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Design and Operation of an Extractable Caisson Foundation for Offshore Structures

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Abstract

This Paper describes the development and first successful application of a caisson foundation providing a reliable and easily extractable foundation solution for offshore structures. The specific structure described is a two piece template called Pin Pile Installation Frames (PPIF, 400te) and Locator Arm (LA, 275te) used together to accurately locate and drive pin piles into the seabed. Pin piles are typically used as alternatives to mudmats for temporary support of jacket structures in deep water soft clay sites, where the required mudmat area would be prohibitively large. The PPIF and LA were successfully used in May 2006 to install eight 96" diameter, 100m penetration pin piles for two jackets in BP's Gunashli field in 175m water depth in the Caspian Sea. The piles were installed well within the ±150mm lateral and vertical positional accuracy and 0.1° inclination tolerance.

The Paper illustrates how a diffuser system utilising a geotextile product routinely used in onshore construction practice, in conjunction with a passive suction system was developed and used to provide a simple yet effective means of avoiding the soil adhesion problem. 1:20 scale 1g physical model tests and laboratory interface friction tests on the special paint system for skirts are discussed. The philosophy developed for sizing the capacity of passive suction system and the back-up active injection system is explained. Also described are the nonlinear geotechnical FE analyses, which made it possible to justify minimizing the size of caisson foundations beyond Code factor of safety to ensure extraction within 30 minutes, whilst maintaining the required foundation reliability for bearing capacity.

Introduction

Azerbaijan International Operating Company (AIOC) is developing the ACG field in the Azerbaijan sector of the Caspian Sea. Phase 3 of the project involves installation of two bridge-linked platforms in the Deep Water Gunashli (DWG) field, the Drilling/Utilities/Quarters (DUQ) platform and the Production/Compression/Water Injection/Utilities platform (PCWU), see Fig. 1. The nominal water depth at the site is 175m.

During installation the platforms were to be placed on four pin-piles, pre-installed one under each corner leg. These pin-piles replaced the conventional mudmats that were used to support the four previous jackets in Phases 1 and 2 of the project for on bottom stability. The reason for this change in Phase 3 was a combination of factors including, soft soil conditions and giving rise to very large sized mudmats with excessive wind resistance on the large sized mudmats during towing on barge to site. To get an appreciation of the scale, the position of each of the four pin piles is at the corners of a full sized soccer pitch.

The eight pin piles were installed by deploying two pieces of temporary structures, the Pin pile Installation Frame (PPIF) and Locator Arm (LA), see Fig. 2. Both these structures were supported on circular caisson foundations (referred to as mudmats for simplicity in the remainder of this paper). At DUQ platform location the PPIF was docked onto the pre-drilling template and placed on the seabed first. The LA, which incorporates the pin pile driving sleeve, was then docked onto each of the four faces of the PPIF structure to locate the position of the corner pin piles in turn, see Fig. 1. Kellogg Brown and Root UK (KBR) designed the platforms as well as the PPIF and LA structures. Installation was performed by Saipem. This paper presents the results and supporting geotechnical calculations for the mudmat foundations of PPIF and LA structures.

The submerged weights of PPIF and LA were 200.6 tonnes and 141.8 tonnes, respectively. Penetration of the skirted mudmats into seabed took place under the self weight of each structure. Extraction of the mudmat foundations from seabed utilized a passive suction system with an active water injection system forming a backup system. In the PS system the mudmats were subjected to an uplifting force (jack or crane lift) and water was sucked into the cylindrical cavity through suction ports as a result of negative pressures developing there in response to the applied load. In the active water injection system water was injected into the cylindrical cavity below the mudmat base to piston the mudmat out of the seabed. Both systems comprised valved penetrations on individual mudmat bases. To avoid the well known adhesion problem between the mudmat base and seabed clay and to ease the breakout of mudmats during lifting off from the seabed all mudmats were provided with a special layer of Terram geotextile on the underside of the base plate.