RIGIDIZED SUPPORT ELEMENT

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ABSTRACT OF THE DISCLOSURE

This invention relates to a foundation member for a structure normally elevated above a working surface such as the ocean floor. The foundation member, or members if more than one is used, is normally in a state of compression and comprises at least two concentrically arranged cylindrical elements, one within the other. The outer of said elements is operably carried on the elevated structure, and the remaining element comprises a pile adapted to penetrate the ocean floor. The respective cylindrical element walls are contiguous, and rigidized at one or more longitudinally spaced joints formed by the peripheral deformation of one element wall into the adjacent wall of the other to define one or more annular rings.

BACKGROUND OF THE INVENTION

Supported structures of the type contemplated are utilized primarily in an oil producing or drilling installation wherein a platform is supported above either the land or the ocean surface. In the instance of an offshore facility, one or more legs extending from the platform into the water, are fixed to the ocean floor by piles connected to the legs. Normally a rigid connection is maintained between the concentric pile and leg by cementing or grouting an overlapping section of the two members for a length of 20 or more feet depending on the weight to be supported and the depth of the water. Such grouted joints however, while assuring rigidity to the structure, are often found weakened due to deterioration. Further, during the installation of the support members, the step of cementing or grouting of the leg to the pile is a rather lengthy operation since the nature of the cement is such that hardening and curing will occur only over a period of time.

In forming such cemented joints, it is further necessary to provide a flow control system of piping to the grouted joint whereby the cement might be directed to the latter. This condition, when considered for deep water operations, can prompt complications, not the least of which is the possibility of prehardening of the cement.

Considering further, such a cemented connection is relatively permanent and unadjustable once installed, regardless of the weight load put on the supported structure. Therefore, the grouted joint is usually made excessively long, or over-designed to assure a safe connection, especially where the overall pile length is greater than several hundred feet.

In overcoming the aforementioned problems related to offshore drilling platform supports, the presently disclosed arrangement is specifically provided with features to afford greater economy, a more positive wall connection, accuracy of installation, and greater versatility in the use of such offshore facilities. Therefore one object of the invention is to provide a composite foundation member adapted to accurately and economically position an oil producing or drilling platform either inland, or in an offshore body of water. A further object is to provide means for readily installing and locking an anchoring element of the composite foundation member with respect to a platform support leg. Another object is to provide a simple, quickly attainable locking connection between concentrically disposed support and anchor units in a foundation member for maintaining an offshore drilling platform above a working surface. A still further object is to provide a firm peripheral joint for a multi-unit foundation member without the use of flowable intermediaries such as cement or the like.

These and other objects of the invention are afforded by the present arrangement which contemplates the use with an elevated oil drilling structure of one or more relatively elongated, although rigid foundation members, which supportably attach to the structure. More specifically, the disclosed device embodies a plurality of such rigid foundation members which extend from the floor of a body of water such as the ocean, to rigidly support an oil drilling platform. Each foundation member includes one or more concentrically arranged heavy walled, metallic tubular elements, one being disposed within the other. A plurality of longitudinally spaced, peripheral joints formed by deformation of adjacent portions of the respective tubular walls, hold the elements into a composite unit.

The deform wall sections may be self sustaining or maintained in a tight interlocked relationship by use of a peripherally expandable retainer disposed internally of the inner element to prevent inward collapse, or deformation of the walls due to compressive stress in the foundation members.

DESCRIPTION OF DRAWINGS

FIG. 1 illustrates an elevation view of a leg supported offshore oil well installation in which a segment of one support leg is shown enlarged in and cross section. FIG. 2 is a segmentary view on an enlarged scale of one of the transverse annular joints shown in the leg section of FIG. 1. FIG. 3 is a segmentary view on an enlarged scale and in cross section similar to the peripheral joint shown in FIG. 2. FIG. 4 is a segmentary view on an enlarged scale and in cross section of another embodiment of the annular joint shown in FIG. 2. FIG. 5 is an isometric view of an expandable ring member adapted to maintain the disposition of the deformed wall joint shown in FIG. 2. FIG. 6 is a cross sectional view taken along line 6 in FIG. 5, and FIG. 7 is a cross sectional view taken along line 7—7 in FIG. 2.

