are aligned with the respective receptacles 15, 15'.

For protection against wear, reinforcements 25, 25' are provided above, respectively in the area of the first and second joining planes of the inner pipe 3, which protect the receiving elements 15, 15' from material flowing through the material pipe 8. The reinforcements 25, 25' are each designed in the form of rings connected to the inner pipe, for example by means of welding, which are arranged axially above the respective annular section 20 and, respectively the receiving elements 15, 15' connected thereto and cover these in the radially inward direction. In this way, the receiving elements 15, 15' are protected from material to be introduced.

A first sealing arrangement 26 is provided between the material pipe 8 of the first pipe body 3 and the material pipe 9 of the second pipe body 4, which seals the annular gap formed between the material pipes 8, 9. The sealing arrangement 26 comprises a plurality of annular seals 27 above and below the connecting plane. The annular seals 27 are arranged in an inner wall of the second material pipe 9 and can be re-adjusted by a tensioning mechanism. For this purpose the annular seals 27 are acted upon axially so that the annular gap between the material pipes 8, 9 can be closed again in the case of wear. The sealing arrangement 26 has the function of preventing an undesired ingress of dirt into the annular gap and enabling a build-up of pressure inside the pipe assembly 2 in order to supply the depth vibrator connected to the pipe assembly 2, for example with compressed air or water. A sealing arrangement 28 is also provided between the cable conduits 10, 11 which

seals the annular gap formed there. The sealing arrangement 28 comprises a plurality of annular seals 29 which are disposed between an outer wall of the first cable conduit 8 and a sealing body 30. The sealing arrangements 25, 28 enable a good sliding of the two pipe bodies 3, 4 relative to one another in addition to the sealing function. Both seals 25, 28 can easily be exchanged and be re-adjusted depending on the abrasion.

Figures 2A to 2D and 3A to 3D are described jointly hereinafter. A depth vibrator device 32 according to the invention is shown in a first embodiment with a depth vibrator pipe assembly 2 according to the invention according to Figures 1A to 1F. The present depth vibrator device 32 is configured for carrying out the vibro replacement method without being restricted to this. The device can equally well be used to produce column-like foundation elements.

The device 32 comprises a mobile apparatus 33 which in the present case is designed in the form of a crawler-type under carriage without being restricted to this. A supporting frame 34 is attached to the apparatus 33 which is also designated as leader mast. The leader mast 34 is pivotable relative to the device 33 by means of a force-actuated actuating unit 35. Guide rails 36 are provided on the leader mast 34 on which a carriage 37 is guided displaceably. The actual depth vibrator tool 38 is fastened to the carriage 37. The depth vibrator tool 38 comprises the pipe assembly 2 and the depth vibrator 39 which is connected to the pipe assembly 2 via an elastic coupling 40. Provided at the upper end of the leader mast 34 is a cantilever jib 41 with a cable winch 42 by which a container 43 can be moved along the leader mast 34. In a position lowered onto the ground the container 43 can be filled with material, for example, gravel which then - in an upper position pulled-up on the leader mast - can flow

in from the container 43 into the upper end 6 of the pipe assembly 2. The material flows through the pipe assembly 2 into the depth vibrator 39 connected thereto, at the tip of which it exits into the ground.

In order that the electric cable for the depth vibrator 39 is not damaged, a cable tensioning device 45 is provided which is shown as a detail in Figures 3A to 3D. The cable tensioning device 45 is designed such that the electric cable 46 for the depth vibrator 39 is always tensioned and guided during telescoping of the first pipe body 3 relative to the second pipe body 4. The cable tensioning device 45 is fastened to the carriage 37 and can be moved together with this on the mast 34. As can be seen in particular in Figure 3A, the cable tensioning device 45 comprises a support arm 47 on which a plurality of first deflection pulleys 48 are rotatably mounted by means of bearings 49 as well as an adjusting arm 50 with second deflection pulleys 51 which is height adjustable relative to the support arm 47. The electric cable 46 is fixed at one end of the support arm 47 in a tensioning device 52 which is shown as detail in Figure 3D and is guided over the first and second deflection pulleys 48, 51 from which the cable 46 leads into the upper opening of the first cable conduit 10. A weight 53 is fastened to the adjusting arm 50, the mass of which is designed such that it counteracts the weight force of the cable 46 to hold this tensioned. A safety cable 54 also acts on the adjusting arm 50 which is part of a load securing device 55 which prevents the adjusting arm 50 from falling down in the event of the cable 46 being ruptured.

