

Foundation pile positioning system

Field of the invention

5 The present invention relates to a foundation pile positioning system for use in a foundation pile installation system for installing a pile into an underwater ground formation, a pile holding device for maintaining a foundation pile in an upright position during installation of the foundation pile into the ground, and a method for installing the pile into the ground, preferably in an offshore location. The invention is of particular use for, but not limited to, offshore applications and for installing piles into the ground with erection
10 of offshore wind-turbines.

Background of the invention

Typically, pile positioning systems comprise a plurality of different assemblies to keep the pile in
15 an upright position, while the pile is being driven into the ground. These types of assemblies can be normally found inside the so-called noise mitigation systems or pile grippers, such that, at least, the top of the pile is kept in its upright position, while the pile is being driven into the ground. However, these assemblies only comprise a plurality of rollers provided at a certain distance from each other having a plurality of passive rollers passively acting against the outer wall of the pile, while the rollers rotate around the horizontal axis.
20 WO2012/177131A1 describes an assembly for centering a first elongate tubular element and a second elongate tubular element, such as an underwater pile accommodated within a noise mitigation screen, at a common central longitudinal axis along which axis both the first and second element extend, and wherein the centering system is provided with first coupling means for fixedly coupling the centering system with one of the first and second tubular elements, and second coupling means for engaging the other tubular
25 element for centering the other tubular element at the central axis. Furthermore, KR102189347_B1 describes a pile gripper having a plurality of adjustments gripping units that comprise a couple of rollers mounted on a roller support. While the roller support is static, the rollers are provided in a vertical configuration, meaning one on top of the other in parallel configuration. The roller support is connected to a sliding arm. The plurality of supporting rollers and the roller support are configured to be rotatable with
30 respect to the horizontal axis of the sliding arm, thereby accurately guiding the position of the pile so that the pile can be tilted in various directions and at various angles during the construction of the pile.

Moreover, it is known in the art that the pile needs to be rotated, before it is driven into the ground. This is normally done with the aid of the lifting and/or upending tool, which is connected to a crane. It is also necessary to have a very skilled crane operator to perform such an operation, specially when in floating
35 vessels, wherein the motion of the vessel itself needs to be compensated accordingly. A foundation pile needs to be rotated to e.g. align its cable aperture or opening, in relation to a central operation unit, within a large plurality of piles in a wind farm, to enable the pile to have a good positioning of said opening for the

power cable(s) and other connecting equipment, as to ease its installation and prospect operation of the foundation pile.

EP3762550B1 describes a system that uses rotational actuators, to maintain the upright position of a pile during installation. The rotational actuators are used to adjust the pile's position by applying rotational forces to the pile. The rotational actuators then make the necessary adjustments to the pile to maintain its upright position. This system can be used for both land-based and offshore pile installation.

Summary of the invention

10 An object of the current invention is to provide an improved foundation pile positioning system in that the system maintains an upright position of a pile during installation and is able to rotate a pile.

Therefore, the invention provides a pile positioning system for use in a foundation pile installation system for installing a pile into an underwater ground formation, preferably offshore, the foundation pile positioning system comprising;

15 - an actuation system for rotating the foundation pile around a central longitudinal pile axis, wherein the actuation system comprises an engaging element for contacting an outer surface of the pile and rotating the pile around the central longitudinal pile axis by friction contact between the engaging element and the outer surface of the pile,

20 wherein the engaging element comprises a rotary member for contacting the outer surface of the pile, wherein the rotary member is constrained in degrees of freedom of movement in order to rotate the pile around the central longitudinal pile axis and to allow rotation of the rotary member around a first axis such that relative movement of the engaging element and the foundation pile along the central longitudinal pile axis is enabled by rolling motion between the rotary member and the outer surface of the pile while the rotary member is contacting the outer surface of the pile.

