Editorial

Dynamic Responses of Bucket Foundations

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This special issue of The Open Ocean Engineering Journal features articles about dynamic responses of bucket foundations. This introductory article provides an overview and perspective for the various contributions.

In recent years, suction bucket foundations have been used increasingly for gravity platform jackets, jack-ups etc. [1]. They also have the potential of being used for several other purposes, such as offshore wind turbines, sub-sea systems and seabed protection structures [2].

Despite some studies on bearing capacity have been studied, the detail responses of the suction bucket foundations under dynamic loads have remained unknown [3]. The dynamic load condition is significant when suction buckets are used as the foundation of an offshore structure. Wave load, ice-induced or wind-induced load cause the foundation to be subjected to cyclic loads [4]. The dynamic load is transmitted to the soils by platform and causes the degradation of soil layer's strength. Sometimes liquefaction and large deformation can occur, which leads to the decrease of the bearing capacity of bucket foundations. Therefore, it is important to clarify the dynamic behavior of bucket foundations in order to provide practical design methods and parameters.

First of all, experiments are required to be carried out to catch the main characteristics and basic data. Prototype tests need considerable expense and time. Thus they are unpractical. But it is much easier to change parameters in small scale tests. The soil type may be varied in these cases. The dimensions of the suction bucket and other process parameters may be varied conveniently also. However, in a small scale test, the problems arise concerning the stress- dependent behavior of soil that the measured loads are so low that measurements are not sufficiently accurate to visualize differences in design. Because the soil behavior depends on stress, small scale model tests can not exhibit the same responses. These restrictions can be overcome by tests in a geotechnical centrifuge. Centrifugal tests are "model" tests in that the results can be scaled up to the size of full-scale buckets. The main reason to select centrifugal test is for the proper modeling of body forces, which are critically important for the full-scale prototype geotechnical problem, and for the capability of investigating both undrained and partially drained conditions [5].

The scaling law is very important in experiments of bucket foundations, especially in centrifugal experiments. The conflict time scaling factors requires special consideration when both the dynamic effect and the seepage are presented [6]. The method to ensure the same time scaling factor for motion and seepage is usually to decrease the effective permeability of solid material by increasing the viscosity of the pore fluid or by changing the grain series of solid material. However, in some conditions, such as under relatively high frequency load, the effects of the variation of frequency are small. That means, no materials need to change (see Xuhui Zhang *et al*.).

Soil properties are the basic data for experiments and numerical and theoretical analysis. The degradation of soil's strength determines directly the dynamic responses of bucket. When soils are saturated, rapid load, such as ice-induced load, occurs under undrained conditions. The pore water instantaneously supports the new load, and the effective stress decreases. After several stress reversals during cyclic load, the pore pressure increases accumulate because the rapid load does not allow for complete dissipation between load cycles. Eventually, the pore pressure (p) will increase or even equal the confining pressure, causing the effective stress to disappear $\sigma_e = \sigma_c - p = 0$, and making the soil susceptible to liquefaction [7]. Once a soil has liquefied, damage such as slope failures, foundation failures, and floatation of buried structures can occur. (see Shuyun Wang and Xiaobing Lu; Li Wang). In recent the initiation of liquefaction and the accordingly large deformation are still the focus. The constitutive relation of soils after liquefaction and the degradation of soils after dynamic load are required deep investigation.

In ocean floor, there exists much silty sand which contains some layered or blocked clay, silt and a few broken shells. Usually, amount of soils are needed in model tests, but it is very difficult and expensive to obtain in-situ soils. Thus it is practical to use mixed soils as substitute of *in-situ* soils [8]. The mixed soils are needed to not only have the close physical and mechanical properties with that of situ soils, but also have good quality of repetition. How to prepare this type of mixed soils is very important and interesting. It is found that the differences of soil structures are the main reason to cause the obvious differences of the mechanical characteristics between undisturbed soils and remolded soils. Thus the mixed soils can be prepared by changing the grain size distribution to make its mechanical characteristics are close to the in-situ soils because of the effects of micro-structure (see Shuyun Wang and Xiaobing Lu and Zhongmin Shi).

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In the tropic marine area, such as in the zone of South China Sea, the Australia Sea, the calcareous sand is distributed widely. This type of sand has special characteristics: crushing and disintegration at low stresses compared with siliceous particles, macropores and cementation [9]. Therefore, it is important and difficult to study the dynamic responses of bucket foundations in this type of sediments. Firstly it is difficult to prepare the samples with the same cementation as that *in-situ* soils. Secondly the constitutive relation must be rebuilt because the developing characteristics of excess pore pressure is different very much from the other types of soils and the skeleton has also special characteristics. Thirdly it is difficult to measure exactly some characteristics such as the changes of microstructures because of its characteristics of crushing and inner pores during experiments (see Li Wang, Xiaobing Lu and Li Wang). The knowledge on the responses of bucket foundation in calcareous sand is very little compared to that in other types of soils, and thus much more studies are needed to be processed.

Effective numerical methods, such as difference method and finite element method, are useful methods to fast and accurately solve the problems in the design of bucket foundations [10]. Finite element analysis has been used quite often in numerical evaluation of marine structures, for an example, evaluation of the bearing capacity of bucket foundations, Effects of aspect ratio of bucket foundation. (see Jianhong Zhang, Jian-min Zhang and Chi Li). Numerical simulation is economical and can deal with complex questions such as the dynamic responses of bucket foundations in layered sediments or the effects of temporary rig (see Yongren Wu). The difficulties in numerical simulation are mainly determination of a suit constitutive relation of the porous media and handling of moving boundary between liquefaction zone and non-liquefaction zone.

The articles contained within this special issue of The Open Ocean Engineering Journal provide both the novice and the expert with a current understanding of dynamic responses of bucket foundations. Although we have done many hard works on the dynamic responses of bucket foundations, as a very difficult problem there are still many fundamental questions needed to solve. What is the most appropriate dynamic constitutive relation for the sediments? How to solve the question by directly and completely coupling of water and skeleton and bucket foundation? How to simulate the deep to very deep water environment in experiments? How to present a simple method for convenient use in practical engineering? With the fast development of ocean engineering, the studies in dynamic responses of bucket foundations have an exciting future.

Finally, we want to express our appreciation to the scientists who reviewed the articles in this special issue. Their comments and suggestions have helped improve the quality of the content and the delivery of the information in a way that we hope will be more understandable to everyone. These scientists are: Li Tao, Li Yong, Tan QM, Liu CT, Zhou WK, Zhang Jian Hong and Zhang Liming.

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