As a result of the telescopability of the pipe assembly 2, it is possible to create columns in the ground which have a greater depth T2 than the height H of the leader mast 34. A method according to the invention by means of a device according to the invention according to Figures 2A to 2D

and 3A to 3D is explained in detail hereinafter with reference to Figures 4A to 4G.

Figure 4A shows the device 32 in the initial position with depth vibrator 39 located above the ground edge 56. As already mentioned the depth vibrator 39 is designed as a bottom-feed vibrator by means of which coarse-grain added material can be introduced into the ground to produce a ground column. In a first step the depth vibrator 39 is penetrated into the ground 57 to a first depth T1. This state is shown in Figure 4B and in Figure 2C. The depth T1 is reached when the locking means 12 lies somewhat above the ground edge 56 so that it can be operated by an operator. Now the locking means 12 can be released which is accomplished by opening the clamping screws 22 and removing the locking elements 14 from the recesses 15. Then the upper first pipe body 3 is moved out from the lower second pipe body 4 by raising up the carriage 37, wherein the second pipe body 4 and the depth vibrator 39 attached thereto remain at the given depth T1 in the ground 57 as a result of their own weight. During the moving apart the vibrator cable 46 is automatically held tensioned and guided with the aid of the cable tensioning device 45. The completely extended state of the pipe assembly 2 is reached when the lower second group of receiving elements 15' of the inner pipe 3 lies in a plane with the openings 24 of the outer pipe 4. After reaching this position, which is shown in Figure 4C and also in Figure 2B, the locking means 12 are closed so that the two pipe bodies 3, 4 are fixed with respect to one another. This is achieved by inserting and bracing the locking elements 14 which then engage form-fittingly into the respective receptacles 15' so that the two pipe bodies 3, 4 are firmly connected to one another. Now the depth vibrator 39 can be vibrated further into the ground 57 and specifically until reaching the end depth T2. This state is shown in Figure 4D.

Now the construction of the column 58 in the ground 57 is begun where fill material, optionally with compressed air, assistance exits at the vibrator tip 44 when pulling the depth vibrator 39. The carriage 37 is moved as far as into the upper position or as far as the end of the stroke where a first column section is created from the depth T2 to the depth T1. After reaching the upper position, the locking means 12 are again freely accessible above the ground edge 56. This state is shown in Figure 4E. Now the locking means 12 are released again which is achieved by opening the clamping screws and removing the locking elements 14. The carriage 37 with the first pipe body 3 attached thereon is again inserted into the second pipe body 4. During the telescoping, i.e. insertion process, the depth vibrator cable 46 is held tensioned and guided with the aid of the tensioning device 52, wherein the required tensile force corresponds to the cable friction produced in the cable ducts 10, 11 and is applied by the adjustable counterweight 53. When the retracted state of the pipe assembly 2 is reached, which is shown in Figure 4F and Figures 2C, 2D, the locking means 12 of the pipe assembly 2 can be closed again which is accomplished by inserting and bracing the locking bodies 14. Now the upper column section is created by stepwise pulling and vibrating of the depth vibrator 39 in the retracted state of the pipe assembly 2. The final state with finished column 58 is shown in Figure 4G.

Figures 5A to 5C which are described jointly hereinafter show a pipe assembly 2 according to the invention in a second embodiment. The present pipe assembly 2 largely corresponds to the pipe assembly according to Figures 1A to 1F so that reference is made to the above description with regard to the common features. In this case, the same or corresponding details are provided with the same reference numbers as in Figures 1A to 1F. In particular the differences are discussed in the following.

A first difference consists in that the pipe assembly 2 according to Figures 5A to 5C is configured for use for a vibro compaction method. In the vibro compaction method a compaction of granular soils is carried out by depth vibrators at relatively low frequency. The vibrator can be used suspended on a crane or digger. Under the influence of the vibrations of the depth vibrator, the soil grains are brought into a tighter packing where a reduction in the volume of the soil occurs. No aggregate is added into the ground in the vibro compaction method. In this respect the first and the second pipe bodies 3, 4 each have only one channel through which the vibrator cable 46 is guided. A material pipe is not provided.

A further feature of the pipe assembly 2 consists in the configuration of the locking means 12 which are configured to be controllable. For this purpose the locking units 13 each have a hydraulically actuatable piston 59 which sits radially movably in a cylinder 60 assigned to the inner pipe 3. The piston-cylinder unit 59, 60 is designed to be double-acting, that is by pressurizing a first cylinder chamber via a first hydraulic line 61 the appurtenant piston 59 is acted upon radially outwards, and by pressurizing a second cylinder chamber via a second hydraulic line 62 the piston is moved radially inwards. Respectively one locking element 14 is fixed to the piston 59, more specifically by means of a screw without being restricted thereto.

