

METHOD OF INSTALLATION OF SCREWED PILE, METHOD OF PRODUCTION OF
GROUP OF PILES, GROUP OF PILES, INSTALLATION MANAGEMENT APPARATUS
OF SCREWED PILE, AND INSTALLATION MANAGEMENT SYSTEM
OF SCREWED PILE

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FIELD

[0001]

10 The present invention relates to a method of installation of a screwed pile, a method of
production of a group of piles, a group of piles, an installation management apparatus of a
screwed pile, and an installation management system of a screwed pile.

BACKGROUND

[0002]

15 In the past, for driving a screwed pile provided with a helical blade etc. into the ground,
for example, installation management methods such as in PTLs 1 and 2 have been proposed.

[0003]

20 PTL 1 discloses an installation management method for installation of a screwed pile
having one or more blades at an outside surface of a bottom end of the pile. This method obtains
measurement data of an amount of screw-in of the pile per turn at the time of installation to
enable optimal installation by screw-in of the screwed pile or enable calculation of the push-in
support or withdrawal resistance together with the measurement data of the torque and vertical
load at the pile head.

[0004]

25 PTL 2 discloses an installation management method of a screw-in steel pipe pile which
connects an all casing machine screwing a steel pipe pile into the ground and a crawler crane or
other heavy machinery through a one-directional reaction bar. In installation of this screw-in
steel pipe pile, the axial force acting on the steel pipe pile or the torque acting on the all casing
machine is controlled to thereby prevent failure of the pile body.

[CITATION LIST]

30 [PATENT LITERATURE]

[0005]

[PTL 1] Japanese Unexamined Patent Publication No. 2002-21076

[PTL 2] Japanese Unexamined Patent Publication No. 2005-23775

SUMMARY

35 [TECHNICAL PROBLEM]

[0006]

However, in the conventional installation management method and the installation management method of PTLs 1 and 2, cases of the screwed pile failing have been reported. Further, failure of the screwed pile is prevented by experience of the installer. As a result, there is the problem of the screwed pile failing or the work efficiency falling when preventing the screwed pile from failing by use of installation conditions at a site set safer than necessary. For this reason, an installation method able to prevent failure of a screwed pile by suitable management of the installation conditions has been desired.

[0007]

Therefore, the present invention was made in consideration of the above-mentioned problem and has as its object to provide a method of installation of a screwed pile able to prevent failure of a screwed pile, a method of production of a group of piles, a group of piles, an installation management apparatus of a screwed pile, and an installation management system of a screwed pile.

[SOLUTION TO PROBLEM]

[0008]

The method of installation of a screwed pile according to a first aspect of the invention comprises a method of installation for driving a screwed pile provided with a blade into the ground, comprising a measurement step of measuring pile information including an amount of displacement of the screwed pile and a rotational torque of the screwed pile while screwing the screwed pile into the ground, a comparison step of judging normality or abnormality of a pile body from a relationship of the rotational torque and misalignment based on preset threshold values, and a control step controlling a condition of screw-in of the screwed pile based on the pile information, the control step performing control based on results of the comparison step so as to decrease the rotational torque of the screwed pile or stop or reverse rotation.

[0009]

The method of installation of a screwed pile according to a second aspect of the invention comprises the first aspect of the invention wherein the measurement step measures as the amount of displacement at least one of an amount of movement of the screwed pile from an initial set position in a horizontal plane and an amount of relative inclination of a casing driver holding the screwed pile and the screwed pile.

[0010]

The method of installation of a screwed pile according to a third aspect of the invention comprises the second aspect of the invention wherein the measurement step measures as the amount of displacement an amount of positional offset of a bearing plate sandwiched between the ground and the casing driver.

[0011]

The method of installation of a screwed pile according to a fourth aspect of the invention comprises any one of the first aspect of the invention to the third aspect of the invention wherein the pile information further includes at least one of an amount of screw-in of the screwed pile and a vertical load of the screwed pile.

5 **[0012]**

The method of installation of a screwed pile according to a fifth aspect of the invention comprises any one of the first aspect of the invention to the fourth aspect of the invention wherein the control step has a comparison step comparing reference pile information relating to a preset condition of screw-in of the screwed pile and the pile information and judging normality or abnormality.

10 **[0013]**

A method of production of a group of piles according to a sixth aspect of the invention comprises a group of piles including a plurality of screwed piles driven down to a bearing layer of the ground by a method of installation of a screwed pile according to any one of the first aspect of the invention to the fifth aspect of the invention.

15 **[0014]**

A group of piles according to a seventh aspect of the invention includes a plurality of screwed piles produced by the method of production of the group of piles of the sixth aspect of the invention and driven down to a bearing layer of the ground.

20 **[0015]**

An installation management apparatus of screwed pile according to an eighth aspect of the invention comprises an installation management apparatus used for driving a screwed pile provided with a blade into the ground, comprising an acquiring means for acquiring pile information measured while screwing the screwed pile into the ground, a storage part for storing the pile information, and a display part for displaying the pile information, the pile information including an amount of displacement of the screwed pile.

25 **[0016]**

The installation management apparatus of a screwed pile according to a ninth aspect of the invention comprises the eighth aspect of the invention further comprising a comparison part comparing reference pile information relating to a condition of screw-in of the screwed pile and the pile information and classifying the pile information as normal or abnormal and a generating part generating alert information alerting a worker of an abnormality when the comparison part classifies the pile information as abnormal, the reference pile information being stored in the storage part in advance.

30 **[0017]**

An installation management system of a screwed pile according to a 10th aspect of the

invention comprises an installation management system used for driving a screwed pile provided with a blade into the ground, comprising an acquiring means for acquiring pile information measured while screwing the screwed pile into the ground, a storage part for storing the pile information, and an output means for outputting the pile information, the pile information including an amount of displacement of the screwed pile.

[ADVANTAGEOUS EFFECTS OF INVENTION]

[0018]

According to the first aspect of the invention to the fifth aspect of the invention, the measurement step measures pile information including the amount of displacement of the screwed pile and rotational torque of the screwed pile while screwing the screwed pile into the ground and judges normality or abnormality of the pile body from the relationship of the rotational torque and misalignment based on preset threshold values. For this reason, a worker can estimate the state of the screwed pile during screw-in based on the amount of displacement and performs control to reduce the rotational torque of the helical body or stop or reverse the rotation based on the results of judgment of normality or abnormality of the pile body. Due to this, it becomes possible to prevent failure of the screwed pile.

[0019]

In particular, according to the second aspect of the invention, the measurement step measures as the amount of displacement at least one of the amount of movement of the screwed pile from the initial set position in the horizontal plane and the amount of relative inclination of the casing driver and the screwed pile. For this reason, it is possible to measure the amount of displacement without greatly changing the conventional installation method. Due to this, it becomes possible to easily measure the amount of displacement.

[0020]

In particular, according to the third aspect of the invention, the measurement step measures as the amount of displacement the amount of positional offset of a support plate. For this reason, compared to when directly measuring the amount of displacement of the screwed pile, it is possible to suppress fluctuation of measurement values accompanying rotation of the screwed pile. Due to this, it becomes possible to measure the amount of displacement with a high precision.

[0021]

In particular, according to the fourth aspect of the invention, the pile information further includes at least one of an amount of screw-in of the screwed pile and a vertical load of the screwed pile. For this reason, a worker can combine the amount of displacement of the screwed pile and screw-in condition to estimate the state of the screwed pile. Due to this, it becomes possible to prevent failure of the screwed pile from multiple viewpoints.

[0022]

In particular, according to the fifth aspect of the invention, the comparison step compares the reference information and the pile information to judge normality or abnormality. For this reason, it is possible to suppress fluctuation of subjective judgment criteria for each worker. Due to this, it becomes possible to prevent the screwed pile from failing without relying on the work skills of the worker etc.

