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(54) **METHOD FOR DRIVING SPIRAL PILES AND A SPIRAL PILE**

(57) According to an example aspect of the present invention, there is provided a method for forming a pile foundation, comprising using a pile having a straight body (1) having a tip (3) and an operating end (4) and a spiral blade (2) extending away from the outer surface of the body (1) as a spiral that starts at the tip (4) of the body (1) and runs as a widening spiral thread towards operating end (4) of the of the body, and pushing the tip (4) of the of the pile towards ground and simultaneously rotating the pile at the operating end (4) so that the combination of pushing and rotating forces cause a movement wherein the axial travel speed of the pile matches the axial travel speed of the pile defined by the speed of rotation and the pitch of the spiral.

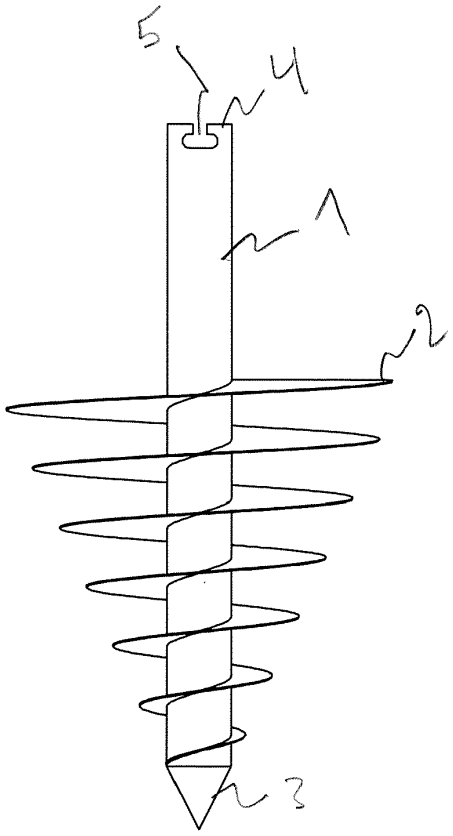

FIG. 1

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Description

FIELD

[0001] The invention relates to a method for forming a pile foundation by using piles with straight body and a helix blade or thread around said body. In particular, the invention relates to driving piles with a spiral blade. The invention concerns also piles with spiral blade for implementation of the method.

BACKGROUND

[0002] The bearing capacity of the ground is a limiting factor in infrastructure and building industry. The bearing capacity or the ground under a building, a road or any other structure has to be sufficient to carry the weight of the buildings, wind and wave loads, vibrations and change in soil humidity, freezing and melting of the soil. Quite often, the loading capacity of the ground is limited and has to be enhanced to be sufficient for intended building purposes. There are several known methods for increasing the loading capacity. One of known methods is piling with screw piles. These piles have a straight body and a helical or conical wing or screw around at least part of the body. The screw piles are driven into the ground by rotating them so that the screw thread draws the pile downwards. The number of piles, dimensions of the piles and their location are determined by properties of the ground and the weight and other loads caused by the structure to be carried by the piling and ground. The piles may be filled with concrete or they may include parts for injecting concrete or other substances to the ground. Such pilings are used in building industry, road and infrastructure industry and even marine infrastructure constructions.

[0003] Examples of screw piles and methods for utilizing them are disclosed in following publications: RU 2537463, RU 2426835, RU 2564714, JP 4828148, SU 870586, RU 2304664, JP 2003027471, RU 194016, JP H09256359 and WO 2020236040.

SUMMARY OF THE INVENTION

[0004] The invention is defined by the features of the independent claims. Some specific embodiments are defined in the dependent claims.

[0005] According to a first aspect of the present invention, there is provided a method for forming a pile foundation, comprising:

- using a pile having a straight body having a tip and an operating end and a spiral blade extending away from the outer surface of the body as a spiral that starts at the tip of the body and runs a s a widening spiral thread towards operating end of the of the body,
- pushing the tip of the of the pile towards ground and simultaneously rotating the pile at the operating end so that the combination of pushing and rotating forces cause a movement wherein the axial travel speed of the pile matches the axial travel speed of the pile defined by the speed of rotation and the pitch of the spiral.