In the radially outwardly driven position of the piston 59, the associated locking elements 14 engage in the respective receptacles 15, 15' of the outer pipe 4. The receptacles 15, 15' are in the present case configured in the form of circumferential annular grooves formed in the inner wall of the outer pipe 4. In the radially projecting position of the piston 59 the inner pipe 3 and the outer pipe 4 are firmly braced to one another. By moving the piston 59

radially inwards, the locking elements 14 release the receptacles 15 so that the inner pipe 3 can be moved relative to the outer pipe 4. Compared with the above embodiment, a kinematic inversion is provided insofar as the locking elements 14 are assigned to the inner pipe 3 and the receptacles 15 are assigned to the outer pipe 4. This has advantages with respect to the manufacture and controlling of the hydraulic lines which are assigned to the upper pipe body 3. The locking elements 14 are provided in a lower pipe section 63 which has a thickened wall compared with the adjoining pipe section 64 so that the piston cylinder units 59, 60 can be accommodated therein. The two pipe sections 63, 64 are welded together. An annular cover element 65 is screwed in a sealing manner on the lower pipe section 63 which cover element terminates face-sided partial sections of the hydraulic channels.

In the completely retracted position which is shown in Figures 5A and 5B, the cover element 65 abuts against an end stop 66 assigned to the outer pipe 4. The stop 66 is formed by an end face of the end section 7 of the pipe body 4 which is inserted into the axially adjoining pipe section 67 and is welded thereto. The pipe section 67 has regions of greater wall thickness in which the radial receptacles 15 are formed. The end section 7 has circumferentially distributed pockets as connecting means 68 for attachment to the depth vibrator 39. Upper and lower sealing means 26, 28 are provided between the inner pipe 3 and outer pipe 4.

It can be seen that the outer pipe 4 has a first group of receptacles 15 at the lower end and a second group of receptacles 15' at the upper end, wherein the two groups of receptacles 15, 15' form the retracted or extended position of the pipe assembly 2. The receptacles 15 of the first group are arranged so as to be circumferentially distributed in two levels. In this case, per locking plane three receptacles 15 are provided distributed over the

circumference, wherein the receptacles 15 of the two locking planes are arranged circumferentially offset with respect to one another. The same applies to the receptacles 15' of the second group which represent the extended state of the pipe assembly 2.

An advantage of the present embodiment with hydraulic actuation consists in that the locking elements 14 can be actuated simultaneously, and specifically automated, whereby the vibration process can be executed rapidly and efficiently.

Figures 6A to 6C and 7A to 7G are described jointly hereinafter. A depth vibrator device 32 according to the invention is shown in a second embodiment with a depth vibrator pipe assembly 2 according to the invention according to Figures 5A to 5C. The present depth vibrator device 32 is configured for carrying out the vibro compaction method.

The depth vibrator device 32 according to Figures 6A to 6C and 7A to 7G largely corresponds to the above embodiment according to Figures 2 and 3, reference being made in this respect to the description thereof. The same or corresponding details are therefore provided with the same reference numbers as in Figures 1 to 5.

The device 32 comprises a mobile apparatus 33 in the form of a caterpillar apparatus. A leader mast 34 is fastened to a support arm of the caterpillar apparatus, which is pivotable relative to the apparatus 33 by means of a force-actuated actuating unit 35. Guide rails 36 are provided on the leader mast 34 on which a carriage 37 is movably guided. The actual depth vibrator tool 38 is fastened on the carriage. The depth vibrator tool 38 comprises the pipe assembly 2 according to Figures 5A to 5C and the depth vibrator 39 which is connected to the pipe assembly 2 via

an elastic coupling 40. Unlike the above embodiment in the present case no container is provided since no material is added to the ground in the vibro compaction method.

A cable tensioning device 45 holds the electrical cable 46 for the depth vibrator 39 continuously tensioned during telescoping of the first pipe body 3 relative to the second pipe body 4 and guides same. With regard to further details for the cable tensioning device 45 reference is made to the description of the first embodiment.

As a result of the telescopability of the pipe assembly 2, it is possible to create columns in the ground which have a greater depth T2 than the height H of the leader mast 34. The method according to the invention by means of the device according to Figures 6A to 6C is shown in Figures 7A to 7G. This corresponds to the method for the first embodiment, reference being made in this respect to the description thereof.

