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The hydrodynamic performance of a novel float-over installation

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ABSTRACT

Floaters float-over (FFO) is a new method of topside/deck installations that has the concept of transporting the topside/deck using two groups of floaters connected at its opposite sides. By ballasting and deballasting the floaters, the system will be able to raise the deck from the transportation barge, and then lower it down to the jacket or spar. FFO can work in wider range of sea states than conventional float-over methods due to its small water plane area and large mass. FFO is, therefore, a competitive method compared to other heavy lift and float-over methods.

In this paper, the concept and design philosophies are presented. The performance of the system during its consequential installation stages is discussed with regard to the stability, motions and strength aspects. The main stages of FFO installation, namely, transportation, lowering of the group of floaters, connecting them to the deck, separation of the deck from the transportation barge and mating of the deck with jacket legs, are presented. In each step, stability and motions are determined at the prevailing sea state. Based on the results of the motion analysis, the impact and internal forces at the deck are computed and evaluated according to the industry codes and standards. A case study for a deck that is to be installed by either heavy lifting or float-over is included, to indicate the suitable sea state for installation and the required stiffening for the deck.

1. Introduction

Topside/Deck of fixed offshore platforms and spars is installed by either heavy lifting or float-over methods. Heavy lifting installations are always constrained by the capacity of the heavy lifting barges and their availability, which makes it an uneconomical solution for heavy deck installations. The circumstances of water depth, sea state, derrick barge availability, and cost of competitive options are combined in such a way to make a float-over an attractive installation method. However, it is very sensitive to weather condition, and has a significant effect on the jacket structural design. The performance of float-over was successfully enhanced using the following techniques.

UNIDECK (Cholley and Cahay, 2007) combines ballasting and jacking to improve the stability of the heavy transport vessel during the transportation phase and uses jacking to provide a quick, and therefore safe, transfer of the integrated deck weight onto the jacket in order to avoid high dynamic impact loads (Tribout et al., 2007). The Strand-Jack (Taylor, 2010) can position topsides at a very low level on barge deck, thus improving the barge stability and reducing the initial contact impact significantly. The Smart-leg (Labbé et al., 1998) uses active hydraulic jacks to neutralize the vertical movements of the barge and to transfer the deck weight from the cargo barge to the piled jacket structure. The deck mating is completed in just a few seconds, less than the swell period. Rather than using leg mating units to absorb the shocks. The Ampelmann technique (Gerner et al., 2007) use a platform consists of six hydraulic cylinders, which is capable of compensating the motions of a vessel in six degrees of freedom. This technique is not implemented in the float-over because it costs more than the conventional hydraulic system. The T-Shape barge is an effort to reduce the slot requirement, thus having less impact on design of the substructure and the topsides. The T-shape barge has protruded pontoons from its port and starboard side at the aft body outwards. Although, the pontoons are used to provide additional stability, the frontal area of the T-Shape barge induces additional acting environmental loads (Wang et al., 2010). Catamaran float-over is performed using a twin-hull vessel, where this vessel is docked around the jacket/spar and then the mating operation is performed. An example of the catamaran float-over is Pioneering Sprit. The catamaran configuration causes huge amount of stresses acting on the ship hull. Analyses (Wang et al., 2010) have shown that in hostile environments such as the North Sea, the motion compensation system is essential on a single-lift vessel to eliminate impact forces on large topsides, due to the giant masses involved. In the absence of such a system, local damage will occur even when the wave height is small and vessel motions are very limited. In addition, the ample lift capacity can accommodate normal inaccuracy of the topsides weight and/or the position of the center of gravity. The

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Nomenclature

AISC	American Institute of Steel Construction
ASD	Allowable Stress Design, (used in the structural analysis code check)
BM_T	Vertical distance between the center of buoyancy and the transverse metacenter (m)
DP	Dynamic Positioning system
E	Modulus of Elasticity (GPa)
FFO	Floaters Float-Over
FS	Floaters System
F_y	Material yield stress (MPa)
GM_T	Metacentric height (m)
H_s	Significant wave height (m)
h_b	Critical draft where transition phase of floaters group lowering occurs (m)
KB	Vertical distance between keel and center of buoyancy (m)
KM_t	Distance between keel and transverse metacenter (m)
PM	Pierson-Moskowitz wave spectrum
RAO	Response Amplitude Operator
SBHQ6	Stretching and Bending Hybrid Quadrilateral with 6 degrees of freedom elements
T_p	Wave spectrum peak period (sec)
WPA	Water plane area (m^2)
WPA_1	Water plane area of floaters group during the first phase of lowering (m^2)
WPA_2	Water plane area of floaters group during the second phase of lowering (m^2)

catamaran system was used in a multipurpose vessel that has several tasks one of them is the float-over.