Enabling rolling motion between the engaging element and the outer surface of the pile avoids excessive mechanical load to the actuation system and associated support structure. During use, such mechanical load is caused by heave motion of a floating vessel supporting the pile positioning system and the foundation pile itself once the pile is in contact with an underwater ground formation. Free rotation of the rotary member all the more avoids excessive mechanical load to the actuation system and associated support structure. It is however conceivable to dampen the rotation of the rotary member to a certain extend.

35 It will be clear that the foundation pile is in a substantially vertical position during installation of the pile into the underwater ground formation, in particular for a monopile of a wind power turbine. However, a certain skewness of the foundation pile is conceivable depending on the type of foundation structure.

The actuation system drives the foundation pile by friction force. It will be clear that relative movement of the engaging element and the pile in a driving direction is constrained at a contact area between the engaging element and the outer surface of the pile. This facilitates to drive the foundation pile by friction force. For rotating the foundation pile around the central longitudinal pile axis, the driving direction is normally tangential to the outer surface of a cylindrical pile.

In other words, the invention provides a versatile solution that can be applied in various fields. The system can be used to maintain the upright position of a pile during installation with a so-called pile gripper, by using rotational features to adjust the angular position of the pile around its longitudinal axis. The rotational features are in particular useful in conjunction with sensors and a control unit to monitor and adjust the position of the pile. The system can also be applied in a noise mitigation system, for example as the one described in EP2446090B1, as well as in a pile gripper in onshore and offshore locations.

According to the invention, the engaging element comprises a rotary member. The rotary member facilitates free relative motion of the engaging element and the pile along the central longitudinal pile axis while the engaging element is contacting the outer surface of the pile. The rotary member can comprise any suitable component of rotation like e.g. roller and/or a wheel. The rotary member comprises an axis of rotation with a horizontal component, in particular the axis of rotation is horizontal. The rotary member is freely rotatable around its axis of rotation. It is however conceivable that rotation of the rotary member is slightly dampened. The rotary member is thus constrained in degree of freedom of motion by a bearing support known per se that allows the rotary member to rotate about its axis of rotation. The bearing support assures that the rotary member rotates in unity with the engaging element around normally the vertical axis to rotate the pile around the central longitudinal pile axis.

In an embodiment of the foundation pile positioning system according to the invention, the engaging element comprises a plurality of rotary members. The engaging element comprising a plurality of rotary members facilitates to increase the friction surface between the engaging element and the outer surface of the pile. Therefore, rotation of the pile can be more robust. Moreover, the engaging element comprising a plurality of rotary members enables a spatial arrangement of the rotary members with respect to the outer surface of the pile. Therefore, contact between the engaging element and the outer surface of the pile can be more distributed and more constant during rotation of the pile with respect to the actuation system. The plurality of rotary members is preferably separately rotatable.

In an embodiment of the foundation pile positioning system according to the invention, the engaging element comprises a drive wheel and wherein the plurality of rotary members are arranged at a tread of the drive wheel. The drive wheel comprising the plurality of rotary members arranged at the tread of the drive wheel facilitates to rotate the foundation pile while at the same time accommodating relative vertical motion

of the pile and the actuation system. In other words, the drive wheel rotates to communicate rotative motion to the foundation pile while the rotary members are arranged at an outer circumference of the drive wheel. The tread of the drive wheel may be an imaginary tread, however it is conceivable that a real tread is present. Important is that the rotary members are arranged at an outer circumference of the drive wheel, and more in general of the engaging element, in order to provide contact between the drive wheel and the outer surface of the pile through the rotary members. The skilled person will understand that the tread is here defined by means of the pattern on which the rotary members are positioned and/or arranged at the driving wheel, by means of either the number of rotary members and/or the distance between the rotary members.

In an embodiment of the foundation pile positioning system according to the invention, the drive wheel comprises two or more treads spaced along a wheel drive rotation axis, and at least two of the plurality of rotary members are staggered when seen along the wheel drive rotation axis. In other words, the at least two of the plurality of rotary members form different imaginary treads. Therefore, contact between the engaging element and the outer surface of the pile can be more distributed and more constant even more during rotation of the pile with respect to the actuation system.