[0006] According to a second aspect of the present invention, there is provided a pile having a straight body having a tip and an operating end and a spiral blade extending away from the outer surface of the body as a spiral that starts at the tip of the body and runs as a widening spiral thread towards operating end of the of the body and the °pitch of the spiral is 16,9°.

[0007] Some further aspects of the invention that are combinable with the first aspect as single features or in any combination are:

- surveying the ground for piling and determining the pushing and rotating forces according to the survey,
- surveying the ground by a ground radar,
- using a geolocation service for placement of the piles,
- measuring the speed of rotation of the pile,
- measuring the rotation torque needed to rotating the pile,
- measuring the axial travel speed of the pile,
- controlling the rotating and pushing forces on basis of at least one of the measured variables including speed of rotation, rotation torgue and axial travel speed,
- the blade of the pile extends in a straight angle from the body,
- the largest diameter of the spiral blade is 600 - 2000 mm preferably at least 1200 mm, the smallest being 0,
- the length of the spiral is 1500 mm,
- the tip of the pile has a shape of a closed cone.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] FIGURE 1 illustrates a spiral pile in accordance with at least some embodiments of the present invention.

EMBODIMENTS

DEFINITIONS

[0009] In the present context, the term geolocation comprises methods based on satellite location systems such as GPS.

[0010] This invention relates to reinforcing ground for building or infrastructure purposes. The invention provides a silent and vibration less method to assembling piles. The method can be used for sites having very low load bearing capacity such as wetlands, swamps and shores. In the method, a screw pile having a large spiral blade is driven on a specifically determined rotating and pushing force on the ground.

[0011] FIGURE 1 illustrates a pile in accordance with at least some embodiments of the present invention. The measurements are presented as examples of dimensions presently considered operable and useful. However, the measurements vary according to the type of the ground and the required load bearing capacity.

[0012] The pile is made of steel. The suitable steel material depends of the environment where the pile is used. The most cost effective is construction steel. Stainless steel or acid-proof steel are used when such durability is needed. Naturally, the pile may be coated to increase durability. The pile comprises a central body 1 defining he longitudinal axis of the pile. The body is formed of a tube that has a diameter of 200 mm, wall thickness of 10 mm and is 2000 mm long. An advantageous range of these measurements are for diameter of the body 100 - 300 mm, for wall thickness of the body tube 10 - 30 mm.

[0013] The tip 2 of the pile is formed of a closed cone that is placed on the first end of the body 1. The largest diameter of the cone is dimensioned to match the diameter of the body, being n the range of 100 - 300 mm. A blade 2 is attached on the outer surface of the body for example by welding. The blade 2 is a spiral that has its point at the end of the tube that forms the body 1 and starts from the boundary joint between the tip and the tube forming the body 1. The spiral of the blade 2 does not extend to the tip 3. The blade 2 is in straight angle in relation to the body 1, i.e. extends away from the surface of the body 1 so that at any given point of the spiral, the crosswise radius line on the spiral is in straight angle to the central axis of the body (and the pile). This is relevant for allowing the compacting action in the mounting stage of the method. The spiral starts from the surface of the body and widens along the length of the spiral. The maximum diameter of the spiral is in this example 1200 mm and the length is 1500 mm. The large diameter at the top of the spiral provides vary large load carrying surface over the whole blade 2. The length of the blade may be adjusted shorter or longer according to the type of the soil in which the pile is used. The pitch of the spiral of the blade 2 is 16,9°. As the blade has to withstand high forces, its material thickness has to be sufficient, in the range of 4 - 16 mm.

[0014] If necessary, the body, or the pipe of the body 1 can be increased by extension tubes, having a length of 2000 - 3000 mm, for example. By using the extension tubes the pile can be turned as deep as desired. At the end opposite to the tip 3 the body has an operating end that comprises a tool fitting 5. The tool fitting is provided for attaching he pile to an operating driver that provides rotating force and pushing force. The tool fitting 5 is designed to accommodate the operating driver. The same tool fitting is used for attaching extension tubes to the pile. The tool fitting shown in the drawing has a groove extending along the longitudinal axis of the pile and ending to crosswise cut. The width of the groove is 50 mm and the width of the cut is 150 for example.