Referring to FIG. 1 the composite foundation member 10 is shown in a substantially upright position. Said member includes an elongated cylindrical casing 11 which extends normally from a position slightly above the ocean floor, through the body of water, and is operably fastened at its upper end by a clamping mechanism 12 to drilling platform 13. A pile 14, comprising an elongated, open ended cylindrical member is disposed concentric within casing 11. The pile 14 lower end penetrates the ocean floor for a suitable distance to anchor and rigidly support platform 13 in a predetermined location. The outer dimension of said pile is sufficiently large to permit the pile to slide freely through the casing and yet have the outer walls thereof contiguous with the casing inner wall,
The relatively long casing 11 and inner pile 14 are joined into a unitary foundation member during the initial installation or positioning of platform 13. In a normal drilling platform arrangement, three or more such foundation members are positioned to provide the necessary stable support to the structure and maintain the latter in a condition of substantial equilibrium during the drilling operation in spite of weather and water conditions.

Casing 11 extends from the ocean floor to platform 13 for a distance of several hundred feet. However, it is contemplated that with the successful progress in drilling technology, future offshore wells will conceivably be positioned in 700 to 1,000 feet or more of water. The herein described foundation member is suitably applicable to an offshore platform installation maintained in any appropriate water depth so long as the physical capabilities of the respective tubular elements are adequate to support the platform load, and resist adverse storm forces.

Referring again to FIG. 1, casing 11 of the foundation member is normally formed of a series of tubing lengths that welded to achieve a desired length. The diameter and wall thickness of the tubing is sufficient to support the platform load at a particular water depth. Since casing 11 upper end is either operatively or fixed held to platform 13 by clamping arrangement 12, both of which arrangements are familiar to the art, the platform might be positioned vertically, stationary, or adjustably as needed, in the manner of a jack-up arrangement.

The lower end of casing 11 according to normal practice terminates a relatively short distance above the ocean floor. Anchor piece or pile 14 extends concentrically with casing 11 lower portion for a sufficient distance to afford a structurally safe overlapping load transfer section. Thus compression loading and bending moment are readily transferred from the elongated casing to the anchor member.

Pile 14 is normally driven into the soft ocean floor by a hammer or similar tool to a predetermined depth, or even to an indefinite depth if the composition of the ocean floor is unknown. Thus, pile 14, which is likewise made up of end connected tubing lengths, could extend several hundred feet into the ocean floor as well as up to about 1,000 feet through the casing. In either event, the concentrically disposed casing 11 and pile elements are joined into the unitary structural member at one or more and preferably a plurality of peripheral locking joints 16 and 17 near the casing lower end. The number of such joints actually needed is limited only by the physical requirements of a particular installation.

Referring to FIG. 2, inner surface 18 of casing 11 is normally disposed contiguous with outer surface 19 of pile 14 to define an annular passage 21 therebetween. The seemingly wide separation of the respective walls as illustrated by the drawing is an exaggeration to more clearly delineate the configuration of the deformation. The annulus defined by the separated walls, facilitates a sliding relationship between the casing and pile during the anchoring operation. However, the width of annulus 21 between adjacent walls is minimized to limit within bounds, the outward deformation of the pile wall which is essential to form the horizontal locking joint. Thus, the annulus width W is sufficient to permit lateral deformation of the pile wall to an extent whereby the material is exerted a sufficient radial force to at least partially deform the latter to a point at which the stress in said casing wall does not exceed the material's elastic limit.

The wall of casing 11 is preferably deformed into a uniform peripheral bottom and to a uniform peripheral engaging surface at the inner face of the casing. To assume that the peripheral joints will maintain their relationship after removal of the expanding force, said joints may be provided with a retainer 22 which, in its ultimate position, is adjusted to exert a continuous outward force against the deformed pile wall.