In an embodiment of the foundation pile positioning system according to the invention, the driving wheel rotation axis is parallel to the central longitudinal axis of the foundation pile. This means that both the drive wheel rotation axis and the central longitudinal axis of the foundation pile extend vertically during pile installation.

In an embodiment of the foundation pile positioning system, the engaging element comprises a support structure to rotatably support the plurality of rotary members. The support structure facilitates to arrange the plurality of rotary members to form an imaginary tread of the drive wheel. The support structure may comprise parallel plate members wherein the plurality of rotary members are arranged between the parallel plate members. It will clear that any suitable support structure will enable this configuration.

In an embodiment of the foundation pile positioning system, wherein the plurality of rotary members each have an axis of rotation that extends perpendicular to the driving wheel rotation axis. This all the more facilitates free relative motion of the engaging element and the pile along the central longitudinal pile axis while the engaging element is contacting the outer surface of the pile.

In an embodiment of the foundation pile positioning system, the plurality of rotary members comprises an elastomeric material. The elastomeric material dampens the impact on the thin-walled pile and improves grip while rotating the foundation pile by friction force. The tread of the rotary member may be made of elastomeric material, however it is conceivable that the rotary member is made of an elastomeric

material. The skilled person will appreciate that the elastomeric materials is any suitable material exhibiting elastic or rubber-like properties.

5 In an embodiment of the foundation pile positioning system according to the invention, the engaging element defines a contact area between the engaging element and the outer surface of the pile. The contact area comprises a line contact or a surface contact. The surface contact facilitates to rotate the pile by friction force. In other words, the engaging element defines a "friction surface" or an "active portion of a path of contact" between the engaging element and the outer surface of the pile.

10 In an embodiment, the foundation pile positioning system comprises an arm member having a connecting portion being pivotably connected to an arm support structure, as well as an arm drive system configured to pivot the arm member, wherein the engaging element is arranged at a free end of the arm member opposite the connecting portion, and wherein the arm member is pivotable between an extended position wherein the actuation system engages the pile, and a retracted position. The arm and the arm drive
15 system enable to prestress the engaging element towards and in contact with the outer surface of the pile.

In an embodiment of the foundation pile positioning system, the connection portion of the arm member and a first end of the arm drive system are positioned at a distance from each other. Advantageously, this configuration wherein the connection portion of the arm member and a first end of the
20 arm drive system are positioned at a distance from each other, allows the foundation pile positioning system to have a wide range of adjustability to adapt to piles of different diameters. The distance between the connection portion of the arm member and the first end of the arm drive system is directly related to the distance of which the arm can be moved within the system.

25 In an embodiment of the foundation pile positioning system, wherein, when engaging element is engaged with the outer surface of the pile, the arm drive system forces the arm member towards the extended position such that the engaging element is constantly in contact with the outer surface of the pile.

Therefore, the invention also provides a pile holding device comprising a ring-shaped element for
30 maintaining a foundation pile in an upright position during installation of the foundation pile into the ground, preferably offshore, the pile holding device comprising the foundation pile positioning system according to the invention. The pile holding device may comprise a plurality of pile positioning systems to constrain a foundation pile during installation.

35 Therefore, the invention provides a method for installing a pile into the ground, preferably offshore, wherein the method comprises;
a) providing a pile positioning system according to the invention;

- b) providing a pile, to be driven into the ground, in a substantially upright position;
c) lowering the pile such us its lower part is in contact with a seabed;
d) connecting the engaging element with the outer surface of the pile such that the pile is kept in its upright position;
5 e) rotating the pile around the central longitudinal pile axis by means of the engaging element (17) and,
f) driving the pile into the ground.

In an embodiment of the method according to the invention, steps d) and e) are repeatably performed.

- 10 In an embodiment of the method according to the invention, the method further comprises the step of blocking rotation of the pile around the central longitudinal pile axis. This facilitates to maintain the pile in a desired position with respect to e.g. a power cable.