[0023]

In particular, according to the sixth aspect of the invention and the seventh aspect of the invention, the screwed pile is driven down to the bearing layer of the ground by the method of installation of a screwed pile in any one of the first aspect of the invention to the fifth aspect of the invention. By screw-in of a plurality of screwed piles down to the bearing layer of the ground by this method of installation, it becomes possible to produce and realize a group of piles including a plurality of screwed piles installed in a state preventing failure.

[0024]

In particular, according to the eighth aspect of the invention and the ninth aspect of the invention, the acquisition part acquires pile information including the amount of displacement of a screwed pile measured while screwing the screwed pile into the ground. Further, the display part displays the pile information. That is, an amount of displacement which would become a factor of failure of the screwed pile can be confirmed by a worker through a display part. For this reason, the worker can estimate the state of the screwed pile based on the amount of displacement. Due to this, it becomes possible to prevent failure of the screwed pile.

[0025]

In particular, according to the ninth aspect of the invention, the generating part generates alert information when classifying the pile information as abnormal at the comparison part. For this reason, by displaying an alert at the display part etc. based on the alert information, a worker can be informed of the higher possibility of failure of the screwed pile. Due to this, the worker does not have to constantly monitor the pile information through the display part etc. and the work efficiency can be improved. Further, it is possible to suppress fluctuation of the subjective judgment criteria for each worker. Due to this, it becomes possible to prevent failure of the screwed pile without regard as to the work skills etc. of the worker.

[0026]

In particular, according to the 10th aspect of the invention, the acquiring means acquires pile information including the amount of displacement of the screwed pile measured while screwing the screwed pile into the ground. That is, it is possible to notify an amount of displacement which would become a factor of failure of the screwed pile through a display part etc. to a worker or work manager etc. For this reason, a worker or work manager etc. can

estimate the state of the screwed pile based on the amount of displacement. Due to this, it becomes possible to prevent failure of the screwed pile.

BRIEF DESCRIPTION OF DRAWINGS

[0027]

FIG. 1A is a cross-sectional view showing one example of a method of installation of a screwed pile in the present embodiment, FIG. 1B is a cross-sectional view showing a state of a screwed pile driven down to a bearing layer in the present embodiment, and FIG. 1C is a cross-sectional view showing a state of a screwed pile being driven into the ground in an eccentric state.

FIG. 2 is a block diagram showing one example of an installation management system of a screwed pile in the present embodiment.

FIG. 3 is a perspective view showing one example of an auger machine and various measuring devices used in an installation management system of a screwed pile in the present embodiment.

FIG. 4 is a perspective view showing an example of a misalignment.

FIG. 5 is a top view showing one example of a casing driver used in an installation management system of a screwed pile in the present embodiment.

FIG. 6A is a cross-sectional view showing one example of a casing driver and various measuring devices used in an installation management system of a screwed pile in the present embodiment, and FIG. 6B is a plan view along the line 6B-6B along FIG. 6A.

FIG. 7A is a flow chart showing one example of a method of installation of a screwed pile in the present embodiment while FIG. 7B is a flow chart showing one example of a control step.

FIG. 8 is a graph showing a relationship between a rotational torque acting on a screwed pile and a result of analysis of a part of stress concentration in the screwed pile.

FIG. 9 is a graph showing a relationship of a misalignment and a rotational torque.

FIG. 10 is a graph showing a relationship among a misalignment, rotational torque, and vertical load.

FIG. 11 is a side view showing one example of a screwed pile during screw-in.

FIG. 12 is a schematic view showing a modification of an installation management system of a screwed pile in the present embodiment.

FIG. 13A is a schematic view showing one example of the constitution of an installation management apparatus of a screwed pile in the present embodiment, while FIG. 13B is a schematic view showing one example of the functions of an installation management apparatus of a screwed pile in the present embodiment.

FIG. 14A is a flow chart showing one example of an operation of an installation

management system of a screwed pile in the present embodiment, while FIG. 14B is a flow chart showing one example of a comparing means and alert means.

FIG. 15 is a graph showing one example of an installation record.

DESCRIPTION OF EMBODIMENTS

[0028]

Below, modes for working a method of installation of a screwed pile, a screwed pile, an installation management apparatus of a screwed pile (below, “installation management apparatus”), and an installation management system of a screwed pile (below, “installation management system”) applying the present invention will be explained in detail while referring to the drawings.

[0029]

Method of Installation of Screwed pile, Screwed pile 17, Installation Management Apparatus 6, and Installation Management System 100

The method of installation of a screwed pile in the present embodiment, as shown in FIG. 1A, is performed so as to drive a screwed pile 17 into the ground 91. In the method of installation of a screwed pile, for example, a casing driver 21 etc. is used to clamp a screwed pile 17, screw a screwed pile 17 into the ground 91 in the pile axial direction Z, and drive the screwed pile 17 down to the bearing layer 92 (for example, FIG. 1B). The method of installation of the screwed pile, for example, is performed using the installation management system 100.

[0030]

In the method of installation of a screwed pile, for example, a deviation measuring device 1 is used to measure the amount of displacement of the screwed pile 17 while screwing the screwed pile 17 into the ground 91. The amount of displacement shows at least one of the amount of movement of the screwed pile 17 from an initial set position in a horizontal plane accompanying screw-in of the screwed pile 17 (amount of positional offset) and amount of inclination (amount of change of inclination angle). Note that, for example, it is possible to use a support plate 41 sandwiched between the ground 91 and casing driver 21 holding the screwed pile 17 to obtain the amount of displacement of the screwed pile 17. In this case, the amount of positional offset of the support plate 41 accompanying screw-in of the screwed pile 17 can be measured as the amount of displacement of the screwed pile 17.

[0031]

Here, the fact that the amount of displacement of the screwed pile 17 while screwing it in relates to the degree of eccentricity of the screwed pile 17 in the pile axis perpendicular direction X (misalignment) was discovered by the inventors. Eccentricity of the screwed pile 17, for example, as shown in FIG. 1C, occurs when screwing the screwed pile 17 into the ground 91. The misalignment of the screwed pile 17 tends to become larger if the helical blade 16 of the

screwed pile 17 contacts the hard soil or an obstacle. For this reason, for example, as shown in FIG. 1C, if continuing to screw in the screwed pile 17 in the state where the screwed pile 17 is eccentric, the bending force acting on the screwed pile 17 increases and the possibility of the screwed pile 17 breaking rises.

5 **[0032]**

While screwing in the screwed pile 17, the misalignment tends to be correlated with the amount of displacement. For this reason, by adding the amount of displacement to the conditions of installation management, it is possible to estimate the misalignment of the screwed pile 17. For example, if the amount of displacement of the screwed pile 17 exceeds a predetermined
10 value, it can be judged to have reached a misalignment with a high possibility of failure of the screwed pile 17. For this reason, the method of installation of the screwed pile measures pile information including the amount of displacement of the screwed pile 17 and rotational torque of the screwed pile and judges normality or abnormality of the pile body from the relationship of the rotational torque and misalignment based on the preset threshold value to thereby enable a
15 worker to estimate the state of the screwed pile 17. Further, it is possible to perform control to decrease the rotational torque of the screwed pile or reverse the screwed pile based on the result of judgment of normality or abnormality of the pile body to thereby prevent failure of the screwed pile 17.

[0033]

20 For example, if measuring as the amount of displacement the amount of positional offset from the initial set position of the screwed pile 17 before screwing in the screwed pile 17 (two-dot chain line of FIG. 1C)) to the position of the screwed pile 17 when the screwed pile 17 reaches the bearing layer 92 (one-dot chain line of FIG. 1C), it is possible to estimate the measured amount of displacement as the misalignment e1 of the screwed pile 17.

25 **[0034]**

The screwed pile 17 in the present embodiment is configured from a screwed pile body and spiral shaped helical blade 16 provided at the front end of the same. The screwed pile body, for example, is comprised of a plurality of steel pipes welded together in the longitudinal direction. The screwed pile 17 is driven into the ground 91 and, for example, driven into the
30 bearing layer 92 at the pile tip. Note that, the shape of the blade of the screwed pile 17 is not limited to a spiral. For example, instead of a helical blade 16, a pair of semicircular shaped blades may be provided at the screwed pile body.