Figure 7A shows the device 32 in the initial position with depth vibrator 39, which is configured as a compaction vibrator, located above the ground edge 56. In the first step the depth vibrator 39 is vibrated into the ground 57 as far as the first depth T1 where the ground is compacted in this first section (Figure 7B). The locking means 12 are then released by hydraulic pressurization in the opening direction, and the upper first pipe body 3 moved out from the lower second pipe body 4 by raising up the carriage 37. During the extension, the vibrator cable 46 is held tensioned and guided with the aid of the cable tensioning device 45. After reaching the upper end position (Figure 7C), the locking means 12 are again closed hydraulically so that the two pipe bodies 3, 4 are fixed to one another. Now the depth vibrator 39 is vibrated further into the ground 57 until it reaches the end depth T2 (Figure 7D). Compaction then takes place from bottom to top in

previously specified lifting steps and time intervals until the end of the stroke is reached or an extended position (Figure 7E). After reaching the end of the stroke, the locking means 12 is again released hydraulically and the carriage 37 with the first pipe body 3 fastened thereon is inserted into the second pipe body 4 again. During the insertion process the vibrator cable 46 is held tensioned and guided with the aid of the tensioning device 52. After reaching the inserted state (Figure 7F), the locking means 12 is closed again. Now the upper column portion is compacted in defined lifting stages and time intervals of the depth vibrator 39. The final state with ready compacted column 58 is shown in Figure 7G.

The pipe assemblies 2 according to the invention and, respectively, the devices 32 fitted therewith have the advantage that columns can be produced herewith whose depth is greater than the available space above the ground edge 56 and/or greater than the height H of the device 32. It is also possible to use smaller devices 32 for the same sinking depth. Another advantage of the variable-length pipe assembly 2 consists in that the transport length can be reduced.

Reference list

2	Depth vibrator pipe assembly
3, 4	(First, second) pipe body
5	First end
6	First connecting means
7	Second end
8, 9	(First, second) casing pipe
10, 11	(First, second) cable conduit
12	Locking means
13	Locking unit
14	Locking element
15	Receptacle, Receiving
16	Flange section
17	End section
18	Flange section
19	Cup section
20	Annular section
21	Opening
22, 23	Bolts
24	Through opening
25	Reinforcement
26	Sealing arrangement
27	Annular seal
28	Sealing arrangement
29	Annular seal
30	Sealing body
32	Depth vibrator device
33	Apparatus
34	Leader mast
35	Actuating unit
36	Guide rail
37	Carriage
38	Depth vibrator tool
39	Depth vibrator
40	Coupling
41	Cantilever jib

42	Cable winch
43	Container
44	Tip
45	Cable tensioning device
46	Cable
47	Support arm
48	First deflection pulley
49	Bearing
50	Adjusting arm
51	Second deflection pulley
52	Tensioning device
53	Weight
54	Safety cable
55	Load securing device
56	Ground edge
57	Ground
58	Column
59	Piston
60	Cylinder
61, 62	(First, second) hydraulic line
63, 64	Pipe section
65	Cover element
66	Stop
67	End section
68	Connecting means
H	Height
L	Length
T	Depth

DEPTH VIBRATOR PIPE ASSEMBLY, DEPTH VIBRATOR DEVICE AND
DEPTH VIBRATION METHOD

CLAIMS

1. Depth vibrator pipe assembly (2) for connecting a depth vibrator (39) to a device (33), comprising:

a first pipe body (3) which is connectable to the device (33);

a second pipe body (4) which is connectable to the depth vibrator (39);

wherein the first pipe body (3) and the second pipe body (4) are telescopeable relative to one another.
2. The depth vibrator pipe assembly (2) according to claim 1, characterized in that locking means (12) are provided which the first pipe body (3) and the second pipe body (4) are detachably connectable to one another at least in a retracted position and in an extended position.
3. The depth vibrator pipe assembly (2) according to claim 2, characterized in that the locking means (12) comprise a plurality of locking units (13) which are arranged distributed over the circumference.
4. The depth vibrator pipe assembly (2) according to claim 3, characterized in that first locking units (13) are arranged in a first plane and second locking units (13) are arranged in a second plane, wherein the first plane and the second plane have an axial distance from one another.

