Numerical simulation of wave motion on the submarine HDPE pipe system
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ABSTRACT
The Philippines is located in the northwest Pacific Ocean, where is also the main occurring area of typhoon. There are 20 typhoons a year on average in this area, and about 8~9 of them are crossing the Philippines. When typhoons pass over land, they will bring strong winds and waves. Therefore, the stability of offshore structures under wave conditions are particularly important. The target object for seawater cooling pipeline is the stability of pipes during wave attacks. Due to the light weight of HDPE pipe, the ballast is usually used to add to the pipe for the purpose of increasing the stability of pipe in engineering practice. The aim of this study is to understand the importance of ballast for the stability of pipe system. FLOW-3D software was applied to simulate the effect of submarine pipes with ballasts under wave motion generated drag force, lift force and inertial force. For accurate numerical analysis, definition of boundary conditions is an important step in the simulation setup. The significant wave height and peak wave period were chosen as design values of 100 year return period. The simulation results of FLOW-3D are put into the Morison equation and lift equation to compare the differences between the forces and coefficients with or without ballasts. The drag coefficient, lift coefficient and inertial coefficient of the ballast and pipe can be both analyzed to see the effect of ballast. By adopting numerical simulation for this study can be improved the engineering design practice work with ballasts.

KEY WORDS: Submarine pipes, Ballast, Morison equation, Drag force, Inertia force, Lift force, Flow-3D

INTRODUCTION
Pipelines are widely used in marine engineering such as taking cooling water from the sea to cool down the facilities and then discharging the effluent back to the environment. Since the pipelines play such an important role, they have become one of the significant concerns in application of engineering field. After the pipeline is settled on the seabed, it is affected by waves, tides, currents and the change of the sea bed. In Fig. 1, the sinking process of the marine pipeline with blocks is shown. In recent years, global warming and climate condition vary rapidly, leading to the increase in the number of typhoons, wave scale and periods. Therefore, it is essential to scrutinize the relations between the marine structures and the surroundings.
Su and Kung (2022) discussed the influence on the surroundings around the pipe with the blocks to get the regression of the drag coefficient to the distances between blocks.
In most cases, instability is the primary cause that leads to the failure of marine structure. So, stability is one of the keys to pipeline design. It is typical to use concrete ballasts for the pipes to avoid buoyancy and to improve stability. Ballasts are designed as different shapes and weights according to the force load on the pipelines.
There are three main inline forces on the pipelines under water, drag force, inertia force and lift force. Drag and lift forces are related to the velocity of water particle, and inertia force is related to the acceleration of water particle. In this study, FLOW-3D was applied to simulate the wave forces. Once the results of simulation, the forces (Force-X & Force-Z) of the pipelines with the wave motion were got, and the coefficients of the forces with or without the ballasts and their influence would be analyzed.