Wave-Structure Interaction Phenomena inside an OWC Wave Energy Device

By, K.Thiruvenkatasamy[1] and Michio Sato[2]
[1]Doctor Course Student, Dept. of Ocean Civil Engineering, KagoshimaUniversity, 1-21-40; Korimoto, Kagoshima-shi, 890, Japan.
[2]Professor, Dept. of Ocean Civil Engineering, Kagoshima University, 1-21-40;Korimoto;Kagoshima-shi, 890, Japan.

Introduction

The Random phenomena of water surface oscillations inside Oscillating Water Column (OWC) device have the prime influence on the compressibility aspects of chamber which influences the OWC structure configuration as well as height of chamber, besides the efficiency of power absorption. Malmo and Reitan(1985) showed that there exists an excess pressure amplitude in relation to the incoming wave amplitude. The hydrodynamic damping of OWC chamber due to the surface oscillations is one of the important phenomena which governs the air pressure aspects as well as hydrodynamic performance behavior. This paper discusses on the hydrodynamic damping process inside OWC chamber.

Damping Process Inside OWC

In an OWC caisson, the power absorbed by the OWC chamber(Fig.1) is maximum for a certain damping condition, which is called optimum damping condition. This optimum damping will be different for different incident wave frequency. Even for a fixed wave frequency, the incident wave steepness, structure configurations may alter the optimum damping considerably. Hence for the prototype condition, it is not possible to fix a single optimum damping value. An average optimum damping for the prevailing wave conditions, dimension of the structure and configuration, is possible. The damping process is explained by the term "Damping Coefficient". The method of calculation of damping coefficient is as given below.

Evaluation of Damping Coefficient

Knowing the water surface oscillations and air pressure inside the chamber, the damping is $D = P*A/v$; here, P is air pressure and v is vertical velocity of water column and A is OWC plan area. Over a period of time, D is also in a time series form. For representation one has to use a representative damping. For regular wave, it is decided to use average maximum and minimum damping, where,

Average positive damping $= P_{max} A / v_{max}$ and

Average negative damping $= P_{min} A / v_{min}$

where, P_{max} and P_{min} are the maximum and minimum values of the air pressures, v_{max} and v_{min} are the maximum and minimum values of the vertical water particle velocity, which is obtained by numerically differentiating the water surface oscillations inside the chamber and is given as

$$v = \frac{(\eta_{OWC})_{i+1} - (\eta_{OWC})_i}{\Delta t}$$

where, $(\eta_{OWC})_{i+1}$ & $(\eta_{OWC})_i$ are the water surface oscillations inside OWC at i+1 and i^{th} instant & Δt is sampling rate in sec. Experiment based time series shows that the damping decreases with increase in a/A. Under fully closed condition of orifice(turbine duct), the maximum positive damping is found to reach about 3000 N-s/m. The maximum negative damping for the present set is about 800 N - s/m only. Even for a sinusoidal wave input, the damping time history is found to be random. This clearly indicates that the damping process is highly non-linear due to the complicated physics of wave-structure interaction process for this type of structures. Fig.2 shows the typical time series of damping process for S/b =3, d/L=0.164, H/L=0.016.(where, S/b- ratio of center to centre distance between devices in array(S) to its harbour width(b); d/L-ratio of water depth to wave length; H/L- wave steepness) Fig.3 shows the impulsive nature of air pressure time series.

Conclusions:

The damping process inside an OWC chamber is non-linear even for regular wave oscillations. Hence, further investigation is needed, before venturing for real-life wave power device. The numerical study of this phenomena is in progress.

Reference

Thiruvenkatasamy(1994) 'An Experimental investigation on wave forces, air pressures and optimum spacing of Oscillating Water Column wave energy caissons in array' M.S.Thesis, Indian Institute of Technology, Madras, India.

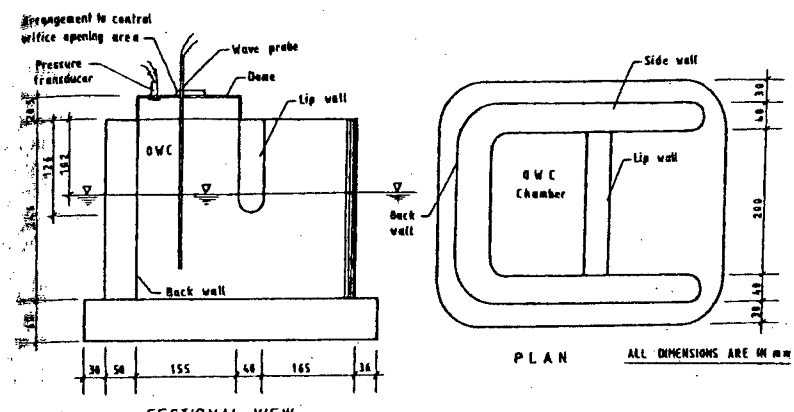

Fig.1. OWC Model

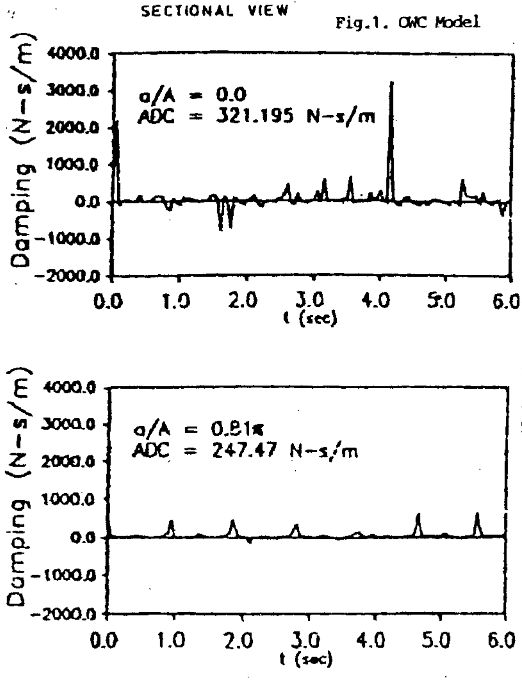

Fig. 2 Time series Damping process
(S/b =3, d/L= 0.164, H/L=0.016)

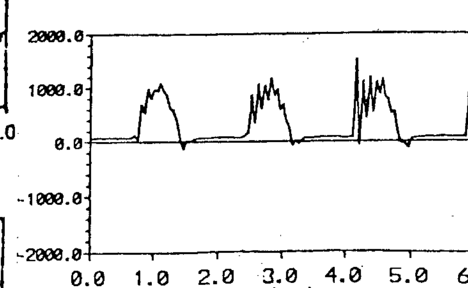

Fig. 3 Time series of air pressure
(d/L=0.087, H/L=0.018)