[0015] The pile is mounted or assembled by using a rotating device that is mounted on a suitable actuator enable for providing a pushing force towards ground. The idea of the method is to turn the pile into the ground in a screw like manner so that the narrow point of the spiral blade forms a beginning of a thread and the widening spiral of the blade 2 extends and follows that thread when the pile is rotated and pushed axially. The rotation of the pile is not allowed to cause downwards pushing force caused by the rotation so that the upper surface of the blade is loaded against the soil. This would cause lifting of the soil upwards whereby the structure of the soil is loosened and loading capacity under the following rounds of the blade is compromised. The pile is driven to the ground as a screw on a thread. This is accomplished by controlling the pushing force and the rotation speed. The tip 3 of the (the whole pile accordingly) is pushed towards to the ground and the pile is simultaneously rotated at the operating end 4. The combination of pushing and rotating forces cause a movement wherein the axial travel speed of the pile matches the axial travel speed of the pile defined by the speed of rotation and the pitch of the spiral. In this way, the soil is compressed and pushed against the body 1 of the pole locking the pile into the soil.

[0016] The pushing force and rotation speed may be controlled by the operator of the mounting apparatus. In that case one indicator that induces need for adjustment is detection of any lifting of the soil around the entry point of the pile. If such lifting is detected, the pushing force should be increased or the rotation speed decreased, or both. In order to facilitate the work of the operator or to fully or partly automate the operation, one or more of the factor affecting the pile driving action may be measured. These include the speed of rotation of the pile, the rotation torque needed for rotating the pile, the axial travel speed of the pile. A change in one or more of these variables indicate deviation of the threaded rotation defined by the pitch and rotation speed and should usually be corrected. The rotating and pushing forces are then controlled on basis of at least one of the measured variables including speed of rotation, rotation torque and axial travel speed.

[0017] The actuator machine providing the mounting action can be accomplished in several ways. One alter-

native is to used a pole tower, for example a mast of a large loading truck whereon a motor providing sufficient torque is mounted. The torque of the motor is 135 000 Nm, for example. The motor provides the rotating force and the pole tower the downward pushing force. In addition to these, the actuator machine has to be sufficiently mobile to be moved to a location where the poles is to be sited. The pole tower may be mounted on a wheeled loader, excavator or a specific combination machine. It can be further contemplated, that the rotating motor of other rotating actuator is mounted on a boom of an excavator or a mobile logging machine so that the boom can provide the pushing force. These machines usually include a geolocation capabilities that can be us for correct placement of the piles. Of course, the piles may be located by using any method used in construction industry. The piles are preferably set crosswise to the ground that is piled. A measurement and signal devices are used for ascertain proper placement.

[0018] The method has several uses. In municipal areas, the method provides a silent and vibration less mounting system. The piles may be located close to each other and/or on different heights. On swamps waterways and shores, the method provides a piling that stays well in place and give solid support. A auxiliary piling to strengthen old wooden pilings is possible and the method gives good access close to walls and other structures. The pile and method can be used for all kinds of building and construction and its silent and vibration les mounting method provides many advantages to, for example concrete piles.

[0019] It is to be understood that the embodiments of the invention disclosed are not limited to the particular structures, process steps, or materials disclosed herein, but are extended to equivalents thereof as would be recognized by those ordinarily skilled in the relevant arts. It should also be understood that terminology employed herein is used for the purpose of describing particular embodiments only and is not intended to be limiting.

[0020] Reference throughout this specification to "one embodiment" or "an embodiment" means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment of the present invention. Thus, appearances of the phrases "in one embodiment" or "in an embodiment" in various places throughout this specification are not necessarily all referring to the same embodiment.

