Method and device for inserting a pile into the ground.

For inserting a prefabricated pile into the ground, in which a shaft is formed in the ground by introducing a steel sheath into the ground, the ground beneath the pile is consolidated by pressing the pile down whilst bearing on the sheath to be held in the ground.
Method and device for inserting a pile into the ground

The invention relates to a method of inserting a prefabricated pile into the ground, in which a shaft is formed in the ground by introducing a steel sheath into the ground, the prefabricated pile is slipped into the sheath and the sheath is removed from the shaft whilst leaving the pile in the ground.

Such a method is known. In the known method there is a risk that after the removal of the sheath the pile may subsequently sink too deeply into the ground due to lack of ground resistance.

The invention has for its object to improve the support of the pile, whilst by means of a comparatively light and readily maniable device the pile can be rapidly inserted into the ground without the risk of destruction of the pile. In a method according to the invention the ground beneath the pile is consolidated by pressing down the pile, which sets off from the sheath to be held in the ground, the sheath being removed from the ground not until has the consolidation been achieved.
The invention furthermore relates to and improves a device for inserting a prefabricated pile into the ground by using the method in accordance with the invention, said device comprising a tubular sheath and a displaceable guide frame having driving means for introducing the sheath into the ground. This device is characterized by setting-off means to be arranged between the pile and the sheath and by means for energizing said setting-off means in order to press down the pile during consolidation of the ground by setting off the pile against the sheath to be held in the ground and by means separated from the setting-off means for withdrawing the sheath from the ground.

The invention provides furthermore a pile inserted into the ground by the method according to the invention, said pile being characterized in that the pile is fixed in place with respect to the pile foot without the interposition of concrete locally shed in shaft by means of undeformable, interengaging contact surfaces between the pile foot and the pile.

The above-mentioned and further features of the invention will be explained in the following description with reference to drawings.

The drawings show schematically in figures 1, 6, 10, 11 and 12 longitudinal sectional views of a sheath with a pile during the consolidation of the ground located beneath the pile,

Figures 3, 4, 5 and 8 longitudinal sectional views of the lower end of the sheath during the introduction thereof into the ground,

Figures 2, 7 and 9 longitudinal sectional views of the lower end of a pile inserted into the ground by using the method shown in Figures 1, 6 and 8 respectively,

Figure 13 a plan view of a site during the insertion of piles into the ground,

Figure 14 on an enlarged scale a detail XIV of Figure 13,

Figure 15 a control-system for the device illustrated in Figure 14,
By the method according to the invention a prefabricated pile 1, for example, of reinforced concrete is inserted into the ground 4. As shown in Figures 1 and 2 a shaft 5 is formed in the ground 4 by introducing a steel sheath 3 into the ground 4. First a pile 1 with an integral, conical pile foot 2 is inserted at the ground surface into
the sheath 3. Subsequently the sheath 3 together with the
pile 1 inserted into it is introduced in some way or other
into the ground 4, after which the ground 29 beneath the pile
1 is consolidated by pressing down the pile 1 set off from
the sheath 3 to be held in the ground 4, which can be per-
formed by means of a hydraulic cylinder 96, the piston 97 of
which exerts pressure on the head 135 of the pile 1, whilst
the cylinder 96 is firmly secured to the sheath 3 by means of
bolts 136. During this consolidation of the ground 29 the
cylinder 96 and hence the sheath 3 are subjected to a weight
G, for example, a ballast weight and/or the weight of a
device for introducing the sheath 3 into the ground 4. Not
until has the ground 29 been additionally consolidated in the
manner described above, the sheath 3 is withdrawn from the
shaft 5, whilst leaving the pile 1 in the ground 4. During
the introduction of the sheath 3 into the ground 4 the pile
foot 2 and the sheath 3 - safeguarded against relative rotat-
ion - are preferably coupled with one another by coupling
means 6. This permits of exerting on the sheath 3 a torsional
moment, which is transferred to the pile foot 2 without the
pile 1 itself being subjected to torsional forces. The
coupling means 6 may be formed by projecting steel wedges 7
embedded in the pile 1 at the foot 2, which snap into
matching cavities 8 of the sheath 3, which are open on the
bottom side. When the sheath 3 is removed, the shaft 5 is
filled by earth or, if necessary, it is filled out from above
with earth, concrete or similar filling material. The sheath
3 can be introduced by exerting a downwardly directed pres-
sure, whilst it is simultaneously rotated in a reciprocatory
manner.