[0035]

The diameter of the screwed pile 17, for example, is $\phi 100$ mm to 1600 mm or so. The
35 pile plate thickness is, for example, 4.2 mm to 25 mm or so. The diameter of the helical blade 16 is, for example, 1.5 times to 2.5 times or so the pile diameter. The bearing layer 92 in which the

tip of the screwed pile 17 is driven is, for example, made of sand, gravel soil, or cohesive soil or a layer with a soil quality of sandy soil or gravelly soil and has an N value of 15 or more.

[0036]

The installation management system 100 of the screwed pile in the present embodiment, for example, as shown in FIG. 2, is provided with the installation management apparatus 6. FIG. 2 is a schematic view of an arrangement of various measuring devices 1 to 5 for measuring pile information showing the state of installation of the screwed pile 17 and the installation management apparatus 6.

[0037]

The installation management system 100 is provided with the deviation measuring device 1 for measuring the amount of displacement of the screwed pile 17. For example, it is provided with at least one of a rotational angle measuring device 2, penetration measuring device 3, rotational torque measuring device 4, and vertical load measuring device 5. The installation management system 100 may be provided with a data converter 7 able to send and receive data with respect to the above-mentioned various measuring devices 1 to 5 and an interface box 8 connecting the data converter 7 and the installation management apparatus 6. Note that, the installation management system 100, for example, may be provided with a data input part 9 into which data of an N value obtained in advance by soil surveys can be input. In addition, for example, data of the N value may be stored in the installation management apparatus 6 in advance. The installation management apparatus 6 acquires data from the various measuring devices 1 to 5 etc., performs processing in accordance with need, and displays the results on a monitor screen 6b. It also can print them out by a connected printer 6c.

[0038]

Auger Machine 15

In the installation management system 100 of the screwed pile, as the screw-in apparatus of the screwed pile 17, for example a pile driver leader 10 and auger machine 15 may be used. FIG. 3 is a perspective view showing one example of the pile driver leader 10 and auger machine 15.

[0039]

The pile driver leader 10, for example, as shown in FIG. 3, is provided with a pile driver body 13 on a turn table 12 supported by endless tracks 11. It is configured with inclined support arms 14 extending upward from the two side parts of one end of the pile driver body 13. The auger machine 15 is supported at the top end of the inclined support arms 14. The auger machine 15 clamps the pile head of the screwed pile 17. The installation management device 6 is, for example, connected to the data converter 7 attached to a driver's compartment 19 and obtains various types of data.

[0040]

The deviation measuring device 1 is used in a state fastened to the ground 91. The deviation measuring device 1, for example, measures the distance to the screwed pile 17. The deviation measuring device 1, for example, measures the distance to the screwed pile 17 while screwing it into the ground using the distance to the screwed pile 17 before screwing it into the ground 91 (initial state) as an initial value and measures the difference of the distances (amount of positional offset) as the amount of displacement.

[0041]

As the deviation measuring device 1, for example, a known distance measuring device such as a laser distance meter may be used. Note that, it is also possible to measure the amount of displacement using the installation management apparatus 6 based on the distance to the screwed pile 17 measured by the deviation measuring device 1.

[0042]

Note that, as the deviation measuring device 1, for example, an inclinometer may be used. In this case, the deviation measuring device 1 is attached to the auger machine 15 or screwed pile 17 etc. In this case, while using the inclination angle in the initial state as the initial value, the inclination angle during screw-in is measured and the difference in inclination angles (amount of inclination) is measured as the amount of displacement.

[0043]

For example, as shown in FIG. 4, when showing the initial set position of the screwed pile 17 by a two-dot chain line and showing the rotational axis of the auger machine 15 by a broken line, the misalignment e_2 based on the amount of inclination (amount of displacement) is estimated based on the following formula (1):

$$e_2 = L_p \times \tan \theta_e \dots (1)$$

where, L_p : distance from pile head to tip of screwed pile 17, θ_e : amount of relative inclination of rotational axis of auger machine 15 and screwed pile 17 sticking out from the ground 91.

[0044]

Further, as the deviation measuring device 1, for example, either of a distance measuring device and inclinometer may be used. In this case, the amount of positional offset and amount of inclination are measured as the amount of displacement. Further, for example, as shown in FIG. 4, if measuring the amount of positional offset and amount of inclination as the amount of displacement, the misalignment “ e ” may be estimated by the following formula (2) based on the amounts of eccentricity e_1 , e_2 :

$$e = e_1 + e_2 \dots (2)$$

[0045]

The rotational angle measuring device 2 measures the rotational angle of the screwed pile 17. As the rotational angle measuring device 2, for example, a rotational angle measurement sensor having a magnetic proximity switch 2a and metal pieces 2b may be used. The magnetic proximity switch 2a is provided at a nonrotating frame member 15b of the auger machine 15. A plurality of metal pieces 2b (for example, two to eight) are provided at a rotation body 15c at the body part 15a of the auger machine 15.

[0046]

In such a rotational angle measurement sensor, the screwed pile 17 and rotation body 15c rotate. Each time a metal piece 2b approaches the magnetic proximity switch 2a in a noncontact manner, a pulse signal is generated, so the rotational angle can be measured. For example, when providing metal pieces 2b equally at eight locations in the pile circumferential direction W, a pulse signal is generated every rotational angle of 45 degrees. Further, for example, when metal pieces 2b are equally provided at two locations in the pile circumferential direction W, a pulse signal is generated every rotational angle of 180 degrees.

[0047]

As the rotational angle measuring device 2, a system using the above-mentioned rotational angle measurement sensor is simplest and infrequent in breakdown, but another contact switch system or encoder angle sensor or other known constitution may also be employed.

[0048]

The penetration measuring device 3 measures the amount of screw-in of the screwed pile 17. As the penetration measuring device 3, for example, a screw-in measurement sensor having a wire rope 3a and an encoder 3b is used. The wire rope 3a is connected to the auger machine 15 at its front end, is turned around at the top end of the pile driver leader 10, and is wound up guided to the pile driver body 13. The encoder 3b is provided on the pile driver body 13 and measures the amount of movement of the wire rope 3a as the amount of screw-in of the screwed pile 17.

[0049]

As the penetration measuring device 3, in addition to the above-mentioned screw-in measurement sensor, a known measurement sensor etc. may be used.

[0050]

The rotational torque measuring device 4 measures the rotational torque when screwing in the screwed pile 17. As the rotational torque measuring device 4, for example, an auger ammeter 4a is used. In this case, this can be measured by a drive current of a known measuring means of an auger as conventionally performed.

[0051]

The vertical load measuring device 5 measures the vertical load given to the head of the

screwed pile 17 (pressing force). As the vertical load measuring device 5, for example, a load cell 5a is used. The load cell 5a is attached between the top end of the pile driver leader 10 and the end of the wire rope 3a from which the auger machine 15 is hung and measures the tensile force of the wire rope 3a. For this reason, the vertical load acting on the screwed pile 17 becomes the value of the weight of the auger machine 15 minus the measurement value of the load cell 5a. Note that, if the vertical load is insufficient with just the weight of the auger machine 15, sometimes the pile driver body 13 is used as a reaction body and another wire rope is provided pulling the auger machine 15 in. In this case, a load cell 5a is attached to the other wire rope as well and the measurement data of the two load cells 5a are added to obtain the vertical load.

[0052]

As the vertical load measuring device 5, in addition to using the above-mentioned load cell 5a, a known pressure measurement sensor may be used.

[0053]

Casing Driver 21

In the installation management system 100 of the screwed pile, for example as shown in FIG. 5 and FIGS. 6A and 6B, as a screw-in device of the screwed pile 17, a casing driver 21 may be used. FIG. 5 is a top view showing one example of the casing driver 21. FIGS. 6A and 6B are schematic views showing one example of the casing driver 21.