[0021] As used herein, a plurality of items, structural elements, compositional elements, and/or materials may be presented in a common list for convenience. However, these lists should be construed as though each member of the list is individually identified as a separate and unique member. Thus, no individual member of such list should be construed as a de facto equivalent of any other member of the same list solely based on their presentation in a common group without indications to the contrary. In addition, various embodiments and example of the present invention may be referred to herein along with alternatives for the various components thereof. It is understood that such embodiments, examples, and alternatives are not to be construed as de facto equivalents of one another, but are to be considered as separate and autonomous representations of the present invention.

[0022] Furthermore, the described features, structures, or characteristics may be combined in any suitable manner in one or more embodiments. In the following description, numerous specific details are provided, such as examples of lengths, widths, shapes, etc., to provide a thorough understanding of embodiments of the invention. One skilled in the relevant art will recognize, however, that the invention can be practiced without one or more of the specific details, or with other methods, components, materials, etc. In other instances, well-known structures, materials, or operations are not shown or described in detail to avoid obscuring aspects of the invention.

[0023] While the forgoing examples are illustrative of the principles of the present invention in one or more particular applications, it will be apparent to those of ordinary skill in the art that numerous modifications in form, usage and details of implementation can be made without the exercise of inventive faculty, and without departing from the principles and concepts of the invention. Accordingly, it is not intended that the invention be limited, except as by the claims set forth below.

[0024] The verbs "to comprise" and "to include" are used in this document as open limitations that neither exclude nor require the existence of also un-recited features. The features recited in depending claims are mutually freely combinable unless otherwise explicitly stated. Furthermore, it is to be understood that the use of "a" or "an", i.e. a singular form, throughout this document does not exclude a plurality.

INDUSTRIAL APPLICABILITY

[0025] The invention can be used in building industry for preparing groundwork and basis for foundations in various circumstances.

REFERENCE SIGNS LIST

[0026]

1 body

2 blade

3 tip

4 operating end

5 tool fitting

CITATION LIST

Patent Literature:

[0027] RU 2537463, RU 2426835, RU 2564714, JP 4828148, SU 870586, RU 2304664, JP 2003027471, RU 194016, JP H09256359 and WO 2020236040

Claims

1. Method for forming a pile foundation, comprising:

- using a pile having a straight body (1) having a tip (3) and an operating end (4) and a spiral blade (2) extending away from the outer surface of the body (1) as a spiral that starts at the tip (4) of the body (1) and runs as a widening spiral thread towards operating end (4) of the of the body,
- pushing the tip (4) of the of the pile towards ground and simultaneously rotating the pile at the operating end (4) so that the combination of pushing and rotating forces cause a movement wherein the axial travel speed of the pile matches the axial travel speed of the pile defined by the speed of rotation and the pitch of the spiral.

2. A method according to the claim 1, comprising surveying the ground for piling and determining the pushing and rotating forces according to the survey.

3. A method according to the claim 2 comprising surveying the ground by a ground radar.

4. A method according to one of the claims 1 - 3, comprising using a geolocation service for placement of the piles.

5. A method according to one of the claims 1-4, comprising measuring at least one of the variables of: the speed of rotation of the pile, the rotation torque needed to rotating the pile, measuring the axial travel speed of the pile.

6. A method according to the claim 5, comprising controlling the rotating and pushing forces on basis of at least one of the measured variables including speed of rotation, rotation torque and axial travel speed.

7. A pile, comprising a straight body (1) having a tip (3) and an operating end (4) and a spiral blade (2) extending away from the outer surface of the body (1) as a spiral that starts at the tip (3) of the body (1) and runs as a widening spiral thread towards operating end (49 of the of the body (1) and the pitch of the spiral is 16,9°.