Preferably a pile 1 shown in Figures 1 and 2 is
introduced into the ground 4 by screwing it together with the
sheath 3 into the ground 4, the sheath 3 being pressed down
and rotated. Preferably the sheath 3 is provided throughout
its length (see Figure 1) or only at the lower end (see Fi-
gure 3) with a screw 12 by which the sheath 3 is also screwed
back upwardly, whilst the pile 1 is left in the ground 4. The pile 1 of Figure 4 has a screw 13 integral with the pile foot 2 having a pitch \( z \), which is equal to the pitch \( y \) of the screw 12.

In the method illustrated in Figures 5, 6 and 7 first a sheath 3 without a pile 1 but together with a pile foot 2, for example, of steel is screwed into the ground 4 (Figure 5). Subsequently the pile 1 with a cylindrical extension 14 is lowered in the sheath 3, the extension 14 penetrating into a matching cavity 15 of the pile foot 2. In this way the pile 1 is fixed in place with respect to the pile foot 2 without the interposition of concrete in the shaft 5 by means of undeformable contact surfaces of the extension 14 and the cavity 15 interengaging between the pile foot 2 and the pile 1. If desired, the extension 14 may be coated previously with a glue, cement or a similar solid adhesive layer.

In the method illustrated in Figure 8 a shaft 5 is formed by screwing a sheath 3 with its open end into the ground 4 and by removing the earth 25 penetrating into the sheath 3 upwardly out of the sheath 3, for example, by means of a rotating driven worm conveyor 16 thus having an excavating effect. Subsequently the pile 1 with a pile foot 2 rigidly connected with the pile above the ground or preferably formed integrally with the pile is lowered in the sheath 3. After an additional consolidation of the ground 29 the sheath 3 is pulled upwards.

In the method shown in Figure 10 the sheath 3 with a pile 1 arranged therein is screwed into the ground 29, whilst the pile foot 2 is secured to the lower end of the sheath 3 by means of screw bolts 137 having a predetermined common tensile strength. In order to additionally consolidate the ground 29 the pile 1 is compressed by means of the hydraulic cylinder 96, which is firmly secured to the top end of the sheath 3. When the screw bolts 137, which together constitute a shear joint, break down, the pile 1 is compressed to a predetermined extent. When the joint breaks
down, the pile 1 blows down on the ground 29, which is thus additionally consolidated, whilst the pile head 135 sets off against the sheath 3. The set-off is improved by the inertia of the sheath 3 and any weight bearing on the same.

Instead of using the method shown in Figure 10 an alternative may be employed though not with preference, in which the pile foot 2 is not connected with the lower end of the sheath 3 and the hydraulic cylinder 96 is connected by shear bolts 138 with the top end of the sheath 3 (see Figure 11). For consolidating the ground 29, the pile 1 is compressed, whilst its top end sets off against the sheath 3 screwed into the ground 4 to an extent predetermined by the strength of the shear bolts 138, at which extent the set-off from the sheath 3 is abruptly eliminated. Then the pile 1 leaps upwards, setting off from the ground 29, which is thus additionally consolidated.

In the method illustrated in Figure 12 the ground 29 is first additionally consolidated with a constant pressure by a small cylinder 143, to which fluid is fed from a pump 139 through an opened valve 140 and a central feeding tube 145 passed through a large cylinder 144. The piston 146 engages the steel, tubular pile 1 by way of a cap 147. The cap 147 is connected with the cylinder 143 by means of slack tensile springs 148. The small cylinder 143 is rigidly secured to the large cylinder 144, a differential piston 149 of which around the feeding tube 145 also extends into the small cylinder 143. The chamber 150 of the cylinder 144 communicates through a rotary gland 152, a spacious feeding duct 151 and a valve 141 with a pressure vessel 142, which is pressurized through a freely movable piston 153 with fluid from a pump 154. After the ground 29 has first been consolidated by a given constant load resulting from pressure in the small cylinder 143 and after a predetermined pressure has been built up in the pressure vessel 142 and measured by a manometer 155, a pawl 157 is removed by means of a lever 156, as a result of which the valve 141 is abruptly opened, since its flap 158 is blown away by the air against the slack spring
159. Then the large cylinder 144 exerts a pressure shock via the pile 1 on the ground 29, the pile setting again off from the sheath 3 screwed into the ground 4. The cylinder 144 is welded to a ring 57, which is fastened to a screw wheel 66 by which the helical movement of the sheath 3 is obtained. Above the ground 4, around the sheath 3, a funnel 160 is arranged for receiving earth 161 when the sheath 3 is screwed into the ground 4 with a higher speed than is required for screwing the sheath 3 into the ground 4 in relation to the pitch of the helix 12. The helix 12 then operates as a worm conveyor, which transports loose earth into the funnel 160. When the sheath 3 is screwed out of the ground 4, the loose earth flows from the funnel 160 back towards the helix 12, which conveys it back into the ground 4.