[0054]

In this case as well, the installation management system 100 is similar in main configuration with the above-mentioned FIG. 2. Below, parts of the configuration different from the case of provision of the auger machine 15 will be explained, while explanations of similar content will be suitably omitted.

[0055]

The casing driver 21, for example, as shown in FIG. 5, is supported through a reaction bar 21b by a crawler crane 21a. The screwed pile 17 is inserted inside the casing driver 21 in the state suspended by the crawler crane 21a.

[0056]

The casing driver 21, for example, as shown in FIG. 6A, is provided on the support plate 41 and holds the screwed pile 17. As the casing driver 21, for example, a known casing driver having pedestals 26, thrust jack 24, nonrotating frame member 27, hydraulic motor 23, swivel ring 22, and clamping part 25 is used.

[0057]

The pedestals 26 are provided on the support plate 41. The thrust jack 24 is set on the pedestals 26. For example, four are used. The nonrotating frame member 27 is attached to the thrust jack 24. The hydraulic motor 23 is supported on the nonrotating frame member 27 and

makes a rotational torque act on the swivel ring 22. The swivel ring 22 rotates through the gear mechanism 28 and bearing mechanism 29 by the hydraulic motor 23. The clamping part 25 is connected to the top part of the swivel ring 22 to rotate integrally with it. A handle 30 is used to clamp the screwed pile 17.

5 **[0058]**

The support plate 41 is sandwiched between the casing driver 21 and the ground 91. The support plate 41 tends to become offset from the position at which it is set along with the casing driver 21 and screwed pile 17 along with an increase in the misalignment in the screwed pile 17 being screwed in.

10 **[0059]**

For example, if estimating the misalignment e1 shown in FIG. 1C, the amount of movement of the support plate 41 from the initial set position in a horizontal plane may be measured as the amount of displacement. In this case, the measured amount of displacement may be estimated as the misalignment e1. Further, when estimating the misalignment e2, the amount of relative inclination of the rotation axis of the casing driver 21 and the screwed pile 17 projecting out from the ground 91 may also be measured as the amount of displacement. In this case, the misalignment e2 is estimated by the above-mentioned formula (1). In addition to the above, the above-mentioned formula (2) may also be used to estimate the misalignment “e”.

[0060]

20 The deviation measuring device 1 is provided on the ground 91 separated from the support plate 41. In this case, the deviation measuring device 1, for example, uses the distance up to the support plate 41 at the initial state as the initial value to measure the distance up to the support plate 41 while screwing in the screwed pile 17 and measures the difference in distances (amount of positional offset) as the amount of displacement of the screwed pile 17.

25 **[0061]**

During screw-in of the screwed pile 17, the scope of displacement of the screwed pile 17 includes not only displacement in a plane parallel to the ground 91 but also displacement in inclination. For this reason, it is preferable to measure at least one of displacement in the plane and displacement in inclination. Note that, FIG. 1C shows the state where the inclination of the screwed pile 17 (amount of relative inclination of casing driver 21 and screwed pile 17) is zero, but sometimes inclination in the screwed pile 17 occurs in the process of transition from the state of FIG. 1A to the state of FIG. 1C.

[0062]

35 Here, the scope of displacement of the support plate 41 includes only displacement in a plane parallel to the ground 91 (amount of movement in horizontal plane). For this reason, if using the deviation measuring device 1 to measure the amount of positional offset of the support

plate 41 as the amount of displacement of the screwed pile 17, the region of displacement is narrower compared with direct measurement of the amount of displacement of the screwed pile 17. Further, if directly measuring the amount of displacement of the screwed pile 17, it is necessary to measure this during rotation of the screwed pile 17. Sometimes the fluctuation of measurement along with rotation becomes larger. If based on these, it is possible to keep the measurement value from fluctuating by measuring the amount of positional offset of the support plate 41 as the amount of displacement of the screwed pile 17.

[0063]

The deviation measuring device 1, for example, may also be provided on the support plate 41. In this case, it is possible to measure the amount of displacement of the screwed pile 17 in the same way as above by providing a measurement reference part on the ground 91 separated from the support plate 41 (for example, the position of the deviation measuring device 1 of FIG. 6A) and measuring the distance to the measurement reference part.

[0064]

As the rotational angle measuring device 2, the above-mentioned rotational angle measurement sensor can be used. In this case, the magnetic proximity switch 2a is provided on the nonrotating frame member 27. The metal pieces 2b are provided on the swivel ring 22. Due to this, in the same way as the above-mentioned rotational angle measurement sensor, a pulse signal is generated in accordance with rotation of the screwed pile 17 so the rotational angle can be measured.

[0065]

As the penetration measuring device 3, for example a stroke sensor 3c measuring the stroke of a thrust jack 24 can be used. The stroke sensor 3c is provided between the cylinder 24a of the thrust jack 24 and the pedestal 26. As the stroke sensor 3c, for example, a linear type displacement meter or a potentiometer using a cord etc. or other known measurement system can be used.

[0066]

As the rotational torque measuring device 4, for example, a known pressure sensor (hydraulic sensor) measuring the hydraulic pressure of the hydraulic motor 23 driving rotation of the swivel ring 22 can be used.

[0067]

As the vertical load measuring device 5, for example, a known pressure sensor measuring the hydraulic pressure of a thrust jack 24 can be used.

[0068]

One Example of Method of Installation of Screwed pile

Next, one example of the method of installation of the screwed pile in the present

embodiment will be explained with reference to FIGS. 7A and 7B. FIGS. 7A and 7B are flow charts showing one example of the method of installation of the screwed pile in the present embodiment.

[0069]

5 The method of installation of the screwed pile in the present embodiment is provided with a screw-in step S100, measurement step S110, and control step S120. For example, the screw-in step S100 is performed while suitably repeating the measurement step S110 and control step S120.

[0070]

10 Screw-In Step S100

 The screw-in step S100 uses the auger machine 15 or casing driver 21 to clamp the screwed pile 17 and make the front end part where the helical blade 16 is provided abut against the ground 91. After that, the screwed pile 17 is screwed into the ground 91.

[0071]

15 Measurement Step S110

 The measurement step S110 measures pile information including the amount of displacement of the screwed pile 17 while screwing the screwed pile 17 into the ground 91. The pile information includes not only the amount of displacement of the screwed pile 17, but also for example at least one of the rotational angle of the screwed pile 17, amount of screw-in of the screwed pile 17, rotational torque of the screwed pile 17, and vertical load of the screwed pile 17.

[0072]

 The periodic interval for measurement of the pile information is, for example, a predetermined value of 1 second to 60 seconds and is freely set in accordance with the installation condition etc. If shortening the periodic interval for measurement of the pile information, the state of the screwed pile 17 can be monitored with a high precision. On the other hand, it is possible to slash the amount of data stored if making the periodic interval for measurement of the pile information longer.

[0073]

 At the measurement step S110, for example, the deviation measuring device 1 is used to measure the amount of displacement from the screwed pile 17, but, for example, the amount of positional offset of the support plate 41 is measured as the amount of displacement of the screwed pile 17. In the measurement step S110, for example, at least one of the amount of movement of the screwed pile 17 from an initial set position in a horizontal plane and an amount of relative inclination of the casing driver 21 and screwed pile 17 is measured as the amount of displacement. Note that, in the measurement step S110, for example, the above-mentioned formula (1) or formula (2) may be referred to so as to obtain either of the amounts of eccentricity

“e”, e1, and e2 calculated based on the amount of displacement as the pile information.

[0074]

At the measurement step S110, in addition to using the deviation measuring device 1 to measure the amount of displacement, for example, a ruler, gauge, or other measurement instrument may be used to measure the amount of displacement. In this case, for example, a worker may use the measurement instrument to measure the amount of positional offset of the support plate 41 from its initial value so as to measure the amount of displacement of the screwed pile 17. For example, a value which the worker measures may be input to the installation management apparatus 6 to measure the amount of displacement.

