UPENDING DEVICE

This invention relates generally to an upending device and a method of upending a tubular pile.

Due to their length, tubular piles, such as monopiles, are usually transported in a horizontal orientation. This means that, upon deployment into a vertical orientation, the tubular piles must be upended. Clearly, due to the size and weight of the tubular piles, such an operation is complex, time consuming, and expensive in terms of the capital cost of equipment and the operating time.

Known types of tubular piles are conical, un-flanged piles, which have an open end without a flange, and flanged piles, which have an inwardly projecting flange at one end. The process of upending flanged piles usually includes inserting an upending tool into the flanged end of the pile and engaging a connection element of the upending tool with the flange such that the tubular pile is effectively lifted by gripping the flange. Upending un-flanged piles typically includes inserting an upending tool into the narrowest end of the pile and using radially extending connection elements which grip the inside radial surface of the pile in a frictional manner. Clearly, both of these upending tools are large, complicated to operated, and expensive to purchase, to transport, and to maintain.

Furthermore, both of these types of upending tool apply significant pressure and bending forces at the locations where the connection elements engage with the pile. This can cause damage to the pile, for example if the engagement is at a defect or a weaker part of the structure, for example at a weld location such as the seam of the pile.

Sometimes these upending tools are used to deploy the pile to the ground into which the pile will be driven. This means that the engagement between the pile and the upending device, which is achieved at the start of the upending operation, is also used during deployment of the pile to the ground. Clearly this has the potential to be suboptimal because the upending tool is inserted into the pile while the pile is horizontal, and so aligning the upending tool with the tubular pile can be challenging, for example because the upending tool is not centrally aligned with the pile.

It would therefore be advantageous to overcome at least some of these limitations.

Summary

In an aspect, the present disclosure refers to an upending device (1) for upending tubular piles, the upending device (1) comprising;

a base element (20) for insertion into an end of, and for extending along an inside of, the tubular pile (FP);

a plurality of connection elements connected to the base element (20) and configured to engage with one or more inside surfaces of the tubular pile; and

a lifting arm (30) for coupling the upending device (1) to a hoisting element (H);

wherein the lifting arm (30) is rotatably coupled to the base element (20), the lifting arm (30) being rotatable relative to the base element (20) about a first axis (A1), wherein the first axis (A1) is a central axis of the base element (20) and is substantially parallel to a central axis of the tubular pile (FP), in use,

characterised in that the lifting arm (30) is rotatable relative to the base element (20) about a second axis (A2), wherein the second axis (A2) is substantially perpendicular to the first axis (A1).

In an aspect, the present disclosure refers to a method of upending a tubular pile (FP), the method comprising the following steps:

a) inserting a base element (20) into a first end of the tubular pile (FP);

b) rotating the base element (20) about a first axis (A1), the first axis (A1) being a central axis of the base element (20) and being substantially parallel to a central axis of the tubular pile (FP), to a desired orientation with respect to the tubular element;

c) radially outwardly moving an engagement part (70) of each of a plurality of connection elements to engage with one or more inside surfaces of the tubular pile (FP);

d) lifting the first end of the tubular pile (FP) by hoisting a lifting arm (30), using a hoisting element (H) connected to the lifting arm (30), the lifting arm (30) being connected to the base element (20);

characterised in that the method further comprises step a1), wherein step a1) precedes step a), step a1) comprising lowering the base element (20), the plurality of connection elements and the lifting arm (30) into a position adjacent the first end of the tubular pile (FP), and rotating the base element (20) and the plurality of connection elements relative to the lifting arm (30) about a second axis (A2), the second axis (A2) being perpendicular to the first axis (A1), to substantially align the first axis (A1) and the central axis of the tubular pile (FP).

In an aspect, the present disclosure refers to a method of deploying a tubular pile (FP), the method comprising a method of upending the tubular pile (FP) according to claim 14 or 15, the method comprising the subsequent step of rotating the base element (20), the plurality of connection elements and the tubular pile (FP) about the first axis (A1) to adjust the heading of the tubular pile (FP).

