EXTRACTION OF FOUNDATION IN OFFSHORE PLATFORMS

Field of the Invention

[0001] The present invention generally relates to offshore technology, and more particularly to the effective extraction of foundations supporting offshore platforms.

Background of the Invention

[0002] Offshore platforms are used extensively for construction of piers and bridges, drilling for natural resources and laying underwater cables. One particular offshore platform is a mobile drilling rig that is mainly used for oil drilling and gas well operations in water depths up to 120 meters. A typical mobile drilling rig has three supporting legs, each leg being able to extend independently through a jacking-up system. The base of each leg comprises a foundation or footing known as a "spudcan". Nowadays, the foundations of most drilling rigs are equipped with an integrated water jetting system to assist in the extraction of the foundations.

[0003] When the drilling rig is moved to a desired drilling location, the legs of the drilling rig are extended until the foundations rest upon the seabed. Throughout the entire drilling operation, the foundations may penetrate deeply into the seabed, thus experiencing soil resistance therefrom. When the drilling rig needs to be relocated, the legs have to be extracted from the seabed. During this stage, the buoyancy of the drilling rig's hull is utilized to overcome the soil resistance exerted on the foundations. The hull is lowered by the jacking-up system controlling each leg to produce the buoyant force. Furthermore, the integrated water jetting system provides highly pressurized water through the outlets located on the foundation during the extraction process. The water jetting system aims to fluidize the soil surrounding the foundation to facilitate the extraction process. Field observations have shown that conventional water jetting system is unable to provide an effective extraction of the foundation. As such, the extraction rate depends largely on the capacity of the jacking-up system, which is usually limited. In cases where the foundations experience large soil resistance, the jacking-up system is required to operate for a longer period in order to provide sufficient buoyant force to overcome the large soil

resistance. This delay is a huge factor for the increasing cost in the industry. Furthermore, continuous extraction attempts to overcome large soil resistance may harm the structural integrity of the drilling rig. Therefore, the extraction process can be considered as one of the critical phases in drilling rig operations.

[0004] US 4,761,096 discloses a universal footing with jetting system for marine platforms and structures. More specifically, the disclosed universal footing comprises a spud-can that functions as a footing base to distribute loadings over a large soil area, and an internal jetting system to fluidize the soil around the footing. Fluidization of the surrounding soil aims to facilitate the penetration of the footing into the seabed and also the extraction of the footing from the seabed. The disclosed universal footing addresses the difficulties encountered during the penetration and retrieval of the footing, but has its drawbacks. For example, the method of distributing pressurized water to fluidize the surrounding soil during extraction could cause channeling effects. Specifically, the jetting system provides pressurized water into the soil through jet nozzle openings located on the spud-can. Some of these nozzle openings could create channeling in the soil once the water pressure is released into the surrounding soil, thereby resulting in a pressure drop at the remaining nozzle openings. Thus, the disclosed universal footing may not fluidize the surrounding soil effectively. Furthermore, studies on soil liquefaction had shown that clayey soil does not fluidize. As such, the disclosed universal footing may not be as effective when deployed in areas with clayey seabed soils.

[0005] In addition, the inventor of US 4,761,096 describes the experimental details of the footing penetration and extraction processes in two publications, namely "A Universal Footing With Jetting" presented in the Offshore Technology Conference in 1987 and "Effect of Jetting on Footing Penetration and Pullout" presented in the International Offshore and Polar Engineering Conference in 1995. The experiments disclosed in the above publications suggest good performance of the universal footing only in limited conditions. For example, the experiments were performed in a test pit containing fine to medium sand with a surface water of depth 0.46 m. The model footing used has a diameter of 0.6 m, a submerged weight of 90 kg and a penetration depth of 1.52 m. This small scale model experimented under 1-g conditions does not provide an accurate simulation of real conditions, wherein the footings deployed have larger diameters and the footing experiences higher levels of stress. In field situations, the footing has diameters ranging

from 10 to 25 m and is deployed in water depths up to 120 m. The penetration of the footing can reach up to 20 m in depth. The seabed may also comprise clayey sediments that are less permeable compared to fine and medium sand. As mentioned above, clayey soil does not fluidize. As such, the disclosed experiments do not provide a realistic simulation of the actual field conditions.