[0075]

By a worker using a measurement instrument to measure the amount of positional offset, it is possible to smoothly perform the measurement step S110 even at a location where the deviation measuring device 1 cannot be set. Note that, for example, a portable small sized deviation measuring device 1 may be used by a worker for measurement to measure the amount of displacement of the screwed pile 17.

[0076]

At the measurement step S110, the rotational angle of the screwed pile 17, the amount of screw-in of the screwed pile 17, the rotational torque of the screwed pile 17, and the vertical load of the screwed pile 17 are respectively measured using, for example, the above-mentioned rotational angle measuring device 2, penetration measuring device 3, rotational torque measuring device 4, and vertical load measuring device 5.

[0077]

Control Step S120

Next, the control step S120 controls the screw-in conditions of the screwed pile 17 based on the pile information. At the control step S120, for example, reference pile information relating to preset screw-in conditions of the screwed pile 17 is referred to as judgment criteria to set the conditions for screwing in the screwed pile 17. The reference pile information, for example, shows the threshold values, allowable ranges, and other control values for amounts of displacement etc. included in the pile information.

[0078]

At the control step S120, for example, if the amount of displacement measured at the measurement step S110 exceeds the threshold value included in the reference pile information, conditions are set so as to reduce or reverse the rotational torque. Note that, the above-mentioned “controls the screw-in conditions of the screwed pile 17” includes not only changing the screw-in conditions of the screwed pile 17 based on the pile information but also proceeding with screw-in without changing the conditions and stopping screw-in. Details of the reference pile

information will be explained below.

[0079]

Further, steps S100 to S120 are performed to insert the screwed pile 17 down to a predetermined depth to thereby realize the method of installation of the screwed pile in the present embodiment. Note that, as shown in FIG. 7A, after performing the control step S120, the measurement step S110 is again performed to thereby realize screw-in of the screwed pile 17 corresponding to any depth of the ground 91.

[0080]

Note that, the control step S120 has a comparison step S121. At the comparison step S121, based on preset threshold values, normality or abnormality of the pile body is judged from the relationship of the rotational torque and the misalignment. As the method for comparison, for example, at the installation management apparatus 6, the reference pile information and pile information are compared and the pile information is classified as normal or abnormal. The result is displayed on the monitor screen 6b. At this time, it is also possible to display an alert when there is an abnormality so that the worker can reliably recognize it. For example, a sound may also be emitted. In addition, for example, a worker may also compare the reference pile information and pile information.

[0081]

If a worker judges a pile to be normal from the displayed result or result of comparison, control is performed to reduce the rotational torque of the screwed pile 17 or reverse the screwed pile, then the measurement step S110 is performed or the installation is ended. In addition to the above, for example, the control step S120 may also have a confirmation step S122 of confirming the state of the screwed pile 17 when judging the pile is abnormal from the result of comparison. In the confirmation step S122, for example, the rotation of the screwed pile 17 is stopped then the state of the screwed pile 17 is checked.

[0082]

Reference Pile Information

Next, one example of the reference pile information will be explained with reference to FIG. 8 to FIG. 11.

[0083]

The reference pile information, for example, as shown in FIG. 8, can be set based on the relationship between the rotational torque and the results of analysis of stress concentration parts in the screwed pile 17. Note that, in FIG. 8, a graph of the results of calculation of the shear stress of the screwed pile 17 body modeled on the pure torsion (Saint-Bouin torsion) as one example is used, but, for example, even if modeled on the bending torsion (warp torsion), the graph can be similarly used. Further, the conditions of the screwed pile 17 used for calculation of

FIG. 8 include a pile diameter of 800 mm, blade diameter of 1200 mm, and plate thickness of 11 mm. Any conditions may be set in accordance with the content of installation, then reference pile information may be set based on the results of calculation.

[0084]

For example, the reference pile information may also be set using an upper limit value of the rotational torque for a standard yield point (first upper limit value T1) based on the result of analysis of the stress concentration parts. Note that, T1 differs from the later explained T2 and T3 and does not consider the torsional strength due to the axial force and added bending.

[0085]

Further, the reference pile information may, for example, be set using an upper limit value of the rotational torque considering the value of the vertical load (second upper limit value T2). In this case, the standard yield point considering the torsion due to the axial force is used. The second upper limit value T2 is set smaller than the first upper limit value T1 (difference between T1 and T2 corresponds to torsional strength due to axial force). That is, the pile can be installed by conditions considering the torsional strength due to the axial force.

[0086]

Furthermore, the reference pile information may also, for example, be set using the upper limit value of the torque considering the values of the amount of displacement and vertical load (third upper limit value T3). In this case, the standard yield point considering the torsional strength due to the axial force and added bending is used. The third upper limit value T3 is set smaller than the second upper limit value T2 (the difference between T2 and T3 corresponds to the torsional strength due to added bending). That is, the installation work can be performed by conditions considering the torsional strength due to axial force and added bending and failure of the screwed pile can be more reliably prevented. For this reason, among T1, T2, and T3, it is most preferable to use T3 to set the reference pile information.

[0087]

Here, the comparison step S121 uses the third upper limit value T3 considering the values of the amount of displacement and vertical load to set the reference pile information. The comparison step S121 using this reference pile information will be specifically explained. If the third upper limit value T3 is made the rotational torque Te, the rotational torque Te is expressed by the following formula (3):

$$T_e = Z_p \times [\sqrt{\{(T/Z_p)^2 + (\Delta M/Z)^2\}} + N/A] \dots (3)$$

where T: rotational torque, Zp: polar section modulus of screwed pile body, ΔM: added bending moment, Z: section modulus of screwed pile body, N: axial force, A: sectional area of screwed pile body.

Further, the added bending moment ΔM is expressed by the following formula (4):

$$\Delta M = T/D_p \times e \dots (4)$$

where, D_p : pile diameter, e : misalignment

[0088]

These formulas are used to set the limit values of the rotational torque and misalignment for the axial force based on the pile body strength of the screwed pile such as shown in for example FIG. 9. Further, at the comparison step S121, normality or abnormality of the pile body is judged from the misalignment estimated by the amount of displacement measured at the measurement step S110 and the rotational torque.

[0089]

For example, when the axial force is 120 kN, if the rotational torque and misalignment are within the ranges shown in FIG. 9A, the result is judged as “normal” while if outside the ranges, the result is judged as “abnormal”. Further, if the result is judged as “abnormal”, the screw-in conditions are controlled so as to decrease or reverse the rotational torque. Due to this operation, the relationship between the ground and the pile changes, so as a result, the rotational torque or the misalignment can be made to fall. If the rotational torque or misalignment falls and becomes the “normal” range of FIG. 9, the pile is again inserted by forward rotation. After screw-in by forward rotation, if the relationship of the rotational torque or the misalignment heads toward the “abnormal” range again, the operation of reducing or reversing the rotational torque may be repeated again. Alternatively, the rotation may be stopped once and the situation judged to study the response.

[0090]

As shown in FIG. 9, if the rotational torque is small, it is possible to continue screw-in of the screwed pile as is deeming the result as “normal” until the misalignment becomes relatively large in range. Further, if the misalignment is small, it is possible to continue screw-in of the screwed pile as is deeming the result as “normal” until the rotational torque becomes relatively large in range. In this way, by controlling the screw-in conditions from the relationship of the rotational torque and misalignment, it is possible to prevent failure of the screwed pile. Further, the work efficiency is kept from falling without setting unnecessarily perfect conditions.

[0091]

Furthermore, the vertical load may be added to the preset threshold values. In this case, in the graph of the three axes of the misalignment, rotational torque, and vertical load such as in FIG. 10, the normality/abnormality of the pile body may be judged from the relationship among the misalignment, rotational torque, and vertical load. By further adding the vertical load to the criteria for judgment in addition to the misalignment and rotational torque and judging normality/abnormality from the relationship among the three amounts, more advanced judgment becomes possible. It becomes possible to prevent failure of the screwed pile and prevent a drop

in the work efficiency to a more advanced degree.