The primary function of retainer 22 is to establish continuous peripheral engagement with the pile, after the expanding member 15 is removed, to maintain a sufficient radial outward force at the lock joint. To be effectively utilized however, retainer 22 is actuated somewhat in the manner of an expandable ratchet. The structure of the retainer thus permits the latter to automatically adjust, or be adjusted, outwardly during the pile expanding operation. This is done simultaneously with the outward deformation of the respective pile and casing walls by a hydraulic expander tool. Further, in the outwardly adjusted position, retainer 22 will remain expanded to permit removal of the hydraulic expanding tool from the formed joint.

One embodiment of a retainer 22 adapted to the herein described purpose is illustrated in enlarged FIG. 5 and comprises essentially a metallic ring or band in the form of a discontinuous circular body 23. The body is fabricated preferably of a relatively ductile metal such as steel. When finally located in position within a pile and adjusted, will be subjected to a continuous compressive stress to resist the combined reactive forces of the deformed casing 11 and pile 14 walls. As mentioned above however, since the pile walls are preferably deformed beyond their yield point, the primary reactive inward force against retainer 22 will be provided by the stressed casing walls.

Retainer body 23 is discontinuous to the extent of including at least one expansion joint. As shown in FIG. 6, ring-like body 23 may be, although not essentially, contoured along the periphery. The configuration of this external surface permits the wall of pile 14 to outwardly deform at a prescribed radius, and in a manner to avoid excessive internal strain and possible rupture of the casing wall as a result of the deformation.

Opposed ends 24 and 26 of body 23 overlap at the expansion joint. Each of said ends is provided along internal adjacent edges with spaced apart mating teeth, or a similar locking means. The teeth are preferably equispaced in pitch to permit enlargement of the body circumference in short incremental distances. The design of the teeth, and the number in engagement under maximum load conditions, is such as to foster self locking of the engaging tooth surfaces and yet preclude part failure due to excessive shear stress concentration.

The tooth profile may be such as to provide a substantially vertical abutting edge normal to the line of shear force. This edge may also be provided with a back angle to realize a self locking component from the horizontal force along the tooth surface.

A clamping member 27 carried on one end of body 23, operatively engages the outer body end 24 and includes upper and lower components 28 and 29 respectively. Upper component 28 is formed with a downturned lip 31 which is slidable received in groove 31 at the upper edge. A similar clamp component 29 is retained in lower clamp half 29 to fixedly position the clamp with respect to body end 29. Clamp components 28 and 29 are preferably engaged by a suitable means which resiliently connects flanges 33 and 34 to permit the entire clamp to be openly deflected as body ends 24 and 26 are adjusted with respect to each other, and yet returned to a clamping position after the mating teeth along the body ends are again in engagement with the pile.

As shown, retainer 22 is provided with a single expansion joint. However it is understood that a number of such joints might be formed in the body in a manner to permit the desired outward expansion of the entire body surface and the retention of the same in the outward deformed position.

Forming of the disclosed foundation member by one or more joints is normally achieved ancillary to the setting of the pile 14. When the composition of the anchoring floor is of a known consistency, pile 14 will be driven by
the usual pile driving mechanism to a predetermined depth along casing 11. Alternate means may be provided for driving the pile from a position directly within casing 11 thereby avoiding the use of excessive pile length which lack a useful function in the support of platform 13.

Referring to FIGS. 7 and 8, with pile 14 driven to a predetermined depth into the ocean floor, retainer 22 is lowered to a desired locating position within the piling 14 either on expander tool 36 or on a separate line. Hydraulically actuated expander tool 36 is lowered through the piling to a position near the lower end of casing 11. A suitable expander tool adapted to the purpose and here shown pictorially, is common to the industry and comprises essentially a plurality of circularly spaced segments 37. The segments are radially movable between outer and contracted positions, and may be actuated by a powering means such as a hydraulic or mechanical system. With segments 37 retracted, tool 36 together with retainer 22, is lowered through piling 14 to the desired position of the lowest vertical joint 16. The expanding tool segments are expanded sufficiently to cooperate with retainer 22 to avoid pad 42 at the section where the lock is extended and to avoid physical deformation thereof in the manner that the casing wall is deformed. Thus the segment 37 may be provided with a roller face or the like such that frictional contact of the latter along the inner surface of retainer body 23 will be minimized and will not result in a stressing of the latter but merely in adjusting the length.

