COMPARATIVE ANALYSIS OF LATERALLY LOADED MONO-PILES BY CLASSICAL AND P-Y METHODS

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Abstract

Mono-piles driven in onshore or offshore areas are loaded laterally by vessels as berthing thrust or mooring tension. In the design of flexible dolphins as breasting dolphins, its energy absorption due to elastic deflection is also considered. Classical calculation models (such as Blum) and P-y curve method are more applicable in design processes. The general target of this paper is to compare the results of Blum and P-y methods for a laterally loaded mono-pile driven in a granular soil in view of bending moment, embedment depth and lateral deflection. Three soil densities are considered and the effect of soil densities is also studied. A new correlation for determining virtual fixity depth is also introduced. The flexibility of mono-pile to absorb the impact energy is also examined by two approaches.

Keywords: mono-pile, lateral load, Blum method, P-y method, energy absorption

Introduction

Mono-piles are large diameter vertical piles that are driven in offshore for vessel berthing and even wind turbines. The former mono-piles are a type of dolphin structures. Dolphins are usually installed to provide a fixed structure when it would be impractical to extend the shore to provide a dry access facility. Typical uses include extending a vessel berth (a breasting dolphin) or providing a point to vessel moor to (a mooring dolphin) and lateral load is applied by vessel. The maximum bending stress and deflection induced by lateral loading are two main criteria for design of mono-piles.

The flexibility of piles allows to deflect simply and even to absorb a part of the impact energy of vessel in the case of breasting dolphins. Therefore where soil conditions are suitable, the flexible mono-piles or dolphins are often attractive because it combines the functions of energy absorption and breasting structure. As the energy absorption capacity of a pile is a function of its length, this type of structure is particularly appropriate in deep-water applications. This means that the capacity of the pile to withstand the loads depends on both the strength and stiffness of the pile. The pile stiffness should therefore be chosen in such a way that hulls should not be able to strike piles when the head of the structure is deflected. According to some codes such as BS, it is necessary that the combined deflection of the dolphin and fender does not exceed 1.5 m to avoid problems with vessel handling.

When lateral loading increases, to remain in marginal safety in view of structural strength and performance, it is necessary to increase the steel strength or pile diameter. Regarding to manufacturers limitations for production of large diameter pipes and expensive costs, another alternative to overcome to these limitations is increasing in number of piles as a group. In this case, the superstructure shall be designed in such a way that does not prevent the pile head from rotation. The superstructure transmits the impact force uniformly to each pile. Torsion moments arising from eccentric impact are also transmitted equally to the single piles of the dolphins by means of torsion bars mounted at the top of superstructure. The mooring and breasting dolphins designed in Iran LNG Project in Tombak are a real case of such dolphins.

The lateral loading on a vertical pile head is initially carried by the soil close to the seabed. At a low loading the soil is compressed elastically but the movement is sufficient to transfer some pressure from the pile to the soil at a greater depth. At a further stage of loading the soil yields