[0092]

For example, when the axial force is 120 kN, if the rotational torque, misalignment, and vertical load are within the ranges shown as “normal” in FIG. 10 (below plane of threshold value), the result is judged as “normal” while if outside the ranges (above plane of threshold value), the result is judged as “abnormal”. Further, if the result is judged as “abnormal”, the screw-in conditions are controlled so as to decrease the rotational torque, stop or reverse rotation, or decrease the vertical load. As shown in FIG. 10, for example, if the rotational torque is small, it is possible to continue screw-in of the screwed pile as is deeming the result as “normal” until the misalignment or vertical load becomes relatively large in range. Further, if the misalignment is small, it is possible to continue screw-in of the screwed pile as is deeming the result as “normal” until the rotational torque or the vertical load becomes relatively large in range. Further, if the vertical load is small, it is possible to continue screw-in of the screwed pile as is deeming the result as “normal” until the rotational torque or the misalignment becomes relatively large in range. In this way, by controlling the screw-in conditions from the relationship of the rotational torque, misalignment, and vertical torque, it is possible to prevent failure of the screwed pile. Further, the work efficiency is kept from falling without setting unnecessarily perfect conditions.

[0093]

In addition, as the reference pile information, for example, as shown in FIG. 11, the allowable range of the amount of screw-in S per turn of the screwed pile 17 for the pitch P of the helical blade 16 may be included. In this case, the rotational angle included in the pile information measured by the measurement step S110 and the amount of screw-in are used to calculate the amount of screw-in S per turn. Further, the calculated amount of screw-in S per turn and allowable range of the amount of screw-in S per turn of the reference pile information are compared to control the vertical load N based on the results of comparison. Note that, the amount of screw-in S per turn may not only be calculated by the installation management apparatus 6, but also be calculated by a worker.

[0094]

For example, when the calculated amount of screw-in S per turn is larger than the amount of screw-in S per turn set in the reference pile information, the vertical load N can be decreased to make the amount of screw-in S per turn calculated using the next measured rotational angle and amount of screw-in approach the amount of screw-in S per turn set in the reference pile information. Due to this, for example, it becomes possible to efficiently install the pile without the helical blade 16 being subjected to unreasonable load and further without disturbing the earth and sand at the front end part of the screwed pile 17.

[0095]

Modification of Installation Management System 100

Next, a modification of the installation management system 100 in the present embodiment will be explained with reference to FIG. 12.

5 **[0096]**

The difference between the above-mentioned installation management system 100 and the modification lies in the point of the installation management apparatus 6 being able to communicate with the management apparatus 101 etc. Note that explanation of configurations similar to the above-mentioned installation management system 100 will be omitted.

10 **[0097]**

In the installation management system 100, the installation management apparatus 6 may be connected with the management apparatus 101 through a communication network 102, for example, may be connected with the server 103.

[0098]

15 The management apparatus 101 may also, for example, be provided at a location separated from the installation site, for example, may be connected with a plurality of installation management apparatuses 6 through the communication network 102. As the management apparatus 101, for example, a personal computer (PC), tablet terminal, smartphone, or other electronic device may be used. The management apparatus 101 may also, for example, be
20 connected with the interface box 8 and the various measuring devices 1 to 5 through the communication network 102.

[0099]

The communication network 102 is the Internet etc. to which the installation management apparatus 6 is connected through a communication circuit. The communication network 102 may
25 also be configured by optical fiber communication using so-called optical fiber cables etc. Note that, the communication network 102 may be realized by cable or wireless or other known art.

[0100]

The server 103, for example, stores the measured pile information or other various information. By using the server 103, it is possible to easily store a tremendous amount of past
30 data.

[0101]

One Example of Installation Management Apparatus 6

Next, one example of the installation management apparatus 6 in the present embodiment will be explained referring to FIG. 13. Note that, the above-mentioned management apparatus
35 101 may also be provided with a configuration similar to at least part of the installation management apparatus 6.

[0102]

FIG. 13A is a schematic view showing one example of the installation management apparatus 6. As the installation management apparatus 6, a personal computer or other electronic device is used. The installation management apparatus 6 is provided with a housing 600, CPU (central processing unit) 601, ROM (read only memory) 602, RAM (random access memory) 603, storage part 604, and I/Fs 605 to 608. The components 601 to 608 are connected by an internal bus 610.

[0103]

The CPU 601 controls the installation management apparatus 6 as a whole. The ROM 602 stores operating codes of the CPU 601. The RAM 603 is a work region used when operating the CPU 601.

[0104]

The storage part 604 stores the pile information and basic pile information or other various types of information. The storage part 604, for example, stores reference pile information in advance. As the storage part 604, for example, an HDD (hard disk drive), SSD (solid state drive), or other known recording medium is used.

[0105]

The I/F 605 is an interface sending and receiving various information with the interface box 8. The I/F 606 is an interface for receiving information input from a keyboard 6a. A worker can input or select various information or control commands etc. of the installation management apparatus 6 through the keyboard 6a. The I/F 607 is an interface for sending various types of information to the monitor screen 6b (display part). The worker can check various information through the monitor screen 6b. As the monitor screen 6b, for example, a liquid crystal display is used. The I/F 608 is an interface for sending and receiving various information with a printer 6c or communication network 102.

[0106]

FIG. 13B is a schematic view showing one example of the functions of the installation management apparatus 6. The installation management apparatus 6 is provided with an acquisition part 611, storage part 612, and output part 613 and, for example, may be provided with a comparison part 614 and generating part 615. Note that, the various functions shown in FIG. 13B are realized by the CPU 601 running programs stored in the storage part 604 etc. using the RAM 603 as a work region.

[0107]

Acquisition Part 611

The acquisition part 611 acquires pile information including the amount of displacement. The acquisition part 611 acquires the amount of displacement measured by the deviation

measuring device 1 through the interface box 8. The acquisition part 611, for example, may acquire the values of distance etc. measured by the deviation measuring device 1 and calculate the differences between the acquired values and preset initial values to acquire the amount of displacement.

[0108]

The acquisition part 611 may acquire not only the amount of displacement, but also, for example, pile information including at least one of the rotational angle of the screwed pile 17, the amount of screw-in of the screwed pile 17, the rotational torque of the screwed pile 17, and the vertical load of the screwed pile 17 measured by the various measuring devices 2 to 5 through the interface box 8. The acquisition part 611, for example, may also acquire data of the N values acquired by the data input part 9 or the keyboard 6a.

[0109]

The acquisition part 611 may also, for example, refer to the above-mentioned formula (1) and formula (2), calculate the misalignment estimated from the measured amount of displacement of the screwed pile 17, and include it in the pile information. In this case, for example, the comparison part 614 etc. can easily compare the threshold value ϵ shown in FIG. 9 and the calculated misalignment.

[0110]

Storage Part 612

The storage part 612 stores various information acquired by the acquisition part 611 in the storage part 604 and takes out various information from the storage part 604 in accordance with need. The storage part 612, for example, stores the reference pile information etc. acquired in advance in the storage part 604.

[0111]

Output Part 613

The output part 613 outputs the pile information and other various information to the monitor screen 6b, management apparatus 101, etc. The output part 613, for example, generates an installation record of the plurality of pile information stored in the storage part 604 for each elapsed time or each depth of the ground 91 and outputs the installation record to the monitor screen 6b etc. Due to this, for example, a graph-like installation record such as shown in FIG. 15 can be displayed on the monitor screen 6b. The graph of FIG. 15 shows one example of an installation record comprised of the N value of the ground 91, the rotational torque of the screwed pile 17, the amount of screw-in of the screwed pile 17, and the vertical load of the screwed pile 17 plotted for each depth of the ground 91. The output part 613, for example, may generate an installation record using only part of the pile information in the plurality of pile information. The output part 613, for example, if necessary uses the rotational angle and the

amount of screw-in to calculate the amount of screw-in per turn. Note that, for example the amount of displacement or the calculated misalignment may be generated as an installation record and output to the monitor screen 6b.