Sufficient hydraulic pressure is applied by expander segments 37 to outwardly urge retainer 22 which in turn deforms piling 14 inner wall, preferably beyond its elastic limit. Simultaneously as the piling wall is deformed and referring to FIG. 3, the retainer body 23 will lengthen incrementally and lock, as determined by the spacing of the retainer teeth along the mating body ends.

After outward expansion of the piling wall a predetermined distance, or in response to an indicating signal, into the casing wall to form the annular joint 16, the latter will resist both crosswise as well as longitudinal relative movement by the casing and pile. Expander segments 37 are then retracted and the tool 36 is raised through the piling for forming the next joint by positioning a second retainer ring outwardly of the expander. In a similar manner the second vertical locking joint 17 is formed and the retainer placed. The same operation is performed successively of the length of the piling wall to in the aggregate provide adequate support to platform 13.

The nature of the retainer 22 placing and expanding operation requires a relatively brief period. Consequently, a series of such joints may readily be formed along the length of the piling, thus, anchoring of the platform is greatly facilitated. This contrasts drastically with the excessive time element necessitated in the formation of a grouted joint of equivalent holding strength by use of cement or other material. In a further embodiment of the deformed wall locking joint, and as shown in FIG. 4, the outer surface of the piling 41 is provided with a back-up pad 42 at the section where the lock is extended and to be formed. Back-up pad 42 may take the form of a plurality of individual pads spaced apart and disposed about the piling surface. It may also comprise a continuous ring held at the piling outer wall. Either of these arrangements permits a larger clearance between the respective piling and the casing if such is required to form a passage or the like. In forming the joint however, the method and structure will be similar to the previously noted arrangement. Thus, the wall of piling 41 is outwardly deformed, which deformation urges back-up plate or ring 42 into the adjacent outer wall 42, thereby similarly deforming the latter. This use of a back-up member requires the pre-placing of the same either on the piling or on the casing, accurately enough to correspond to the depth of the expander tool when the latter is lowered into expanding position. Positioning means not presently shown may of course be provided at the piling inner surface for locating the expander tool at the proper depth.

In a further embodiment of the novel joint as shown in FIG. 3, casing 46 may be provided on the outer surface with a plurality of spaced apart reinforcing rings 47 and 48. Such rings are disposed to straddle the deformed casing area and limit deformation to the casing to the area encompassed by the respective rings.

Obviously many modifications and variations of the invention, as hereinafter set forth, may be made without departing from the spirit and scope thereof, and therefore, such limitations should be imposed as are indicated in the appended claims.

