Experimental Investigation into Structural Deformation of Large Flexible Semi-Submersible Structure

Hidetaka Senga¹, Takahito Iida¹, Akira Tatsumi¹, Iijima Kazuhiro¹, Yuwang Xu² and Shixiao Fu²
¹ Dept. of Naval Architecture and Ocean Engineering, Osaka University, Suita, Osaka, Japan
² School of Naval Architecture, Ocean and Civil Engineering, Shanghai Jiao Tong University, Shanghai, China

ABSTRACT

Fish resource is sustainable, cheap and available to people worldwide. It can be harvested efficiently by using aquaculture. Recent trend is using a large offshore structure for fish farming in deeper seawaters. The present study focuses on the experimental measurements on the structural behavior of a semi-submersible and flexible structure under the currents and waves. In the experiment, the overall structural deformation is measured by using the optical tracking system while the strains are measured at various locations by using strain gages. It is found out that the structural response of the semi-submersible structure under co-existing waves and current is not equal to the sum of the responses due to waves and current, respectively.

KEY WORDS: aquaculture, current, wave, offshore structure, tank test, scaled model, flexibility

INTRODUCTION

The world population is increasing. One must consider a fact that more people will eat more fish in the future. The fish resources need to be developed to meet the expanding demand for food. Fish farming or aquaculture may give a solution to it. In 2008, the aquaculture provided 46% of the fish produced globally for human consumption with a mean yearly increase rate of 7% since 1970. Thus, the development of the aquaculture is in line with Sustainable Development Goals (SDGs) adopted at United Nation Summit in 2015. Fish resource can be sustainable, cheap and available to people worldwide, but, still the technology is at the developing stage.

Currently, researchers are discussing to adopt a large offshore structure for fish farming in deep seawaters, distant from coastal area (Aksnes, 2017, Engelhaupt, 2007, Fore et al, 2018). One pioneering pilot project of the offshore aquaculture is already initiated in Norway (Figure 1, Sal Mar 2016). By using the large offshore structure, fish aquaculture may be performed much more efficiently due to the size economy, in a cleaner area. It poses other challenges since the seas in offshore is much harsher than the coastal area, in general; higher waves, higher sea current, deeper water depth, large distance from shore, etc. Meanwhile, the structure becomes relatively flexible due to its size. One concern is how the structure may behave in the sea current and waves (Ma, et al, 2016, Takagi, et al, 2011).

With these backgrounds, the present study focuses on the experimental measurements on the structural behavior of a semi-submersible and flexible structure under the current and waves. To this end, a prototype model of a semi-submersible type structure is firstly designed, then scaled to an experimental model with a scale ratio 1/15, taking account of the hydroelasticity. The dimension of the prototype model is 34m in length and width, and 15m in depth, consisting of many steel pipes with the diameter ranging from 0.25 m to 0.7 m. Then, a series of tank tests is performed at the towing tank of Osaka University. The behavior under waves and coexisting waves and current, is compared. It is found out that the structural response of the semi-submersible structure under co-existing waves and current is not equal to sum of the responses due to waves and current, respectively.

Figure 1. Sample of large offshore structures for fish farming (Ocean Farm, Sal Mar 2016).

MODEL

Prototype Model

A semi-submerged fish farming structure consists of four components, i.e., pontoon, steel frameworks, mooring lines and fish net. The draught of the structure is 12.9 m. The freeboard height is about 2m. Detailed arrangement of the prototype model is given in Figure 2.