[0112]

Comparison Part 614

The comparison part 614 may not only compare the reference pile information and the pile information and classify the pile information as normal or abnormal, but also classify it into multiple stages (for example five to 10 stages). The comparison part 614 may not only compare one pile information and reference pile information, but also, for example, may compare a plurality of pile information acquired periodically (for example the installation record) and reference pile information. In this case, as the object for comparison, the largest, smallest, or average value of the plurality of pile information or results of dispersion or other processing may also be used.

[0113]

Generating Part 615

The generating part 615 generates alert information alerting a worker of an abnormality when the comparison part 614 classifies pile information as abnormal. The generating part 615 outputs the generated alert information to the monitor screen 6b through the output part 613. Due to this, alert information may be displayed at the monitor screen 6b and a worker may be alerted to an abnormality in installation.

[0114]

One Example of Operation of Installation Management System 100

Next, one example of the operation of the installation management system 100 in the present embodiment will be explained with reference to FIG. 14. FIG. 14 is a flow chart showing one example of the operation of the installation management system 100 in the present embodiment.

[0115]

The installation management system 100 in the present embodiment may be provided with the acquiring means S220 and the output means S230. For example, it may also be provided with a measuring means S210 operating before the acquiring means S220. Note that, the installation management system 100 is utilized for the above-mentioned method of installation of the screwed pile, so explanations of common content will be suitably omitted.

[0116]

Measuring Means S210

The measuring means S210 measures the pile information including the amount of displacement of the screwed pile 17 while screwing the screwed pile 17 into the ground 91. The

deviation measuring device 1 measures the distance of the screwed pile 17 or support plate 41 etc. at any periodic interval while screwing in the screwed pile 17 and measures the amount of displacement.

[0117]

5 The measuring means S210, for example, may measure at least one of the rotational angle of the screwed pile 17, amount of screw-in of the screwed pile 17, rotational torque of the screwed pile 17, and vertical load of the screwed pile 17 while screwing in the screwed pile 17. In this case, the rotational angle measuring device 2 measures the rotational angle of the screwed pile 17, the penetration measuring device 3 measures the amount of screw-in of the screwed pile
10 17, the rotational torque measuring device 4 measures the rotational torque of the screwed pile 17, and the vertical load measuring device 5 measures the vertical load of the screwed pile 17. The measurements may be performed, for example, at the same timings of measurement of the amount of displacement and also at timings different from displacement.

[0118]

Acquiring Means S220

15 The acquiring means S220 acquires pile information including the amount of displacement of the screwed pile 17. The acquisition part 611 of the installation management apparatus 6 acquires the amount of displacement measured by the deviation measuring device 1 through the interface box 8 and I/F 605.

[0119]

20 The acquisition part 611 may also, for example, acquire at least one of the rotational angle of the screwed pile 17, the amount of screw-in of the screwed pile 17, the rotational torque of the screwed pile 17, and the vertical load of the screwed pile 17 measured by the measurement devices 2 to 5 through the interface box 8 and I/F 605. The acquisition part 611 acquires data
25 including the above-mentioned amount of displacement etc. as the pile information and, for example, stores the pile information in the storage part 604 through the storage part 612. Due to this, the storage part 604 stores periodically acquired pile information. Note that, the acquisition part 611, for example, refers to the above-mentioned formula (1) and formula (2) to calculate the misalignment estimated from the acquired amount of displacement of the screwed pile 17 and
30 includes this in the pile information.

[0120]

Output Means S230

35 The output means S230 outputs the pile information to the monitor screen 6b. The output part 613, for example, takes out the stored pile information from the storage part 604 through the storage part 612. The output part 613 outputs the pile information on the monitor screen 6b through the I/F 607. Due to this, the monitor screen 6b displays the pile information to enable the

pile information to be checked by a worker.

[0121]

The output part 613 may, for example, generate an installation record and output it to the monitor screen 6b. In this case, the elapsed time and range of depth and the pitch and other display conditions can, for example, be set by a worker through the keyboard 6a and can be suitably set in accordance with the installation situation. For example, if the measuring devices 1 to 5 acquire data every second and the acquisition part 611 acquires pile information for every second, the output part 613 may not only output pile information stored every second, but also generate and output an installation record showing, for example, pile information regarding the depth etc. every 10 seconds or every 1 meter.

[0122]

The output part 613 may, for example, output pile information through the I/F 608 and communication line 102 to the management apparatus 101 or server 103. In this case, the output part 613 may not only output pile information each time the acquisition part 611 acquires it, but also output pile information stored at any set time period at one time.

[0123]

Due to this, the operation of the installation management system 100 in the present embodiment is ended. Note that, as shown in FIG. 14A, by the acquiring means S220 or the output means S230 being performed, then the measuring means S210 again being performed, the state of the screwed pile 17 while screwing in the screwed pile 17 can be monitored.

[0124]

Note that, the installation management system 100, as shown in for example FIG. 14B, may also be provided with at least one of a comparing means S240 and alert means S250. In the comparing means S240, the comparison part 614 compares reference pile information and pile information. As the method for comparison, for example, comparison of a value of the reference pile information and a value of pile information for magnitude or other known art may be used. For example, the comparison part 614 classifies the pile as normal when the value of the pile information is the value of reference pile information or less and classifies the pile as abnormal when the value of the pile information is more than the value of the reference pile information. Note that, the classification criteria may be freely set.

[0125]

If the result of comparison is that the pile information is classified as normal, the measuring means S210 or the output means S230 is performed or the operation is ended. On the other hand, if the pile information is classified as abnormal, the alert means S250 is performed. In the alert means S250, the generating part 615 generates alert information alerting a worker of an abnormality. The generating part 615 may not only output alert information to the monitor

screen 6b through the output part 613 and I/F 607 but also, for example, output alert information to the management apparatus 101 through the output part 613, I/F 608, and communication line 102.

[0126]

5 As alert information, for example, not only is information for displaying an abnormality on the monitor screen 6b included, but also information for emission of a sound may be included. Due to this, a worker can be smoothly alerted of an abnormality.

[0127]

10 According to the method of installation of a screwed pile in the present embodiment, the measurement step S110 measures the pile information including the amount of displacement of the screwed pile 17 while screwing the screwed pile 17 into the ground 91. For this reason, a worker can estimate the state of a screwed pile 17 being screwed in based on the amount of displacement. Due to this, it becomes possible to prevent failure of the screwed pile 17.

[0128]

15 Further, according to the method of installation of a screwed pile in the present embodiment, the measurement step S110 measures at least one of an amount of movement of the screwed pile 17 from its initial set position on a horizontal plane and amount of relative inclination of the casing driver 21 and screwed pile 17 as the amount of displacement. For this reason, it is possible to measure the amount of displacement without a great change from the
20 conventional method of installation. Due to this, it becomes possible to easily measure the amount of displacement.

[0129]

 Further, according to the method of installation of the screwed pile in the present embodiment, the measurement step S110 measures the amount of positional offset of the support
25 plate 41 as the amount of displacement. For this reason, compared with when directly measuring the amount of displacement of the screwed pile 17, it is possible to suppress fluctuation of the measurement value accompanying rotation of the screwed pile 17. Due to this, the amount of displacement can be measured with a high precision.

[0130]

30 Further, according to the method of installation of the screwed pile in the present embodiment, the pile information includes at least one of the amount of screw-in of the screwed pile 17, the rotational torque of the screwed pile 17, and the vertical load of the screwed pile 17. For this reason, a worker can combine the amount of displacement of the screwed pile 17 and the screw-in condition then estimate the state of the screwed pile 17. Due to this, it becomes possible
35 to prevent failure of the screwed pile 17 from multiple viewpoints.