I claim:
1. A foundation element for a drilling platform to position the latter above a drilling surface, said foundation element extending from said drilling surface to said platform in supporting relation to the latter, and penetrating below said drilling surface a sufficient depth to fixedly anchor said platform; said foundation element including:
(a) an elongated cylindrical casing having an outwardly expandable wall with an inner surface forming an axial passage therethrough, said casing being disposed in a substantially upright attitude with the upper end engaging said platform,
(b) an elongated cylindrical anchor piece positioned in said casing axial passage and extending longitudinally thereof for at least a portion of the casing length, the lower end of said anchor piece being imbedded in said drilling surface, said anchor piece having a peripheral surface disposed contiguous with said casing inner surface,
(c) at least one locking section in said foundation, being formed by a portion of said anchor piece being radially deformed to an outwardly expanded position, and into engagement with an adjacent segment of said casing inner surface, whereby to outwardly deform the latter and fixedly engage the deformed surface thereof to prevent relative axial movement between said casing and said anchor piece, and
(d) a retainer disposed within said anchor piece at said locking section, said retainer being prestressed to bear outwardly against the anchor piece deformed portion, and including at least one expansion joint for fixing said anchor piece at an expanded position engaging said deformed portion after having been adjusted to said expanded position.
2. In a foundation element as defined in claim 1 wherein said retainer includes a generally circular body having an outer engaging pad abutting said casing wall at said locking section, and at least one peripherally expandable joint in said circular body to permit radial enlargement of the latter without subjecting said body to tensional stress.
3. In a foundation element as defined in claim 1 wherein said retainer includes a generally circular body having an outer engaging pad bearing against said casing section, and a plurality of expandable joints incorporated into said body to permit radial displacement thereof without subjecting said body to tensional stress.
4. In a foundation element as defined in claim 1 wherein said retainer includes a discontinuous ring-like member defined by a circularly formed body having opposed overlying ends, at least one peripheral expansion joint incorporated into said ring-like member and including means for maintaining said overlapping ends in fixed, adjustable relationship.
5. In a foundation element as defined in claim 1 wherein said retainer element includes:
(a) an adjustable, discontinuous circularly formed body having at least one expansion joint therein defined by opposed overlapping body ends;
(b) said respective overlapping ends being adapted for
mating engagement to permit unidirectional relative movement therebetween when said discontinuous circularly formed body is peripherally lengthened and (c) means for maintaining said overlapping body ends in mating engagement during relative movement therebetween in a direction for peripherally lengthening said body, and for prohibiting relative movement therebetween in a direction to decrease said body length.

6. In a foundation element as defined in claim 5 wherein said retainer element includes:
(a) an adjustable circular body having at least one expandable joint therein formed by overlapping body ends, the respective overlapping ends being adapted for mating engagement permitting unidirectional movement between said ends when said circular body is peripherally lengthened;
(b) and means for resiliently maintaining said overlapping body ends in mating engagement during relative movement therebetween for peripherally lengthening said body, and said resilient means adapted for prohibiting said relative movement between said ends in a direction to decrease said body length.

7. In a foundation element as defined in claim 1 wherein said retainer includes an adjustable member adapted to be outwardly altered to maintain a radial force against the said wall of said anchor member as the latter is expanded radially outwardly, said adjustable member including a pair of oppositely positioned overlapping ends having a contact face therebetween defined by a plurality of teeth formed in each of said ends, said teeth being spaced incrementally apart thereby permitting unidirectional movement between said respective opposed ends when said member is peripherally adjusted to lengthen the same.

8. In a foundation element as defined in claim 7 including means to resiliently maintain said teeth in engagement during said unidirectional movement, and for prohibiting movement of said respective body ends in a direction for decreasing the length of said circular member.

9. In a foundation element as defined in claim 1 including a back-up ring carried on the external wall of said casing at said locking section for engaging the inner surface of said casing when said anchor piece wall is outwardly deformed.

10. In a foundation element as defined in claim 9 and including a pair of peripheral reinforcing rings spaced longitudinally apart and disposed on opposite sides of said deformed portion of said casing.

11. Method for supportably positioning an offshore platform from an ocean floor which comprises the steps of: suspending a hollow, deformable side wall casing, between said platform and said ocean floor, passing a piling longitudinally through said hollow casing to penetrate the ocean floor to an anchoring depth, said piling having an outer wall disposed adjacent to, and initially in sliding relation to said casing deformable wall, positioning retaining means within said piling at said outwardly deformable side wall, and radially deforming an annular portion of said piling outer wall into abutting engagement with the adjacent disposed casing deformable side wall whereby to similarly deform said casing side wall and provide a peripheral juncture between said casing and said piling, whereby said retaining means will maintain said casing side wall and piling wall respectively in interlocked deformed condition.

12. In the method as defined in claim 11 wherein said piling outer wall is radially deformed a sufficient distance to induce a tensile stress in said wall exceeding the elastic limit thereof.

13. In a method as defined in claim 11 wherein said piling wall is radially displaced a sufficient distance outwardly to induce a stress therein in excess of the said piling elastic limit, and said casing is indented by said deformed piling to a degree that the resulting stress induced in the latter does not exceed the casing material elastic limit.

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