[0006] Therefore, there is an imperative need to have an effective and efficient method for extracting the foundation of an offshore platform. This invention satisfies this need by disclosing an improved foundation that is able to minimize the soil resistance so as to facilitate the extraction process. Furthermore, the present invention is designed to be easily implemented into existing offshore platforms. Other advantages of this invention will be apparent with reference to the detailed description.

Summary of the Invention

[0007] The present invention provides a foundation for use in offshore platforms and a system for extraction the foundation penetrated in a seabed.

[0008] Accordingly, in one aspect, the present invention provides a foundation comprising a body having a base, wherein the body is adapted to receive pressurized fluid; and a plurality of outlets disposed on the base, wherein the plurality of outlets are terminated with an interface layer for allowing pressurized fluid to be released to the base external and preventing the ingress of seabed sediments into the body, whereby the body is configured to provide a uniform distribution of the pressurized fluid to the base external through the plurality of porous outlets, wherein the pressurized fluid released through the plurality of porous outlets increases the pore pressure at the base external, and thereby minimizing the suction on the base.

[0009] In another aspect, the present invention provides a system for extracting an offshore platform foundation penetrated in a seabed, comprising a channel for transferring pressurized fluid to the foundation; a chamber disposed within the foundation, wherein the chamber is adapted to receive pressurized fluid from the channel; and a plurality of outlets disposed on the base of the foundation, wherein the plurality of outlets are terminated with an interface layer for allowing pressurized fluid to be released to the base external and preventing the ingress of seabed sediments into the chamber, whereby the chamber regulates the pressurized fluid received, thereby providing a uniform distribution of the

pressurized fluid to the base external via the plurality of porous outlets, wherein the pressurized fluid released through the plurality of porous outlets increases the pore pressure at the base external, thereby minimizing the suction on the base.

Brief Description of the Drawings

[0010] Preferred embodiments according to the present invention will now be described with reference to the drawings, in which like reference numerals denote like elements.

[0011] FIG. 1 illustrates a cross-sectional side view of a foundation.

[0012] FIG. 2 illustrates a bottom view of a foundation comprising a plurality of outlets according to one embodiment of the present invention.

[0013] FIG. 3 illustrates a cross-sectional side view of an outlet with an interface material according to one embodiment of the present invention.

[0014] FIG. 4 illustrated an alternative bottom view of a foundation comprising a plurality of outlets according to another embodiment of the present invention.

[0015] FIG. 5 illustrates the contribution of the suction force and the overlying soil resistance to the net soil resistance of a penetrated foundation, with respect to the operation period.

[0016] FIG. 6 illustrates the behavior of the pore pressure at the base of the foundation without the application of an external pressure.

[0017] FIG. 7 illustrated the behavior of the pore pressure at the base of the foundation under the application of an external pressure.

Detailed Description of the Invention

[0018] The present invention may be understood more readily by reference to the following detailed description of certain embodiments of the invention.

[0019] Throughout this application, where publications are referenced, the disclosures of these publications are hereby incorporated by reference, in their entireties, into this application in order to more fully describe the state of art to which this invention pertains.

[0020] The present invention provides a foundation for an offshore platform that enables the extraction process to be performed effectively and efficiently. In one embodiment, the foundation **1** comprises an upper body **10** and a lower body **20**, wherein the upper body **10** and lower body **20** have a frustum shape (see FIG. 1). It should be understood by one skilled in the art that the foundation **1** can take on other shapes. For instance, a caisson is contemplated. The base **22** of the lower body **20**, which also refers to as the base **22** of the foundation **1**, comprises a plurality of outlets **24** and a spigot **26**. A chamber **30** is located within the lower body **20**, wherein the chamber is configured to receive pressurized fluid **60**, for example water. The pressurized fluid **60** is supplied from a source (not shown) located at the hull of the offshore platform to the foundation **1** via a pipeline **40**, wherein the pipeline is connected to the upper body **10**. In specific, the pressurized fluid **60** from the pipeline **40** is channeled to the chamber **30** via a plurality of conduits **12**, wherein the conduits are disposed in the upper body **10** of the foundation **1**.