[0131]

Further, according to the method of installation of the screwed pile in the present embodiment, the comparison step S121 compares reference information and the pile information and judges normality or abnormality. For this reason, it is possible to suppress fluctuation of the subjective judgment criteria for each worker. Due to this, it becomes possible to prevent failure of the screwed pile 17 without regard as to the work skills etc. of a worker.

[0132]

Further, according to the method of installation of a screwed pile in the present embodiment, the comparison step S121 judges normality or abnormality based on a threshold value et preset from the relationship of the rotational torque T_e and the misalignment. For this reason, it is possible to render a judgment utilizing an optimal threshold value along with a state of installation. Due to this, it becomes possible to realize prevention of failure of a screwed pile along with changes in the installation situation.

[0133]

Further, according to the method of installation of the screwed pile in the present embodiment, the control step S120 performs control so as to reduce or reverse the rotational torque of the screwed pile 17 based on a threshold value et preset from the relationship of the rotational torque T_e and the misalignment. For this reason, it is possible to control the screw-in conditions of the screwed pile 17 before an abnormality in the screwed pile 17 arises. Due to this, it is possible to keep down the possibility of failure of the screwed pile 17 while proceeding with installation.

[0134]

According to the screwed pile 17 in the present embodiment, the above-mentioned method of installation of the screwed pile is used to insert the screwed pile down to the bearing layer 92 of the ground 91. For this reason, it becomes possible to realize the screwed pile 17 installed in a state preventing failure.

[0135]

According to the installation management apparatus 6 of the screwed pile in the present embodiment, the acquisition part 611 acquires pile information including the amount of displacement of the screwed pile 17 measured while screwing the screwed pile 17 into the ground 91. Further, the display part (monitor screen 6b) displays the pile information. That is, an amount of displacement causing failure of the screwed pile 17 can be confirmed through the monitor screen 6b by a worker. For this reason, a worker can estimate the state of the screwed pile 17 based on the amount of displacement. Due to this, failure of the screwed pile 17 can be prevented.

[0136]

Further, according to the installation management apparatus 6 of the screwed pile in the

present embodiment, the generating part 615 generates alert information when classifying pile information as abnormal in the comparison part 614. For this reason, by displaying an alert on the monitor screen 6b etc. based on the alert information, a worker can be notified of a high possibility of failure of the screwed pile 17. Due to this, a worker can try to improve the work efficiency without the need for constantly monitoring pile information through the monitor screen 6b etc. Further, it is possible to suppress fluctuation of the subjective judgment criteria for each worker. Due to this, it becomes possible to prevent failure of the screwed pile 17 without regard as to the work skills etc. of a worker.

[0137]

According to the installation management system of the screwed pile 100 in the present embodiment, the acquiring means S220 acquires pile information including the amount of displacement of the screwed pile 17 measured while screwing the screwed pile 17 into the ground 91. That is, it is possible to notify a worker or work manager etc. of an amount of displacement causing failure of the screwed pile 17 through the display part (monitor screen 6b) etc. For this reason, a worker or work manager etc. can estimate the state of a screwed pile 17 based on the amount of displacement. Due to this, it becomes possible to prevent failure of the screwed pile 17.

[0138]

Above, examples of embodiments of the present invention were explained in detail, but the above-mentioned embodiments only show illustrations of specific cases of working the present invention. The technical scope of the present invention should not be limitatively interpreted by these.

REFERENCE SIGNS LIST

[0139]

- 1: deviation measuring device
- 2: rotational angle measuring device
- 2a: magnetic reaction proximity switch
- 2b: metal piece
- 3: penetration measuring device
- 3a: wire rope
- 3b: encoder
- 3c: stroke sensor
- 4: rotational torque measuring device
- 4a: auger ammeter
- 5: vertical load measuring device
- 5a: load cell

	6: installation management apparatus
	6a: keyboard
	6b: monitor screen
	6c: printer
5	7: data converter
	8: interface box
	9: data input part
	10: pile driver leader
	11: endless track
10	12: turn table
	13: pile driver body
	14: inclined support arm
	15: auger machine
	15a: body part
15	15b: nonrotating frame member
	15c: rotation body
	16: helical blade
	17: screwed pile
	19: driver's compartment
20	21: casing driver
	21a: crawler crane
	21b: reaction bar
	22: swivel ring
	23: hydraulic motor
25	24: thrust jack
	24a: cylinder
	25: clamping part
	26: pedestal
	27: nonrotating frame member
30	28: gear mechanism
	29: bearing mechanism
	30: handle
	41: support plate
	91: ground
35	92: bearing layer
	100: installation management system

	101: management apparatus
	102: communication line
	103: server
	600: housing
5	601: CPU
	602: ROM
	603: RAM
	604: storage part
	605: I/F
10	606: I/F
	607: I/F
	608: I/F
	610: internal bus
	611: acquisition part
15	612: storage part
	613: output part
	614: comparison part
	615: generating part
	S100: screw-in step
20	S110: measurement step
	S120: control step
	S121: comparison step
	S122: confirmation step
	S210: measuring means
25	S220: acquiring means
	S230: output means
	S240: comparison means
	S250: alert means
	X: pile axis perpendicular direction
30	W: pile circumferential direction
	Z: pile axial direction

CLAIMS

[Claim 1]

A method of installation of a screwed pile for driving a screwed pile provided with a blade into the ground,

5 the method of installation of a screwed pile comprising
 a measurement step of measuring pile information including an amount of displacement of the screwed pile and a rotational torque of the screwed pile while screwing the screwed pile into the ground,
 a comparison step of judging normality or abnormality of a pile body from a
10 relationship of the rotational torque and misalignment based on preset threshold values, and
 a control step controlling a condition of screw-in of the screwed pile based on the pile information,
 the control step performing control based on results of the comparison step so as to decrease the rotational torque of the screwed pile or stop or reverse rotation.

15

[Claim 2]

The method of installation of a screwed pile according to claim 1, wherein the measurement step measures as the amount of displacement at least one of an amount of movement of the screwed pile from an initial set position in a horizontal plane and an amount of
20 relative inclination of a casing driver holding the screwed pile and the screwed pile.

20

[Claim 3]

The method of installation of a screwed pile according to claim 2, wherein the measurement step measures as the amount of displacement an amount of positional offset of a
25 bearing plate sandwiched between the ground and the casing driver.

25

[Claim 4]

The method of installation of a screwed pile according to any one of claims 1 to 3, wherein the pile information further includes at least one of an amount of screw-in of the
30 screwed pile and a vertical load of the screwed pile.

30

[Claim 5]

The method of installation of a screwed pile according to any one of claims 1 to 4, wherein the control step has a comparison step comparing reference pile information relating to a
35 preset condition of screw-in of the screwed pile and the pile information and judging normality or abnormality.

35

[Claim 6]

A method of production of a group of piles including a plurality of screwed piles driven down to a bearing layer of the ground by a method of installation of a screwed pile according to any one of claims 1 to 5.

[Claim 7]

A group of piles including a plurality of screwed piles driven down to a bearing layer of the ground produced by a method of production of a group of piles of claim 6.

[Claim 8]

An installation management apparatus used for driving a screwed pile provided with a blade into the ground, the installation management apparatus comprising:

an acquiring means for acquiring pile information measured while screwing the screwed pile into the ground,

a storage part for storing the pile information, and

a display part for displaying the pile information,

the pile information including an amount of displacement of the screwed pile.

[Claim 9]

The installation management apparatus of a screwed pile according to claim 8, further comprising:

a comparison part comparing reference pile information relating to a condition of screw-in of the screwed pile and the pile information and classifying the pile information as normal or abnormal and

a generating part generating alert information alerting a worker of an abnormality when the comparison part classifies the pile information as abnormal,

the reference pile information being stored in the storage part in advance.

[Claim 10]

An installation management system of a screwed pile used for driving a screwed pile provided with a blade into the ground,

the installation management system comprising:

an acquiring means for acquiring pile information measured while screwing the screwed pile into the ground,

a storage part for storing the pile information, and

an output means for outputting the pile information,
the pile information including an amount of displacement of the screwed pile.