The problem of float-through in the jacket was solved using VERSATRUSS and Twin barges techniques. In VERSATRUSS (Barbara, 1997), Two lift barges are symmetrically moored alongside a transport barge or fixed jacket. However, the workability of this system is limited by: 1) The connection of the booms to the deck must be down in sheltered area close to the installation site. 2) The high stresses in the deck structure during the time when the lift booms are stabbed and the deck legs are connected to the jacket structure. The restraining forces of lift barge motion are transmitted into the deck structure and the jacket structure causing high stresses on both of them. The main disadvantage in the Twin barges (Seij and Grook, 2007), is the limitation of the transportation sea state due to the raking effect.

A new method of float-over, that has been called floaters float-over (FFO), is innovated and presented in this paper. In this method the float-over can be performed in harsher sea states than those related to the conventional float-over methods. The main objective of FFO is to have a floating topside installation system with a relatively small amplitude motion response. This can be achieved by designing a FFO system having small water plane area and large mass which lead to the FFO system having small heave, roll and pitch natural frequencies, usually less than the modal frequency of the expected sea states, and hence resonance can be avoided. The small water plane area (WPA) also reduces the excitation wave forces. The small WPA combined with the high center of gravity of the deck give bad stability characteristics to the system, which is overcome by adding permanent ballast at the base. The performance of Floaters Float-Over (FFO) has been investigated numerically, and it has been proved that FFO has a wider sea state operability compared to other conventional float-over methods. Geba et al. (2014) shows a comparison between the maximum response in beam waves for FFO and a conventional float-over barge where the FFO has much calmer response about one third of the barge's. Accordingly, it is clear that FFO will give less impact forces during mating and less mooring tension forces than the conventional float over methods, which allows the proposed FFO to has a wider sea state operability compared to other conventional float-over methods

2. FS Installation procedure

FFO concept is illustrated in Figs. 1 and 2. The deck is transported above a transportation barge. When the deck arrives in location, two groups of floaters are lowered (Fig. 1-a) and then connected to the deck (Fig. 1-b). The deck and floaters groups then act as one rigid floating body, named as Floaters System (FS). FS is moored to the sea bed using several mooring lines and connected to the jacket using several soft lines. Then, a separation between the FS and the barge is performed by

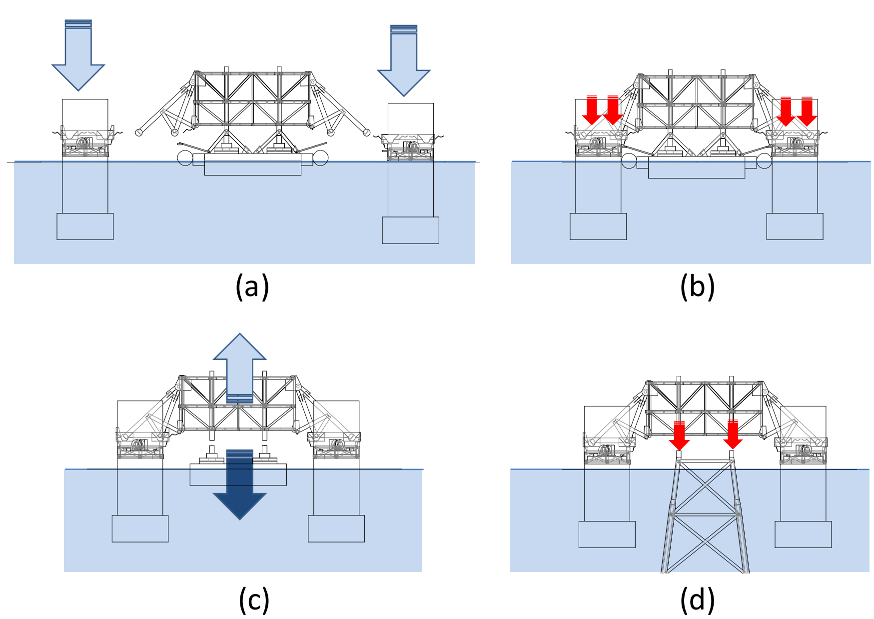

Fig. 1. FFO main steps, described as: (a) Floaters group lowering, (b) Connecting Floaters groups to the deck, (c) separation of the FS from the barge, and (4) mating of FS with the jacket.