5. The depth vibrator pipe assembly (2) according to claim 3 or 4, characterized in that the locking units (13) each comprise a locking element (14) and a compatible receptacle (15, 15') wherein the locking element (14) is associated with one of the two pipe bodies (3, 4) and the receptacle (15, 15') is associated with the other of the two pipe bodies (4, 3) and wherein the locking element (14) can be brought into engagement with the respective receptacle (15, 15').
6. The depth vibrator pipe assembly (2) according to claim 5, characterized in that the locking elements (14) are supported on the associated pipe body (3, 4) by clamping bolts (22) and are radially movable, wherein the locking elements (14) in the clamped state engage in the respective receptacle (15, 15') of the other pipe body (4, 3) so that the first pipe body (3) and the second pipe body (4) are firmly connected to one another.
7. The depth vibrator pipe assembly (2) according to claim 5, characterized in that the locking element (14) is supported on the associated pipe body (3, 4) by a piston (59) and is radially movable by hydraulic pressurization of the piston (59), wherein the locking elements (14) in the braced state engage in the respective receiving elements (15, 15') of the other pipe body (4, 3) so that the first pipe body (3) and the second pipe body (4) are firmly connected to one another.
8. The depth vibrator pipe assembly (2) according to any one of claims 1 to 7, characterized in that at least one sealing arrangement (26, 28) is provided between the first pipe body (3) and the second pipe body (4)

which seals the annular gap between the first pipe body (3) and the second pipe body (4).

9. The depth vibrator pipe assembly (2) according to any one of claims 1 to 8, characterized in that the first pipe body (3) and the second pipe body (4) are designed for use for a bottom-feed vibrator and each comprise a material pipe (8, 9) through which material for compacting the ground can flow as well as a cable conduit (10, 11) which is disposed laterally adjacent to the material pipe and through which an electrical cable (46) for the bottom-feed vibrator can be guided.
10. The depth vibrator pipe assembly (2) according to claim 9, characterized in that a reinforcement (25) is provided on an inner wall of the material pipe (8, 9) in the region of the locking units (13) which protects the locking unit (13) from through-flowing material.
11. The depth vibrator pipe assembly (2) according to any one of claims 1 to 8, characterized in that the first pipe body (3) and the second pipe body (4) are designed for use for a pressure vibrator and each have an inner channel through which an electrical cable (46) for the pressure vibrator can be guided.
12. Device (32) for depth vibration comprising:

an apparatus (33) with a mast (34),

a depth vibrator pipe assembly (2) according to any one of claims 1 to 11, which is held height-adjustably on the mast (34),

a depth vibrator (39) which is fastened to a lower end (7) of the depth vibrator pipe assembly (2),

a cable tensioning device (45) which is designed in such a manner that the electrical cable (46) for the depth vibrator (39) is guided in a tensioned condition during telescoping of the first pipe body (2) relative to the second pipe body (4).

13. The device (32) according to claim 12, characterized in that the cable tensioning device (45) is attached to the mast (34) and comprises a plurality of deflection pulley (48, 51) via which the electrical cable (46) is guided, and a weight (53) which acts upon at least one of the deflecting rollers (51) in order to tension the cable (46).

14. The device (32) according to claim 12 or 13, characterized in that a carriage (37) is provided which is held in a height-adjustable manner on the mast (34) wherein the depth vibrator pipe assembly (2) and the cable tensioning device (45) are fastened to the carriage (37).

15. Depth vibration method for producing columns in the ground with an device according to any one of claims 12 to 14, comprising the steps:

penetrating the depth vibrator (39) into the ground with retracted pipe assembly (2) as far as a first depth (T1);

releasing the locking means (12) effective between the first pipe body (3) and the second pipe body (4);

extending the pipe assembly (2) from the retracted into an extended position wherein the electrical cable (46) is guided by the cable tensioning device (45);

closing the locking means (12) so that the first pipe body (2) and the second pipe body (4) are axially firmly connected to one another in the extended position;

penetrating the depth vibrator (39) into the ground with extended pipe assembly (2) as far as a second depth (T2) which is greater than the first depth (T1);

constructing a first column section in the ground upon pulling the depth vibrator (39) with extended pipe assembly (2);

releasing the locking means (12) effective between the first pipe body (3) and the second pipe body (4) in the extended position;

retracting the pipe assembly (2) from the extended into a retracted position, wherein the electrical cable (46) is guided by the cable tensioning device (45);

closing the locking means (12) so that the first pipe body (3) and the second pipe body (4) are axially firmly connected to one another in the retracted position;

constructing a second column section above the first column section upon pulling the depth vibrator (39) with retracted pipe assembly (2).