[0021] When the pressurized fluid **60** is channeled to the chamber **30**, the pressurized fluid is regulated in the chamber and distributed uniformly over the plurality of outlets **24**. The height and base area of the chamber **30** is configured to ensure the proper regulation and uniform distribution of pressurized fluid **60** over the plurality of outlets **24**. Furthermore, the chamber is preferably made from materials that are able to withstand high pressure, for example steel. In existing foundations **1**, the internal framework of the lower body **20** is typically composed of several compartments or cubicles. These compartments can be interconnected to form the chamber **30**. Furthermore, the interconnected compartments allow equalization of the pressurized fluid **60** received by each compartment. This ensures the uniform distribution of pressurized fluid **60** through the plurality of outlets **24**.

[0022] In a preferred embodiment, the plurality of outlets **24** are disposed at the base **22** of the foundation **1** in an arrangement illustrated in FIG. 2. Each of the outlets **24** is adapted to terminate with an interface material **50**, for example porous metal (see FIG. 3). The interface material **50** acts as a membrane that allows the transfer of pressurized water through the outlet **24** to the external of the base **22**, and prevents the ingress of seabed sediments into the chamber **30**. Furthermore, the interface material **50** must be able to withstand the pressure exerted by the soil surrounding the base of the foundation during the entire operation period. The interface material **50** is preferably made from porous

materials with a pore size smaller than clay particles, for example steel. In an alternative embodiment, four triangular outlets **24'** are arranged at the base **22** (see FIG. 4). The outlets **24'** are also adapted to terminate with the interface material **50**. The arrangement and number of outlets can be manipulated to provide effective transfer of pressurized fluid **60** to the external of the base **22**.

[0023] As afore-discussed, the foundations **1** supporting the structural weight of the offshore platform may penetrate deeply into the seabed when they are first lowered. The conical spigot **26** at the base **22** of the foundation **1** provides additional structural stability for the offshore platform. As the foundation **1** penetrates deeply into the seabed, soil deposits on top of the foundation **1** and surrounds the base **22** as well.

[0024] Centrifuge tests were performed to simulate the actual field conditions of the foundation **1** penetrating into clayey seabed. The tests utilize a centrifuge model to overcome the limitations of the 1-g model test adopted in the afore-discussed prior art. In FIG. 5, a series of tests consistently show that the net soil resistance **110** during the extraction of the foundation **1** consists of two main components: the suction **112** of the soil at the base of the foundation **1** and the overlying soil resistance **114** at the top of the foundation. In particular, suction **112** increases at a much higher rate over a predetermined period of time compared to that of the overlying soil resistance **114**. Over a longer operation period, suction **112** contributes significantly, up to 60%, to the net soil resistance **110**. The present invention minimizes the suction **112** effectively so as to facilitate the extraction process of the foundation **1**.

[0025] In general, the water in the pores of soil is known as pore water. The pressure within the pore water is referred to as the pore pressure. Suction **112** can be defined as negative excess pore pressure with respect to the hydrostatic pressure at the base **22** of foundation **1**. This negative excess pore pressure is induced by the extraction of foundation **1**. Hydrostatic pressure can be referred to as the pore pressure for any given depth where there is no water flow. FIG. 6 illustrates the behavior of the pore pressure at the base **22**, wherein pore pressure at the base increases with depth. Experimental studies on the present invention have shown that a portion of the extraction-induced excess pore pressure in the soil surrounding the base **22** of the foundation **1** transforms into suction **112**. The magnitude of suction **112** depends on the pore pressure prior to the extraction of the foundation **1**. Referring again to FIG. 6, the pore pressure at the base **22** increases

during the penetration of the foundation **1** into the seabed, wherein the foundation stabilizes at a stage **210**. Thereafter, the pore pressure starts to dissipate during an extended operation period until it reaches a level proximal to the hydrostatic pressure, as shown in stage **220**. When the foundation **1** is extracted during stage **220**, the extraction-induced excess pore pressure transforms into suction **112**. Continual uplift of the foundation **1** is required to overcome the maximum suction **112** at stage **230**, followed by the remaining overlying soil resistance **114** until the foundation **1** can be fully extracted at stage **240**.