- 15 The invention provides a solution to the problem of maintaining the vertical alignment and adjusting an angular position of a foundation pile or structure during installation, which is especially challenging in adverse conditions. The invention can be used in different applications and devices to improve the installation process and ensure that the final structure is correctly aligned and performs as intended.

Short description of drawings

- 20 The present invention will be discussed in more detail below, with reference to the attached drawings, in which
fig. 1 is a schematic side view of a foundation pile installed in an underwater ground formation;
fig. 2 is a schematic side view of a foundation pile installation system;
25 fig. 3 is top view of a pile gripper device comprising a foundation pile positioning system according to the invention;
fig. 4 is a perspective view of a foundation pile positioning system according to the invention;
fig. 5a-c different views of a detail of the foundation pile positioning system of fig. 4; and
fig. 6 a top view of a detail of a second embodiment of the foundation pile positioning system according to
30 the invention.

Description of embodiments

- Fig. 1 is a schematic side view of a foundation pile 20 installed in an underwater ground formation 36.
35 The foundation pile 20 has a longitudinal axis 2. The foundation pile 20 is installed in a vertical stance. The foundation pile 20 has a cylindrical shape with a pile wall outer surface 22. In the pile wall, an opening 34 is provided. The opening 34 is provided proximate a ground formation 36 below a body of

water 4. The opening 34 allows access to an interior of the foundation pile 20. A power cable 35 is provided in such a way that it can be provided through the opening 34 and extends into the interior of the foundation pile 20. The power cable 35 exits the opening 34 in such a way that it can be inserted into the ground formation 36. The power cable 35 is configured to transport electrical power generated by a wind turbine (not shown) that is supported by the foundation pile 20. The figure 1 illustrates the benefit of the current invention in that the opening 34 can be positioned to facilitate access of the power cable 35 into the interior of the foundation pile 20. To position the opening 34 with respect to the power cable 35, the foundation pile 20 is rotated around its longitudinal axis 2.

Fig. 2 is a schematic side view of a foundation pile installation system 37. The foundation pile installation system 37 includes a vessel 39. The vessel 39, or the pile installation system 37 in general, is equipped with a crane system (not shown) to suspend the foundation pile 20 from a hoisting line 43. The vessel 39 has a support structure 7 that extends outboard. The free end of the support structure 7 is provided with a so-called pile gripper 40. The embodied pile gripper 40 extends around the foundation pile 20. The pile gripper 40 contacts the pile outer surface 22 of the foundation pile 20 to maintain a vertical stance of the foundation pile 20.

Fig. 3 is top view of a pile gripper device 40 comprising a foundation pile positioning system 1 according to the invention. In this case, the pile gripper device 40 has three foundation pile positioning systems 1 to constrain the foundation pile 20 within the pile gripper device 40. Therefore, the pile positioning systems 1 are distributed along a circumference 41 of the pile gripper device 40. The pile positioning systems 1 are evenly distributed along the circumference 41 of the pile gripper device 40.

The foundation pile positioning system 1 comprises an arm member 3. In this case each foundation pile positioning system 1 comprises an arm member 3. The arm member has a connecting portion 5. The connection portion 5 is connected to the support structure 7. The support structure 7 holds the pile gripper device 40 and the connection portion 5 is pivotably connected to the circumference 41 of the pile gripper device 40. The foundation pile positioning system 1 comprises an arm drive system 9. The drive system 9 is configured to pivot the arm member 3. The engaging element 17 is arranged at a free end 11 of the arm member 3 opposite the connecting portion 5. The connection portion 5 of the arm member 3 and the free end 11 of the arm drive system 9 are positioned at a distance from each other. The arm member 3 is pivotable between an extended position as shown, and a retracted position. In the extended position of the arm member 3, the actuation system 15 engages the pile. The actuation system 15 engages the pile with the engaging element 17. Therefore, the engaging element 17 contacts the outer surface 22 of the pile wall.

When the engaging element 17 is engaged with the outer surface 22 of the pile 20, the arm drive system 9 forces the arm member 3 towards the extended position such that the engaging element 17 is constantly in contact with the outer surface 22 of the pile 20. Therefore, in the extended position of the arm member 3, the engaging element 17 maintains contact with the foundation pile 20.