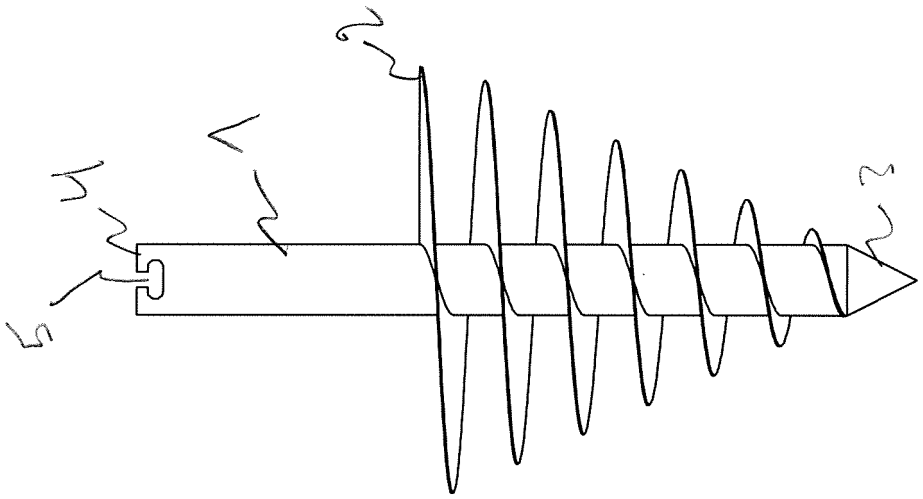
8. A pile according to the claim 7, wherein the blade (2) of the pile extends in a straight angle from the body (1).

9. A pile according to the claim 7 or 8, wherein the the largest diameter of the spiral blade is at least 1200 mm.

10. A pile according to one of the claims 7-9, wherein the length of the spiral is 1500 mm.

11. A pile according to one of the claims 7 - 10, wherein the tip (4) of the pile has a shape of a closed cone.

Fig. 1



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EUROPEAN SEARCH REPORT

Application Number
EP 23 16 0036

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X Y	CN 112 922 011 A (UNIV TIANJIN) 8 June 2021 (2021-06-08) * the whole document *	1,3,7-11 2,4-6	INV. E02D5/56 E02D7/22 E02D1/02
X	AU 2003 200 645 A1 (EVOLUTION INTERNAT PTY LTD) 2 October 2003 (2003-10-02) * pages 10-15 *	1,3,7-11	
X	GB 2 365 455 A (BESSINGER HENRY JOHN [GB]) 20 February 2002 (2002-02-20) * the whole document *	1,3,8-11	
X	RU 2 537 463 C1 (KHRUSTALEV EVGENIJ NIKOLAEVICH [RU]) 10 January 2015 (2015-01-10) * abstract; claims; figures *	1,3,8-11	
Y	JP 2019 218788 A (YBM CO LTD) 26 December 2019 (2019-12-26) * paragraphs [0003], [0019] - [0022]; figures *	2,5,6	
			TECHNICAL FIELDS SEARCHED (IPC)
Y	US 9 002 539 B2 (KAISER FRANZ [DE]; KRINNER INNOVATION GMBH [DE]) 7 April 2015 (2015-04-07) * columns 4-6; figures *	4	E02D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	27 July 2023	Movadat, Robin

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

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Application Number
EP 23 16 0036

CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing claims for which payment was due.

☐ Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due and for those claims for which claims fees have been paid, namely claim(s):

☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due.

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

see sheet B

☐ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.

☒ As all searchable claims could be searched without effort justifying an additional fee, the Search Division did not invite payment of any additional fee.

☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:

☐ None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:

☐ The present supplementary European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims (Rule 164 (1) EPC).

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LACK OF UNITY OF INVENTION
SHEET B

Application Number
EP 23 16 0036

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

1. claims: 1-11

Method and device for forming a pile foundation

1.1. claims: 7-11

Pile with a pitch of 16,9°

Please note that all inventions mentioned under item 1, although not necessarily linked by a common inventive concept, could be searched without effort justifying an additional fee.

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 23 16 0036

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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27-07-2023

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- RU 2537463 **[0003] [0027]**
- RU 2426835 **[0003] [0027]**
- RU 2564714 **[0003] [0027]**
- JP 4828148 B **[0003] [0027]**
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- RU 2304664 **[0003] [0027]**
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- RU 194016 **[0003] [0027]**
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- WO 2020236040 A **[0003] [0027]**