Referring to Figures 13 to 23 the piles 1 are inserted into the ground 4 at the locations 30 with the aid of a screwing tool 31 provided with the means shown in Figure 12.

From a pile store 32 a lifting implement 36 deposits each pile 1 on a sequence of rollers 33 of a pile inserting device 34. A sheath 3 being located in line on stationary supports 35 of the pile inserting device 34, the pile 1 is slipped in a lying state into the sheath 3 with the aid of a driving carriage 37, which by means of a control-member 38 sets control-slides 39 in a position in which the hydraulic cylinder 40 supporting each time a roller 33 is lowered for allowing a pile foot 2 integral with the pile 1 to pass. When the pile foot 2 hits the lower end of the sheath 3, the pile 1 is clamped tight to the sheath 3 by means of the clamping device 41 of Figures 12, 16 and 17. The clamping device 41 comprises three wedges 42, each of which is drawn by means of a hydraulic cylinder 43 into a clamping position and pushed out of said clamping position by springs 44, when the cylinders 43 are de-energized, each wedge being then conducted away from the pile 1 by means of an elongated member 46 fastened to the wedge along a pin 45 of a sliding guide 47. The sheath 3 with the pile 1 slipped into and clamped tight in it is deposited by means of the lifting
carriage 36 on a carriage 48, conveyed to the locations 30 and lifted by means of hoisting cables 49 from the screwing implement 31 into a vertical position and disposed along a stay frame 50 having rails 51, the sheath 3 being inserted into a support 52, which is passed by guide members 53 along the rails 51. During the insertion lugs 54 of the sheath 3 are passed through recesses 56 of a ring 57, which can be rotated by means of a hydraulic cylinder 55 and which is firmly held by clamps 58 on the above-mentioned helical wheel 66 rotatable in a bearing 162 of the annular support 52, whilst a lower ring 60 of the sheath 3 bears on the helical wheel 66. During the insertion of the sheath 3 into the ground 4 by screwing the vertical speed of the sheath 3 is related to the rotational speed thereof in accordance with the pitches y and z of the helices 12 and 13 on the sheath 3 and/or the pile foot 2 respectively (see Figure 24).

An electric motor 59 drives a gear wheel 61 with high power along a vertical toothed rack 62, whilst a further electric motor 63 actuates the rotation of said helical wheel 66 through a helical wheel 64. The speed of the electric motor 63 and hence the rotational speed of the sheath 3 is measured by means of a speedometer 67, whereas the speed of the motor 59 and hence the vertical speed of the sheath 3 is measured by means of a speedometer 68. The speedometers 67 and 68 apply a signal 69 and 70 respectively to a comparator 71 and 72 respectively both being adjusted by a common setting member 65 and each controlling a control-member 73 and 74 respectively for governing the electric motors 63 and 59 respectively. The power of the motors 63 and 59 is so high that the vertical load on the sheath 3 overcomes the sum of the sheath friction and the resistance of the pile foot. By means of the screwing implement 31 described above the sheath 3 is screwed into the ground 4 in a continuous advancing movement.

The screwing implement 31 shown in Figures 25 to 27 comprises a hydraulic worm device 76 having two clamps 77T and 77R engaging the sheath 3, each of which is provided with a hydraulic cylinder 78T and 78R respectively for energizing
the clamping jaws 79T and 79R respectively, which engage the sheath 3. The clamps 77T and 77R are vertically displaceable with respect to a turntable 89 by means of hydraulic cylinders 81T and 81R respectively. Referring to Figure 28 an electric motor 82 drives the identical pumps 85T, 85R and 86 through a driving gear 83 and a common driving shaft 84. By way of a hydraulic motor 87 and a pinion 88 the pump 86 drives the turntable 89, which is journalled in the frame 80 so as to be rotatable about a vertical axis 90. Furthermore an electric motor 94 drives a pump 93 for energizing the hydraulic cylinders 78T and 78R. Each pump 85T, 86, 85R and 93 is provided with a control-slide 91T, 92, 91R and 95 respectively, each of which is attracted towards the relay concerned by the energization of the relays 101 to 114.

In Figures 29 and 30 the energization diagrams of the relays are plotted versus time t by shaded beams for screwing the sheath 3 into the ground 4 and withdrawing the same respectively. The pumps, hydraulic cylinders, motor 87 and pinion 88 are proportioned so that the vertical rate of the sheath 3 hydraulically coupled with the rotational speed of the sheath 3 corresponds to the pitch y and/or z.

Figure 31 shows a different clamp 77, each hydraulic cylinder 81 being linked to a chain 98, which is stretched by means of a hydraulic cylinder 78 setting off from the other hydraulic cylinder 81.