The pile gripper device 40 in this case takes up the form of a ring-shaped element. The pile gripper device 40 is part of a pile holding device or system in general. The pile holding device comprises a pile positioning system according to the invention. The pile holding device does maintain a foundation pile 20 in an upright position during installation of the foundation pile 20 into the ground.

5 The arm drive system 9, as embodied, is connected, in its most apart end from the free end 11 of the of the arm member 3, to a supporting structure that is protruding outside the outer circular periphery of the embodied pile gripper device 40. This supporting structure protruding outside the outer circular periphery or circumference provides facilitates to drive the arm member 3 by the arm drive system 9 while at the same time enabling use of a compact gripper device with a decreased diameter which saves steel and thus weight and cost. The supporting structure has an asymmetrical form, wherein the arm drive system 10 9 is able to extend and retract as needed by the arm member 3 to efficiently operate. It should be noted that in the case wherein the associated support structure is the so-called noise mitigation system (not shown) the support structure can be an internal wall of the so-called noise mitigation system such that the internal wall comprises a connection point for the arm drive system can be easily connected in a moveable 15 and/or hingeable manner, allowing the movement of said arm drive system 9 along the horizontal plane, as well as to extend and retract, accordingly.

Fig. 4 is a perspective view of a foundation pile positioning system 1 according to the invention. The foundation pile positioning system 1 comprises an actuation system 15. The actuation system 15 is 20 configured for rotating the foundation pile 20 around a central longitudinal pile axis. Therefore, the actuation system 15 can align the opening 34 and the power cable 35 as shown in fig. 1. To rotate the foundation pile 20, the actuation system 15 comprises an engaging element 17. The engaging element 17 contacts an outer surface 22 of the pile to rotate the foundation pile around the central longitudinal pile axis 2. The engaging element 17 contacts the foundation pile 20 by friction contact between the engaging 25 element 17 and the outer surface of the pile 20.

The engaging element 17 comprises a rotary member 28. The engaging element 17 contacts the foundation pile 20 through the rotary member 28. The engaging element 17 contacts the foundation pile 20 through the rotary member 28 only. The rotary member 28 is constrained in degrees of freedom of movement. The rotary member 28 is constrained in degrees of freedom of movement in order to rotate 30 the pile 20 around the central longitudinal pile axis 2 and to allow rotation of the rotary member 28 around a first axis 32 such that relative movement of the engaging element 17 and the foundation pile 20 along the central longitudinal pile axis 2 is enabled. The relative movement is enabled by rolling motion between the rotary member 28 and the outer surface 22 of the pile while the rotary member is contacting the outer surface of the pile.

35 The engaging element 17 comprises a driving wheel 29. The driving wheel 29 is being driven by a driving motor 38 providing rotary motion to the driving wheel 29 in either rotational direction. The driving motor 38 is provided to controllably rotate the driving wheel 29, and therefore the pile 20, when in engaging

position, about its vertical axis or longitudinal axis 2. A driving wheel rotation axis 31 is parallel to the central longitudinal axis 2 of the foundation pile 20. The driving wheel 29 communicates rotational motion to the foundation pile 20. The plurality of rotary members 28 are arranged at an outer circumference of the driving wheel 29. In wheel terminology, the rotary members 28 do form an imaginary tread of the driving wheel. To put it differently, the rotary members 28 make up an, active portion of a path of contact, a running surface; a tyre contact patch or an external friction surface of the driving wheel 29. Like any wheel, the driving wheel 29 is rotatably supported to allow motion in both a forward direction and a backward direction. In order to provide friction contact between the rotary member 28 and the outer surface 22 of the pile 20, the plurality of rotary members 28 comprise an elastomeric material. By having the elastomeric material, which can be any material exhibiting elastic or rubber-like properties, the external walls or outer surface of the pile 20 will not be damaged, thus enabling the engaging element 17 to contact the outer surface 22 of the pile in a non-damaging manner.

