Dynamics of a completely immersed nonlinear beam under the action of a sea wave

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Abstract. The dynamic study of structures completely or partially immersed in fluids is necessary to ensure not only their stability but also the safety of their users. The present work treats the vibrations of a completely submerged beam subjected to sea wave excitations. The expressions of the external forces that the fluid exerts on the structure are found as well as the equation of the movement of the system. Using the numerical resolution we show the accordance between the analytical and numerical results. A comparative study of the vibration amplitudes of the structure under the action of one and several waves. The stability study allows us to have a better insight into the dynamics of the structure. The influence of some hydrodynamic parameters, namely the immersion height of the structure, the density of the fluid, and the nonlinear term have been studied.

Introduction

The study of the dynamic behavior of mechanical structures has grown considerably in recent years. These structures such as buildings, boats, and bridges are for this purpose very exposed to external stresses such as wind, earthquakes, and waves, which can lead to them breaking if they are not protected. Several researchers, to prevent destruction by waves of submerged mechanical structures have studied and designed shock absorbers like fully submerged plates, and double plates. For years, several studies have been carried out to study the dynamics of rigid structures in contact with a fluid. The first results revealed that the plates were good candidates to protect rigid structures against sea waves. They are easily adaptable to structures and can be used to protect ports, ships, and offshore structures [1]. Theoretical and experimental investigations carried out so far led to the development of a mathematical model of a double-plate system from which the velocity potential in each fluid domain is derived using three sets of orthogonal eigenfunctions. A series of experiments on plates in contact with anomalous waves were carried out. The objective of this work is to set up a plate system with a fluid to reflect the incident waves as much as possible. The effect of a flow field on the dynamic behavior of a structure is generally studied to dimension the structure which is in interaction with a fluid [2]. This work deals with the interaction of a mechanical structure subjected to sea waves. The results of such a study are crucial insofar as they can lead to a better dimensioning of underwater structures, ships, and rudders. The influence of some parameters of the studied system on the dynamics of the structure is presented.

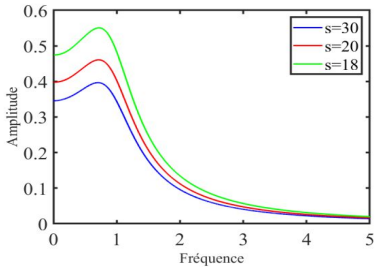

Figure 1: Amplitude-frequency curves for different values of the immersion height

Results and discussion

The evaluation of the beam dynamics in the case of several sea waves made it possible to reveal, through the amplitude curve, the effect of the multiple frequencies relating thereto and the increase in amplitude observed. As a result, the mechanical structure will be safer in low-density fluids. The effect of the immersion height of the beam on the dynamics of the system reveals that the increase in the height of immersion of the beam causes a decrease in the maximum amplitude of vibrations around the resonance frequency. Taking into account the nonlinearity of the beam leads to an extension of the resonance zone of the system, but contributes to a reduction of the vibration amplitude.

References

[1] Tune et al. (1956) **Stiffness and Deflection Analysis of Complex Structures** *J. of Aeronautical Sciences 9,23.*

[2] V.H. Vu, M. Thomas, A.A. Lakis and L. Marcouiller, EFFECT OF ADDED MASS ON SUBMERGED VIBRATED PLATES, 25th Seminar on machinery vibration, Canadian Machinery Vibration Association.