Accordingly, a first example provides an upending device for upending tubular piles, the upending device comprising;

a base element for insertion into an end of, and for extending along an inside of, the tubular pile;

a plurality of connection elements connected to the base element and configured to engage with one or more inside surfaces of the tubular pile;

a lifting arm for coupling the upending device to a hoisting element;

wherein the lifting arm is rotatably coupled to the base element, the lifting arm being rotatable relative to the base element about a first axis, wherein the first axis is a central

In embodiments, the upending device comprises a hoisting element controller rotatably connected to the lifting arm about a third axis. The third axis may be parallel to the second axis. The third axis may be perpendicular to the first axis The hoisting element controller may comprise first and second connecting elements connecting spaced apart plates of the hoisting element controller together. The first and second connecting element may be elements of circular cross-section, such as tubes or robs, connected at either end to respective spaced apart plate. An opening may be defined by the connecting elements and the spaced apart plates of the hoisting element controller, such that, in use, the hoisting element can pass, or extend, through the opening.

The hoisting element controller may be rotated about the second shaft between a first position and a second position. In the first position, the opening of the hoisting element controller may be perpendicular, for example a plane of the opening may be perpendicular, to a central axis of the lifting arm, for example to an axis, or line, extending between the third axis and the second axis. In the second position, the opening may be at an oblique angle, for example a plane of the opening may be at an oblique angle to, the central axis of the lifting arm, for example to the axis, or line, extending between the third axis and the second axis.

Advantageously, the lifting line applied by the hoisting element may be offset from a centreline of the base element by rotating the hoisting element about the third axis, due to one of the connecting elements intersecting a lifting line from the lifting point of the lifting arm.

The hoisting element controller may comprise securing means for securing, i.e., to prevent relative rotating movement about the third axis, the hoisting element controller to the lifting arm in the second position. The securing means may secure the hoisting element controller in the second position. Advantageously, when the hoisting element controller is secure din the second position the lifting line of the hoisting element may be more closely aligned, or may be aligned, with a centreline of the base element while the base element is orientated with the centreline parallel to a centreline of a pile which is lying on a deck.

According to a further example there is provided an upending device for upending tubular piles, the upending device comprising:

a base element for insertion into an end of, and for extending along an inside of, the tubular pile;

a plurality of connection elements connected to the base element and configured to engage with one or more inside surfaces of the tubular pile;

a lifting arm for coupling the upending device to a hoisting element, the lifting arm rotatably coupled to the base element about a lifting arm axis;

a hoisting element controller rotatably connected to the lifting arm about a hoisting element controller axis, the hoisting element controller axis being parallel to the lifting arm axis.

The hoisting element controller may be the aforementioned hoisting element controller. The lifting arm axis may be the aforementioned second axis. The hoisting element controller axis may be the aforementioned third axis.

According to a further example there is provided a method of upending a tubular pile, the method comprising the following steps:

a) inserting a base element into a first end of the tubular pile;

b) rotating the base element about a first axis, the first axis being a central axis of the base element and being substantially parallel to a central axis of the tubular pile, to a desired orientation with respect to the tubular element;

c) radially outwardly moving an engagement part of each of a plurality of connection elements to engage with one or more inside surfaces of the tubular pile;

d) lifting the first end of the tubular pile by hoisting a lifting arm, using a hoisting element connected to the lifting arm, the lifting arm being connected to the base element.

The method may further comprise step a1), wherein step a1) precedes step a). Step a1) may comprise lowering the base element, the plurality of connection elements and the lifting arm into a position adjacent the first end of the tubular pile. Step a1) may comprise rotating the base element and the plurality of connection elements relative to the lifting arm about a second axis. The second axis may be perpendicular to the first axis. Rotating the base element and the plurality of connection elements relative to the lifting arm about a second axis may substantially align the first axis and the central axis of the tubular pile.

Step d) may comprise rotating the lifting arm, relative to the base element and the plurality of connection elements, about the or a second axis. The second axis may be perpendicular to the first axis. Step d) may comprise rotating the lifting arm, relative to the base element and the plurality of connection elements, about the or a second axis while the first end of the tubular pile is suspended by the upending device.

According to a further example there is provided a method of deploying a tubular pile, the method comprising the aforementioned method of upending the tubular pile, the method comprising the subsequent step of rotating the base element, the plurality of connection elements and the tubular pile about the first axis to adjust the heading of the tubular pile.

According to a further example there is provided an upending device for upending tubular piles, the upending device comprising:

a base element for insertion into an end of, and for extending along an inside of, the tubular pile;

a lifting arm connected to the base element, the lifting element being for coupling the upending device to a hoisting element;

interconnected by a plurality of outer webs. The intermediate ring and the inner ring of the concentric rings may be interconnected by a plurality of inner webs.

