International Journal of Offshore and Polar Engineering (ISSN 1053-5381)

Vol. 30, No. 1, March 2020, pp. 94–104; https://doi.org/10.17736/ijope.2020.jc763

http://www.isope.org/publications/publications.htm

A Novel Conceptual Telescopic Positioning Pile for VLFS Deployed in Shallow Water: Function Verification

Chuanpeng Ji, Shengwen Xu*, Xuefeng Wang and Xiaolei Liu
SKLOE, CISSE, School of Naval Architecture, Ocean and Civil Engineering, Shanghai Jiao Tong University
Shanghai, China

Yongzhi Shang
Division of Research and Development, Shanghai Shocktorm Ocean Engineering Co. Ltd.
Shanghai, China

A novel conceptual telescopic pile is proposed to position a multi-modular very large floating structure (VLFS), which is supposed to serve as a movable floating airport. The telescopic piles can automatically plug in and pull out of the soil to resist the environmental forces. The demonstration of the feasibility of this conceptual design includes two parts: function verification and structure design. In the function verification, the bearing capability and dynamic responses are primarily investigated by the finite element method (FEM) using Abaqus software. The obtained results reveal that the dynamic response feature is quite good. Based on the coupled Eulerian–Lagrangian (CEL) method, the plugging and pulling processes are explicitly simulated. The results indicate that both the operations are quite safe and can be independently accomplished by vertical forces supplied by the adjustment of the ballast water and draft of the module.

INTRODUCTION

Very large floating structures (VLFSs) have many important applications, of which the floating airport is one of the most valuable, as specifically described in previous relevant research (ISSC, 2006). The applications of VLFS, such as floating airports, floating piers, floating fuel storage facilities, floating hotels, floating bridges, floating stadiums, and even floating cities, have triggered extensive research in the past two decades (Kyoung et al., 2005, 2006; Wang and Tay, 2011). The first concept of VLFS that appeared in the modern world after the industrial revolution was the Floating Island described by the 19th century French novelist Jules Verne. The first VLFS promoted in earnest was the Armstrong Seadrome. It was proposed initially to enable airline routes across the world's oceans (Armstrong, 1924). Detailed and concentrated efforts were then undertaken in the mobile offshore base (MOB) and Mega-Float projects (Suzuki et al., 2007). Shipbuilding technology had attracted the attention of architects in the late 1950s (Kikutake, 1994). Several concepts and designs of floating cities were then proposed in the 1970s and 1980s. Currently, research institutes such as the Technological Research Association of Mega-Float (TRAM) and International Ship and Offshore Structures Congress (ISSC) have paid much attention to the development and utilization of the VLFS (Suzuki, 2005). Except for the Mega-Float in Tokyo Bay, the only manufactured VLFS in existence, all VLFSs are only at the design stage (Lamas-Pardo et al., 2015).

In a VLFS serving as a floating airport, the motion responses in the operational condition should be constrained strictly. Additionally, the safety of the VLFS should be guaranteed in the survival condition. The mooring system is conventionally employed as a means of mature positioning in the offshore engineering field. However, the anchorage and the unmooring processes are complex and require the aid of auxiliary vessels. Recently, the development of laterally loaded piles with large diameters have been widely applied in jackup platforms and offshore wind turbines (Byrne et al., 2015). Compared to a mooring system, positioning by piles affords better positioning accuracy. In this paper, a novel telescopic positioning pile for a multimodular VLFS deployed in shallow water is proposed. More specifically, telescopic piles are plugged into the seabed to resist the hydrodynamic loads of the VLFS and can be pulled out when necessary. Since the vertical forces are supplied by the changes of the ballast water and the draft of the module, the plugging and pulling processes can be accomplished by the VLFS itself. It is quicker, more convenient, less expensive, and affords more precise positioning than a conventional mooring system.

Many studies have been conducted on the characteristics of laterally loaded piles, such as the bearing capacity, dynamic response, and plugging and pulling processes. Some offshore structure design cores, with formulae to calculate the bearing capacity of the pile, have been published by the American Petroleum Institute (API, 2000) and Det Norske Veritas Germanischer Lloyd (DNV GL, 2011). However, almost all of these formulae are semi-empirical and are derived from model piles with small diameters (less than 3 meters). The availabilities of large-diameter piles are incognizable. The bearing capacity of piles calculated by centrifuge model test and FEM have been compared and studied by Danno and Kimura (2009), Sun (2016), and Meng (2017). Their research showed that simulation results coincided perfectly with model test data.

Kim and Jeong (2011) have compared the results of field load tests and three-dimensional (3D) numerical methodology about the soil resistance on laterally loaded piles and found their good

*ISOPE Member.
Received November 28, 2018; updated and further revised manuscript received by the editors January 17, 2019. The original version (prior to the final updated and revised manuscript) was presented at the Twenty-eighth International Ocean and Polar Engineering Conference (ISOPE-2018), Sapporo, Japan, June 10–15, 2018.
KEY WORDS: Conceptual telescopic positioning pile, feasibility demonstration, bearing capacity, dynamic response, plugging and pulling processes, very large floating structure (VLFS).