The rotary members 28 itself, are arranged to rotate perpendicular to the central longitudinal axis 2 of the foundation pile 20.

The engaging element 17 defines a contact area between the engaging element 17 and the outer surface 22 of the pile. The contact area comprises a line contact or a surface contact, or even a point contact.

Fig. 5a-c are different views, perspective-, top- and side view in cross section, of a detail of the foundation pile positioning system 1 of fig. 4, the detail being the engaging element 17. The rotary member 28 comprises a roller that is shaped to provide a wheel shape to the driving wheel 29. The embodied roller is shaped like an American football being a prolate spheroid, although the skilled person will appreciate that any other suitable shape, such as substantially cylindrical, can be also used. The engaging element 17 comprises a plurality of rotary members 28. The rotary members 28 are distributed along the outer circumference of the driving wheel 29 to provide an even contact between the engaging element 17 and the outer surface 22 of the pile 20 while rotating the pile 20. The plurality of rotary members 28 are arranged at a tread 30 of the driving wheel 29.

The engaging element (17) comprises a support structure 33 to rotatably support the plurality of rotary members 28. The support structure 33 comprises to parallel plates 24, 26 have a circular shape. The parallel plates 24, 26 are arranged at a mutual distance defined by spacers 43. The rotary members 28 are arranged between the parallel plates 24, 26.

Additionally, the driving wheel 29 comprises a number of static engaging elements 42 (see fig. 4) provided in-between adjacent rotary elements 28. These static engaging elements 42 are provided to facilitate the fine rotational movement of the driving wheel 29, while at the same time protecting the parallel plates 24, 26, as well as the rotary members 28, when in use, against excessive load and wear.

The rotary members 28 are rotatably coupled to the spacers 43. Each rotary member 28 is supported by two opposite spacers 43. Each rotary member 28 is rotatable around a first axis 32. The plurality of rotary members 28 are arranged to rotate perpendicular to the central longitudinal axis 2 of the foundation pile

20. In other words, as shown in fig. 5A, the first axis 32 is perpendicular to the wheel rotation axis 31. It should be noted that the rotary members 28 are of a shorter length, along the first axis, than the distance between two vertical parallel plates 24, 26, since the rotary member is provided in-between said two opposite spacers 43.

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Moreover, the rotary members 28, are rotatable around a first axis 32, here embodied as a horizontal roller shaft, and can be of a much-shorter longitudinal distance than the distance between two opposite spacers 43 of a support structures 33, such that the rotary members can be moved, passively or actively, side ways in-between a space between two opposite spacers 43. In this manner, the engaging element 17 has some freedom to be moved sideways with respect to the pile 20. The sideways movement is limited by the two opposite spacers 43. The rotary member therefore in this case has some free play along its axis of rotation 32. This provides some freedom for the pile and engaging element to seek a mutual position and facilitates contact between the engaging element 17 and the pile wall 22.

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Fig. 6 is a top view of a detail of a second embodiment of the foundation pile positioning system according to the invention. The engaging element 17 of this second embodiment is shown.

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The driving wheel 29 comprises two treads 30a, 30b. The two treads 30a, 30b are spaced along the driving wheel rotation axis 31. The two treads 30a, 30b are build up by respective support structures 33a, 33b each supporting four rotary members 28. The sets of four rotary members 28 are staggered when seen along the driving wheel rotation axis 31.

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The present invention has been described above with reference to a plurality of exemplary embodiments as shown in the drawings. Modifications and alternative implementations of some parts or elements are possible, and are included in the scope of protection as defined in the appended claims.