The screwing implement 31 of Figure 32 differs from the screwing implements 31 described above in that it comprises a boom 120 adapted to pivot upwards about a shaft 99 by means of a hoisting cable 100, said boom having two clamps 121, each of which comprises a stationary clamping jaw 122 and two pivotable clamping jaws 123.

Referring to Figure 33 the empty sheath 3 is replaced by the pivotal movement of the clamps 121 in the direction of the arrow 124 about the boom 120 by a sheath 3 filled with a pile 1. When it is fixed in place in front of the stay frame 50 in the screwing device (not shown) of the screwing implement 31, the sheath 3 of Figure 34 is disengaged by the clamping jaw 123 pivoting in the direction of
the arrow 125, after which, as shown in Figure 35, the boom 120 swings down in the direction of the arrow 126, whilst in addition the clamps 121 turn in the direction of the arrow 127.

Referring to Figure 36, the empty sheath 3 is deposited on a carriage 128, whilst a sheath 3 filled with a pile 1 is removed therefrom by a pivotal movement of the clamping jaws 123 in the direction of the arrows 129 and 130 respectively, after which the boom 120 is again lifted in the direction of the arrow 131 and turned in the direction of the arrow 132 against an empty sheath 3 shown in Figure 37, when it is screwed out of the ground 4. Then the next cycle of Figure 33 starts. In this method the time of replacement of an empty sheath 3 by a filled one is very short. Thus the high power and the means required thereto for screwing the sheath 3 into and out of the ground 4 within a short time can be utilized effectively.
1. A method of inserting a prefabricated pile into the ground, in which a shaft is formed in the ground by introducing a steel sheath into the ground, the prefabricated pile is slipped into the sheath and the sheath is removed from the shaft whilst leaving the pile in the ground, characterized in that the ground beneath the pile is consolidated by pressing down the pile, which sets off from the sheath to be held in the ground and in that not until has the consolidation been achieved the sheath is removed from the ground.

2. A method as claimed in claim 1, characterized in that during the consolidation of the ground, whilst the pile is setting off against the sheath, said sheath is loaded by weight.

3. A method as claimed in claim 1 or 2, characterized in that during the consolidation of the ground the pile is compressed, whilst its top end is setting off against the sheath screwed into the ground, up to a predetermined extent,
at which setting off against the sheath is abruptly eliminated.

4. A method as claimed in claim 1, 2 or 3, characterized in that the pile foot is connected by means of an interruptible joint with the sheath and is introduced simultaneously with the sheath into the ground and in that the ground beneath the pile is consolidated by breaking said interruptible joint not until has the pile setting off against the sheath been compressed to a predetermined extent.

5. A method as claimed in claim 1 or 2, characterized in that during the consolidation of the ground the pile is set off from the sheath by pressing means producing a short pressure shock.

6. A method as claimed in anyone of the preceding claims, characterized in that the sheath is screwed into the ground.

7. A method as claimed in anyone of the preceding claims, characterized in that the pile with a pile foot rigidly connected herewith is inserted into the sheath above the ground surface and in that the sheath together with the pile held therein is introduced into the ground.

8. A method as claimed in claim 7, characterized in that the pile is inserted into the sheath held in a recumbent position.

9. A method as claimed in anyone of claims 1 to 6, characterized in that with respect to the pile foot the pile is fixed in place without the interposition of concrete locally shed in the sheath by means of undeformable, inter-engaging contact surfaces between the pile foot and the pile.

10. A method as claimed in anyone of the preceding claims, characterized in that the sheath is screwed into the ground by a substantially continuously advancing movement.

11. A device for inserting a prefabricated pile into the ground by using a method as claimed in anyone of the preceding claims, said device comprising a tubular sheath and a displaceable guide frame having driving means for introducing the sheath into the ground, characterized by setting-off means to be arranged between the pile and the sheath and
by means for energizing said setting-off means in order to press down the pile during consolidation of the ground by setting off the pile against the sheath to be held in the ground and by means separated from the setting-off means for withdrawing the sheath from the ground.

12. A device as claimed in claim 11, characterized by a pile inserting device for slipping a pile into a sheath being in a recumbent position.

13. A device as claimed in claim 11 or 12, characterized by driving means which drive the sheath in a continuously advancing movement.

14. A pile inserted into the ground by the method claimed in claim 9, characterized in that the pile is fixed in place with respect to the pile foot without the interposition of concrete locally shed in shaft by means of undeformable, interengaging contact surfaces between the pile foot and the pile.

15. A pile characterized by a pile foot with coupling means for a disengageable linkage to a sheath.

16. A pile as claimed in claim 15, characterized in that the coupling includes a connection which can be broken at a predetermined load.