The upending device may comprise a lifting arm driving device. The lifting arm driving device may be for rotation of the lifting arm. The lifting arm driving device may be for rotation of the lifting arm about the second axis, with respect to the base element.

The lifting arm driving device may be a linear actuator. The linear actuator may be pivotally connected, at a first end, to the lifting arm. The linear actuator may be pivotally connected, at a first end, to the lifting arm at a position spaced from the second axis. The linear actuator may be pivotally connected, at a second end, to the mounting element. The linear actuator may be pivotally connected, at a second end, to the mounting element at a position spaced from the first axis.

The pipe upending device may comprise driving means located between the mounting element and the base element. The driving means may be for controlling rotational movement, about the first axis, of the base element with respect to the lifting arm.

The driving means may comprise a pinion and a gear rack. The pinion may be rotatably mounted to the mounting element. The gear rack may be provided in or on the base element. There may be at least two pinions rotatably mounted to the mounting element. There may be three pinions rotatably mounted to the mounting element where one of the pinions is an emergency, or backup, or dummy gear. The upending device may comprise pinion rotation means, such as an electric motor, for rotating the pinion. The upending device may comprise a plurality of pinion rotation means, such as electric motors, each pinion rotating means for rotating a respective one of the pinion.

According to a further example there is provided an upending system, the upending system comprising:

the aforementioned upending device;

the axial locking means; and

the actuation means;

wherein each connection element has a frictional lifting configuration and a flange lifting configuration.

In the frictional lifting configuration, the engagement parts may be connected or connectable to the actuation means when the actuation means are connected to the connection means of the base element. In the flange lifting configuration, the engagement parts may be connected or connectable to the axial locking means when the axial locking means are connected to the respective at least one connection part.

Each connection element may comprise the or an engagement part. Each connection element may comprise at least one strip of teeth. The at least one strip of teeth may be attachable to a radially outer surface of the respective engagement part. In the frictional lifting configuration the

at least one strip of teeth is attached to each engagement part. Each connection element may comprise at least one radial rail. The at least one radial rail may be attached or attachable to the radially outer surface of the respective engagement part. The connection element may comprise at least one axial rail. The at least one axial rail may be attached or attachable to an axial surface of the respective engagement part. The at least one axial rail may be attachable to the axial surface of the respective engagement part proximal the radially outer surface of the respective engagement part. The axial surface may face the lifting arm, in use. In the flange lifting configuration the at least one axial rail may be attached to each engagement part. In the flange lifting configuration at least one radial rail may be attached to each engagement part.

In the frictional lifting configuration the axial rails may be detached from each engagement part. In the flange lifting configuration the strip of teeth may be detached from each engagement part. In the frictional lifting configuration the strips of teeth may be configured to engage with an inside radial surface of the pile. In the flange lifting configuration the radial rails may be configured to abut, or be proximal to, an inside radial surface of the pile, and the axial rails may be configured to abut an inside axial surface of a flange of the pile.

Advantageously, the engagement parts can be interchanged or reconfigured for use with a flanged pile or with an un-flanged pile. For example, the strips of teeth and the axial and radial rails may be interchangeable on a given engagement part such that the upending device can be easily and quickly changed for use with a flanged pile or with an un-flanged pile.

The plurality of engagement parts may comprise frictional engagement parts, the frictional engagement parts being connectable to the actuation means when the actuation means are connected to the connection means of the base element. Each frictional engagement part may comprise at least one strip of teeth.

The plurality of engagement parts may comprise flange engagement parts, the flange engagement parts being connectable to the axial locking means when the axial locking means are connected to the respective at least one connection part. Each flange engagement part may comprise at least one axial rail. Each flange engagement part may comprise at least one radial rail.

According to a further example there is provided a method of upending a tubular pile using the aforementioned upending system, the method comprising the following steps:

a) connecting each one of the plurality of engagement parts to a respective one or more connection part to form the respective connection element;

b) inserting the base element into a first end of the tubular pile;

c) radially outwardly moving the plurality of connection elements to engage with one or more inside surfaces of the tubular pile;

d) lifting the first end of the tubular pile by hoisting a lifting arm, using a hoisting element connected to the lifting arm, the lifting arm being connected to the base element.