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Wave Theory Selection in the Simulation of Gravity Cage

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ABSTRACT

A special study is carried out to analyze the wave theory selection in the simulation of Gravity cage. Airy theory and Fifth Order Stokes theory are applied in the numerical model to simulate the behavior of the float collar and fishing net which are the main parts of Gravity cage bearing most waved-induced forces. Comparisons between experimental and simulated results are made to analyze the effect of different wave theory applied on the simulation results. Such conclusion can be obtained that when the value of relative water depth is larger than 0.18, linear wave theory is appropriate to be applied to simulate the behavior of Gravity cage.

KEY WORDS: gravity cage; model test; numerical simulation; Morison equation; wave theory

INTRODUCTION

Fishing farm and aquaculture industry are expanding, and more fishing farms are being located offshore, as the number of suitable near-shore location is limited. These calls for new technological challenges, as fishing farms are being installed at location more exposed to waves and current. Relative to other net cage structures, gravity cage has the characteristics of cheapness and easy management. At present, gravity cage is widely used in the fishing farms all over the world.

To our knowledge, Aarsnes et al.(1990) conducted the first research for proposing a calculation method for determining the shape and internal forces on supple net cages. In their theory the three-dimensional (3D) effects were neglected. The cage thus consists of net panels, which are discretized into line-finite elements in the plane of symmetry. The calculation of hydrodynamic forces depends on the results of test models. Théret (1993) proposed an original 3D numerical model for modeling fishing nets. He succeeded in developing software for calculating the shapes and tension forces of a trawl towed at a constant speed. Bessonneau and Marichal (1998) chose to use and generalize the assumptions adopted by Théret (1993) and developed a dynamic study of submerged and reticulated structures. Tsukrov et al. (2003) described the theoretical models and calculation methods of nets, using the consistent net element method, compared the results of previous research with those of their models and applied them to interpreting the movement of the cage system. Li et al (2006a and 2006b) developed a lumped mass method to simulate the hydrodynamic behavior of the plane net and net cylinder in current. In their method the lumped masses were set at each mesh knot and the center of each mesh bar, and the mesh grouping method was applied to reduce the number of lumped masses.

However, most researches as mentioned above are carried out only in current. So far, the research productions of net cage in waves are few, either in experimental or numerical study. In the numerical simulation of Gravity cage in waves, it is important to apply the wave theory properly according to practical conditions. In general, the gravity cage is located in the sea area where the value of relative water depth d/L(where d is water depth, L is wave length)is larger than 0.1, and thus the Stokes wave theory is available. Based on the experimental study by Zhu(2006), the linear and Fifth Order Stokes theories are regarded as better methods than other Stokes wave theories in the calculation of waves force on marine structure, and their usage ranges are suggested: when $T\sqrt{g/d} < 6.0$ (equivalent to $d/L>0.2$),$H/d<0.2$(where H is wave height，g is gravity acceleration), linear wave theory is appropriate, then when $T\sqrt{g/d} < 10.0$ （equivalent to $d/L>0.1$, Stokes Fifth Order wave theory is appropriate Komar(1976) believe that when $d/L>0.25$, linear wave theory is appropriate for the calculation of wave velocity. According to the experimental data by Morison (1950), even if the value of d/L is about 0.2, the linear wave theory can also be applied to describe the horizontal velocity of water particle accurately.

Although many discussions, as mentioned above, about selection of wave theory for general marine structure have been carried out, the analysis of wave theory selection for net cage which is flexible and floating structure made of members of small diameter is few in existed literature. In this paper, a special discussion is carried out to analyze the selection of wave theory in the simulation of Gravity cage. Linear wave theory and Stokes fifth order theory are applied in the numerical model respectively to simulate the behavior of the float collar and fishing net which are the main parts of Gravity cage bearing most waved-induced forces. Comparisons between experimental and simulation results are