[0026] The present invention improves the extraction of the foundation **1** by increasing the pore pressure at the base **22** prior to the extraction, and supplying pressure throughout the extraction process to compensate for the suction **112** that would have developed at the base **22**. As such, an external pressure needs to be supplied at the base **22** to build up the pore pressure at the base external. Preferably, the pore pressure is accumulated to the maximum level as shown in stage **250** of FIG. 7 when the extraction starts. This provides for an initial pressure that is sufficient to compensate for the negative pressure (suction **112**) that is generated during the extraction process.

[0027] The pressurized fluid **60** acts as a means for the transferring the external pressure to the base **22**. Pressurized fluid **60** is first supplied to the chamber **30** from the pipeline **40** via the plurality of conduits **12**. The chamber **30** regulates the pressurized fluid **60** received and provides a uniform distribution of the pressurized fluid through the plurality of outlets **24**. The pressurized water transferred to the base **22** external builds up the pore pressure of the soil surrounding the base **22**. Furthermore, the uniform distribution of pressurized water through the plurality of outlets **24** minimizes any channeling effects that may result from the water jetting system discussed above. The size and arrangement of the plurality of outlets are designed to ensure that the coverage area of the pressurized fluid **60** released from one outlet overlaps the neighboring outlets. This ensures that the pore pressure build-up over at the entire base **22**. Pressure sensors (not shown) can be mounted at the base **22** to monitor the pressure thereof.

[0028] While the present invention has been described with reference to particular embodiments, it will be understood that the embodiments are illustrative and that the invention scope is not so limited. Alternative embodiments of the present invention will become apparent to those having ordinary skill in the art to which the present invention

pertains. Such alternate embodiments are considered to be encompassed within the spirit and scope of the present invention. Accordingly, the scope of the present invention is described by the appended claims and is supported by the foregoing description.

CLAIMS:

1. A footing for use in an offshore platform comprising:

a body having a base, wherein the body is adapted to receive pressurized fluid; and

a plurality of outlets disposed on the base, wherein each outlet has a porous member disposed across its opening such that the pressurized fluid is operable to exude out of the porous member without fluidizing or channeling the soil beneath the base to form a film or layer of pressurized fluid between the base and the external soil for reducing negative soil excess pore pressure in the soil when an uplifting force is applied to the footing during extraction, thereby easing the induced suction at the base of the body and expediting extraction of the footing.

2. The footing of claim 1, further comprising a chamber disposed within the body, wherein the chamber is adapted to receive the pressurized fluid, thereby regulating the pressurized fluid to provide a uniform distribution of the pressurized fluid through the plurality of outlets.

3. The footing of claim 1 or 2, wherein the plurality of outlets are arranged so that the coverage area of the pressurized fluid released from one outlet overlaps the neighboring outlets.

4. The footing of any one of claims 1-3, wherein the body is a spudcan.

5. The footing of any one of claims 1-3, wherein the body is a caisson.

6. A system for extracting an offshore platform footing penetrated in a seabed, comprising:

a channel for transferring pressurized fluid to the footing;

a chamber disposed within the footing, wherein the chamber is adapted to receive pressurized fluid from the channel; and

a plurality of outlets disposed on a base of the footing, wherein each outlet has a porous member disposed across its opening such that the pressurized fluid is operable to

exude out of the porous member without fluidizing or channeling the soil beneath the base to form a film or layer of pressurized fluid between the base and the external soil for reducing negative soil excess pore pressure in the soil when an uplifting force is applied to the footing during extraction, thereby easing the induced suction at the base of the footing and expediting extraction of the footing.

7. The system of claim 6, wherein the plurality of outlets are arranged so that the coverage area of the pressurized fluid released from one outlet overlaps the neighboring outlets.

8. The system of claim 6 or 7, wherein the footing further comprises a plurality of conduits for transferring pressurized water from the channel to the chamber.

9. The system of any one of claims 6-8, wherein the footing is a spudcan.

10. The system of any one of claims 6-8, wherein the footing is a caisson.