Claims

1. A pile positioning system (1) for use in a foundation pile installation system for installing a pile into an underwater ground formation, the pile positioning system comprising;
- 5 - an actuation system (15) for rotating the foundation pile (20) around a central longitudinal pile axis, wherein the actuation system comprises an engaging element (17) for contacting an outer surface (22) of the pile and rotating the pile around the central longitudinal pile axis (2) by friction contact between the engaging element and the outer surface of the pile,
- 10 wherein the engaging element (17) comprises a rotary member (28) for contacting the outer surface (22) of the pile, wherein the rotary member (28) is constrained in degrees of freedom of movement in order to rotate the pile around the central longitudinal pile axis (2) and to allow rotation of the rotary member (28) around a first axis (32) such that relative movement of the engaging element and the foundation pile along the central longitudinal pile axis is enabled by rolling motion between the rotary member (28) and the outer surface of the pile while the rotary member is contacting the outer surface of the pile.
- 15 2. A foundation pile positioning system according to claim 1, wherein the rotary member (28), comprises one or more of a roller, a wheel and any suitable component of rotation.
- 20 3. A foundation pile positioning system according to claim 1 or 2, wherein the engaging element comprises a plurality of rotary members.
- 25 4. A foundation pile positioning system according to claim 3, wherein the engaging element comprises a driving wheel (29) and wherein the plurality of rotary members are arranged at a tread of the driving wheel.
- 30 5. A foundation pile positioning system according to claim 4, wherein the driving wheel comprises two or more treads spaced along a driving wheel rotation axis (31) and wherein at least two of the plurality of rotary members are staggered when seen along the driving wheel rotation axis.
- 35 6. A foundation pile positioning system according to any preceding claim, wherein the driving wheel rotation axis is parallel to the central longitudinal axis of the foundation pile.
7. A foundation pile positioning system according to any preceding claim 3-6, wherein the engaging element (17) comprises a support structure to rotatably support the plurality of rotary members.

8. A foundation pile positioning system according to any preceding claim 3-7, wherein the plurality of rotary members each have an axis of rotation (32) that extends perpendicular to the driving wheel rotation axis (31).
- 5 9. A foundation pile positioning system according to any preceding claim 3-8, wherein the plurality of rotary members comprise an elastomeric material.
- 10 10. A foundation pile positioning system according to any preceding claim, wherein the engaging element defines a contact area between the engaging element and the outer surface of the pile, and wherein the contact area comprises a line contact or a surface contact.
- 15 11. A foundation pile positioning system according to any preceding claim, comprising an arm member (3) having a connecting portion (5) being pivotably connected to an arm support structure (7), as well as an arm drive system (9) configured to pivot the arm member (3), wherein the engaging element is arranged at a free end of the arm member opposite the connecting portion, and wherein the arm member is pivotable between an extended position wherein the actuation system engages the pile, and a retracted position.
- 20 12. A foundation pile positioning system according to claim 11, wherein the connection portion (5) of the arm member (3) and the free end (11) of the arm drive system (9) are positioned at a distance from each other.
- 25 13. A foundation pile positioning system according to claim 11 or 12, wherein, when the engaging element (17) is engaged with the outer surface (22) of the pile (20), the arm drive system (9) forces the arm member towards the extended position such that the engaging element (17) is constantly in contact with the outer surface (22) of the pile (20).
- 30 14. A pile holding device comprising a ring-shaped element for maintaining a foundation pile in an upright position during installation of the foundation pile (20) into the ground, preferably offshore, the device comprising the pile positioning system of any of the preceding claims.
- 35 15. A method for installing a pile into the ground, preferably offshore, wherein the method comprises:
- a) providing a pile positioning system of any of the claims 1-13;
- b) providing a foundation pile (20) in a substantially upright position;

- 5 c) lowering the foundation pile (20) such that its lower part is in contact with an underwater ground formation;
- d) connecting the engaging element (17) with the outer surface (22) of the foundation pile (20) such that the pile is kept in its upright position;
- 5 e) rotating the pile around the central longitudinal pile axis by means of the engaging element (17), and
- f) driving the foundation pile into the underwater ground formation.
- 10 16. The method for installing a pile into the underwater ground formation according to claim 15, wherein steps d) and e) are repeatably performed.
17. The method for installing a pile into the ground according to claim 15 or 16, further comprising the step of blocking rotation of the pile around the central longitudinal pile axis.